An Empirical Study of Teenagers' Friendship versus Smoking and Drinking Patterns

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1 Abstract

This empirical paper delves into the broader topic of "the effect of social influence and conformity to social norms." Specifically, we examine the smoking and drinking behaviors of teenagers in secondary school, investigating whether students' behaviors are influenced by their friends (social influence) and, conversely, if students prefer to befriend peers with similar behaviors (social selection). We empirically test the social influence process to determine whether students conform to the smoking norms of their peer groups. Utilizing the Stochastic Actor-Oriented Model (SAOM), we verify the proposed hypotheses. Our findings indicate that teenagers are significantly influenced by their friends regarding smoking behavior, affirming the existence of the social influence process. Additionally, we find that students tend to form friendships with others who exhibit similar smoking behaviors, underscoring the relevance of the selection process.

2 Introduction

Social influence is a ubiquitous mechanism where individuals modify their opinions, attitudes, beliefs, or behavior to resemble those of others they interact with [3]. This modification can occur due to persuasion, a tendency to seek similarity, or uncertainty when making decisions. Thus, it is worth studying whether and how social influence within the network impacts the behavior of individuals. In our study, we focus on the smoking and drinking behaviors of teenagers as the target variables that we want to explain and the friendship network as the explanatory variable. Conversely, we also examine how these behavioral patterns influence their friendships. The main contribution of this work is that we bridge theory to empirical analysis in a real-world scenario, studying the dynamic interplay between social influence and individual behavior. By understanding how teenagers change their behavior, we can deduce whether they conform to group norms, particularly the smoking habits of their friends. Last but not least, we

hope that our analysis will inform adequate prevention strategies to promote healthier behavior among adolescents.

3 Literature Review

Social influence has always been an active area of research. A recent study by Flache et al. [6] delves into various models of social influence, particularly focusing on three types: assimilative influence, similarity-biased influence, and repulsive influence. These models help to explain how individual interactions can lead to broader societal patterns of behavior and opinion. The theoretical framework is grounded in classic theories of social influence such as Festinger's cognitive dissonance theory [5] and Heider's balance theory, which emphasize the mechanisms through which individuals strive for internal consistency and social harmony. The three model categories from [6] serve as a theoretical framework for our topic. For instance, the assimilative influence model suggests that individuals tend to become more similar over time due to continuous social interactions, which could be particularly relevant in understanding how teenagers might adopt smoking or drinking behaviors to fit in with their peer group. Furthermore, its exploration of how social influence models can be empirically validated and calibrated (for example, agent-based modeling (ABM) as a method to explore how individual behaviors aggregate to produce macro-level patterns) provides a methodological blueprint for analyzing social behaviors in teenagers for our study.

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To better understand the power of social influence in a more practical context, we reviewed the work of Asch (1956) [1], which employed an experimental design where participants performed a visual discrimination task. A single critical participant faced a unanimous incorrect judgment from a group of confeder-

ates, creating a controlled environment to observe conformity. High conformity rates were observed. Asch's study is grounded in the theory of social conformity, which posits that individuals often change their behavior to align with group norms to avoid social rejection or to gain acceptance [4]. This work extends earlier theories by emphasizing the conditions under which individuals resist or succumb to group pressure. The study challenges the simplistic view that conformity is merely a result of a desire for social approval, instead highlighting the complexity of social influence and the various factors that contribute to conformity and independence. Asch's study highlights the strong influence of group norms on individual behavior even when such norms contradict their perceptions, which in our study could explain whether some students change their smoking behavior due to peer pressure.

The previous literature concerned an artificial experiment. To generalize the idea of social influence into different contexts (e.g., diffusion of drug use), Burt's [2] study was also reviewed. It provides a comparative analysis of cohesion (individuals are influenced by those with whom they have frequent and empathic communication, suggesting that strong ties within a network facilitate the spread of behaviors) and structural equivalence (individuals are influenced by others who occupy similar positions in a social structure, driven by competition and comparison) to understand the diffusion of innovation. It explores the mechanisms of social influence and contagion within social networks, shedding light on how behaviors spread through both cohesive groups and structurally equivalent positions. Burt finds that structural equivalence, rather than cohesion, more significantly explains the diffusion of the new drug; physicians adopted innovations based on the actions of peers occupying similar positions. Burt's findings are crucial for our study of teenage smoking and drinking behaviors. The emphasis on structural equivalence suggests that teenagers may be influenced not just by close friends but also by peers in similar social positions or roles, such as classmates or teammates. This insight can help design interventions that target these influential peer groups to curb harmful behaviors.

Having reviewed some of the empirical studies, we move towards some theories to arm ourselves with theoretical foundations. Friedkin's theory [7] integrates structural social psychology and social influence network theory (SINT) to explain how interpersonal influences shape individual attitudes and behaviors. The framework emphasizes the importance of network structures in determining the flow of influence, suggesting that individuals' positions within a network significantly impact their susceptibility to social influence. The formalized approach of incorporating network structure into mathematical models is highly relevant to our research, as it provides a framework for understanding how social influence and peer networks shape individual behaviors in group settings. The structural effect will be included in our implementation of the SOAM model.

To support our empirical analysis with SAOM, Snijders' paper [17] was reviewed. Snijders' framework is built on the stochastic actor-oriented model (SAOM), which views network changes as the outcome of decisions made by individual actors within the network. This model allows for the analysis of both the formation and dissolution of ties based on actors' preferences and external

covariates. By treating network evolution as a continuous-time Markov process, SAOMs can effectively capture the dynamic nature of social influence and how individuals adapt their behavior in response to their social environment. Snijders demonstrates that behaviors and network ties co-evolve, meaning that changes in one can lead to changes in the other. In section 6 of Empirical Analysis, we proposed several hypotheses regarding the co-evolution of smoking/drinking behavior with the friendship network, corresponding to the social selection process and social influence process.

4 Theoretical Framework

Our research focuses on understanding how smoking and drinking behaviors evolve within friendship networks among teenagers. By fitting a model that predicts these behaviors and inspecting the parameters, we aim to better grasp how social influence changes teenagers' choices regarding smoking and drinking and whether they tend to conform to the norms of their friends. To comprehensively address this, integrating various theoretical concepts from our course is very helpful. The following sections outline how each concept can be integrated into our research.

4.1 Group

Understanding the concept of "group," as we have explored throughout the course, is fundamental to our research question. A group is typically defined as a collection of individuals who interact and have a sense of belonging or identity [16]. In the context of our study, the groups are subsets of the friendship networks among teenagers. Recognizing the characteristics and dynamics of these groups helps identify the social structures within which smoking and drinking behaviors are adopted and perpetuated. This foundational concept allows us to explore how group membership influences individual behavior and how changes in group composition (e.g. new friendships) affect smoking and drinking patterns.

4.2 Cohesion

Social cohesion refers to the bonds that bring group members together and foster a sense of belonging and solidarity [11]. In our research, examining the level of cohesion within teenage friendship groups can shed light on how tightly-knit groups may exert stronger influence over individual behaviors. Highly cohesive groups may have more robust mechanisms for enforcing social norms, including those related to smoking and drinking [9]. This concept prompts us to investigate whether teenagers in more cohesive groups are more likely to conform to the group's smoking and drinking behaviors.

4.3 Social influence and conformity to social norms

At the heart of our research is the concept of social influence and conformity to social norms. This theory posits that individuals adjust their behaviors to align with the perceived norms of their social group [4]. In teenage friendship networks, if smoking and drinking are seen as normative behaviors, individuals are likely to conform to these behaviors to gain acceptance and avoid social sanctions. This concept guides us to examine the specific mechanisms of social influence (e.g. peer pressure) that encourage conformity and how these mechanisms operate within different types of friendship networks.

4.4 Identification and Self-Categorization with Groups

Social identity theory [19] and self-categorization theory [8] suggest that individuals derive a part of their identity from the groups to which they belong. Teenagers who strongly identify with their friendship group are likely to adopt the group's norms and behaviors as part of their self-concept. This concept is pivotal in understanding why teenagers might start smoking or drinking to align with their group identity. Investigating how self-categorization influences the likelihood of adopting smoking and drinking behaviors helps us understand the interplay between individual identity and group dynamics.

4.5 Homophily and Blau Space

Homophily, the tendency of individuals to associate with similar others, plays a significant role in the formation of friendship networks [13]. Blau space [12], which considers multidimensional social spaces defined by various sociodemographic variables, helps us understand the patterns of homophily in teenage friendship networks. Analyzing how homophily influences the formation of groups with similar smoking and drinking behaviors can provide insights into the diffusion of these behaviors. This concept prompts us to explore whether teenagers with similar backgrounds and attitudes towards smoking and drinking are more likely to form friendships and reinforce these behaviors.

5 Methodology

In this paper, we formulate several hypotheses inspired by the theoretical framework discussed in Section 4, with some hypotheses directly related to the reviewed literature. We will list the proposed hypotheses and empirically verify them using the Stochastic Actor-Oriented Model (SAOM) implemented in RSiena. Note that two different models were implemented. Model0 corresponds to the social selection process, addressing Hypotheses 1 and 2 (where smoking and drinking behaviors are the explanatory variables and the friendship network is the dependent variable). Model1 corresponds to the social influence process, addressing Hypotheses 3 and 4 (the reverse direction of the former process).

5.1 Stochastic Actor-Oriented Model

The Stochastic Actor-Oriented Model (SAOM) is a statistical framework designed for analyzing the co-evolution of social networks and individual behaviors over time. This model treats network dynamics as a series of micro-steps, where actors make decisions to form, maintain, or dissolve ties based on their attributes and the influence of their peers. SAOM can handle longitudinal data, capturing the dynamic interplay between social structures and behavioral changes, making it particularly suitable for our study. An additional advantage of SAOM is its ability to incorporate network structures into the model, aligning with the concept of social influence network theory [7], which includes network mechanisms such as reciprocity, transitivity, and more.

6 Empirical Analysis

6.1 Description of the dataset

The dataset utilized in this study is available here [14]. It comprises early to middle adolescent students from a secondary school in Glasgow. Out of 160 total pupils, we focused on the 129 students who were present across all three measurement waves. The friendship networks were established by allowing students to name up to six friends. Additionally, students provided information about their lifestyle habits, including smoking and drinking behaviors. The school's demographic composition was representative of other schools in the region concerning social class. A detailed description of the relevant variables for this paper is provided in Table 1. For a visual representation of the network, refer to Figure 1 and Figure 2. The code for analysis, visualization, and simulation is accessible here [10].

Variable	Description
Smoking	Ordinal values, coded from 1 to 3, with 1 being no-smoking and 3 being most frequent
Drinking	Ordinal values, coded from 1 to 5, with 1 being no-drinking and 5 being most frequent
Sex	Binary values, 1 being boys and 2 being girls
Age	Discrete values
Money	Discrete values, the pocket money student had per month
Romantic	Binary values, indicating whether the student has a romantic relation, 1 being no and 2 being yes
FamilySmoking	Binary values, With 1 being no family members smoke, 2 being yes

Table 1: Description of the variables

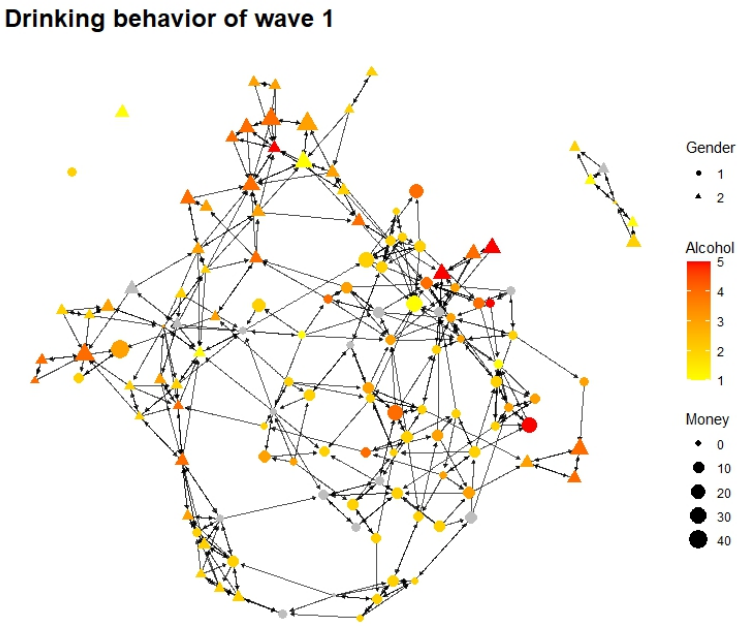

Figure 1: Drinking behavior of the students in wave 1, with the circle being boys and triangle being girls, no-drinking in yellow and most frequent drinking in red, size of the nodes proportional to the pocket money.

6.2 Preliminary analysis

Before applying the Stochastic Actor-Oriented Model (SAOM) to the dataset, it is essential to calculate the Jaccard index to determine the suitability of SAOM for our data. The Jaccard index measures the continuity between two consecutive observations to ensure that neighboring waves do not differ significantly. According to the RSiena official manual, Jaccard values of 0.3 and above are considered acceptable [18]. The Jaccard value from wave 1 to wave 2 was 0.304, and from wave 2 to wave 3 was 0.351. These values indicate that SAOM is an appropriate model for this dataset.

6.3 Model Specification

As previously mentioned, model0 was implemented to test hypotheses 1 and 2, incorporating network effects related to gender and behaviors to examine behavioral homophily and gender homophily. For the social influence process, model1 was used to test hypotheses 3 and 4. It is important to note that only smoking patterns were included in this model. Including drinking patterns caused the

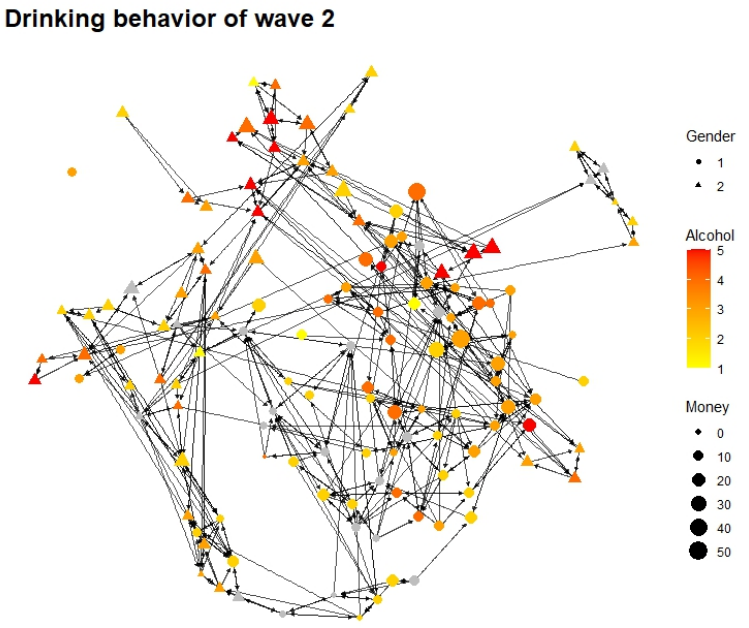

Figure 2: Drinking behavior of the students in wave 2, with the circle being boys and triangle being girls, no-drinking in yellow and most frequent drinking in red, size of the nodes proportional to the pocket money.

model to fail to converge and significantly prolonged the fitting process.

6.4 Social selection – model0

To implement the model0 that accounts for the social selection process we want to test, we include the necessary statistics as shown in the figure3. By default, RSiena always includes the rate statistics, the outdegree, and the reciprocity statistics. Additionally, we incorporated drinking/smoking behavior and gender into the model0, a complete list of effects and the convergence of the model can be seen in figure3.

We observed that the model has successfully converged, as indicated by the convergence t-ratios and the overall maximum convergence ratio, which measure deviation from the target. The convergence t-ratios are all less than 0.1 in absolute value, and the overall maximum convergence ratio is below 0.2. This confirms that model0 has reached convergence.

```
Estimates, standard errors and convergence t-ratios

                                   Estimate    Standard    Convergence
                                                 Error       t-ratio

Rate parameters:
  0.1      Rate parameter period 1  8.9578  ( 0.7511   )
  0.2      Rate parameter period 2  7.6047  ( 0.6280   )

Other parameters:
   1. eval outdegree (density)     -3.1433  ( 0.0832   )    0.0451
   2. eval reciprocity              2.4832  ( 0.0852   )    0.0328
   3. eval sex alter               -0.1195  ( 0.0889   )   -0.0048
   4. eval sex ego                  0.1802  ( 0.0951   )   -0.0135
   5. eval same sex                 0.9765  ( 0.0857   )    0.0415
   6. eval tobacco alter            0.0371  ( 0.0672   )   -0.0145
   7. eval tobacco ego             -0.0121  ( 0.0697   )    0.0141
   8. eval tobacco similarity       0.3801  ( 0.1199   )   -0.0191
   9. eval alcohol alter            0.0507  ( 0.0377   )   -0.0065
  10. eval alcohol ego              0.0342  ( 0.0412   )    0.0134
  11. eval alcohol similarity       0.5255  ( 0.1658   )    0.0142

Overall maximum convergence ratio:    0.0739


Total of 3180 iteration steps.
```

Figure 3: Network effects and their convergence of model0.

6.4.1 Hypothesis 1: Do students tend to befriend students with similar smoking/drinking behavior?

Inspired by section 4.5 of homophily, a natural and straightforward hypothesis is to ask whether students with similar smoking or drinking behavior are more likely to become friends. Specifically, in our model implementation, we analyze how the statistics of similar tobacco/alcohol influence the dependent variable(friendship nomination). As shown in the figure 4. The statistics "tobacco similarity" and "alcohol similarity" are both significant with p-values being both 0.002, the estimates are 0.380 and 0.525, respectively. The positive signs of the estimates indicate that students indeed tend to make friends with others who have similar drinking and smoking behaviors.

6.4.2 Hypothesis 2: Is there a tendency to befriend with students of the same gender?

Similarly, upon inspecting the figure 4, we found that the parameter responsible for gender homophily "same sex" has a p-value equal to 0, indicating statistical significance. The estimate of 0.976 is positive, suggesting that individuals of the same gender are more likely to become friends. This observation confirms the presence of gender homophily, thereby verifying Hypothesis 2.

	dependent	effect	theta	s.e.	p.value	sig.	t.conv
1	rate	constant friendship rate (period 1)	8.958	0.751			
2	rate	constant friendship rate (period 2)	7.605	0.628			
3	friendship	outdegree (density)	-3.143	0.083	0	***	0.045
4	friendship	reciprocity	2.483	0.085	0	***	0.033
5	friendship	sex alter	-0.119	0.089	0.179		-0.005
6	friendship	sex ego	0.180	0.095	0.058	.	-0.014
7	friendship	same sex	0.976	0.086	0	***	0.042
8	friendship	tobacco alter	0.037	0.067	0.581		-0.014
9	friendship	tobacco ego	-0.012	0.070	0.862		0.014
10	friendship	tobacco similarity	0.380	0.120	0.002	**	-0.019
11	friendship	alcohol alter	0.051	0.038	0.179		-0.006
12	friendship	alcohol ego	0.034	0.041	0.406		0.013
13	friendship	alcohol similarity	0.525	0.166	0.002	**	0.014

Figure 4: Parameters of model0.

6.5 Social influence – model1

We analyze the co-evolution of the friendship network and smoking behavior to determine whether influence mechanisms explain changes in friendship ties.

Before analyzing the data, we investigate whether the network correlates with smoking and drinking behavior using the Moran index. This index quantifies the similarity or dissimilarity of a variable (e.g., behavior, opinion) across connected individuals in a network [15]. We found that the Moran index for all waves, for both smoking and drinking behavior, is higher than 0.2. This indicates a positive autocorrelation between smoking behavior and friendship ties, exceeding the recommended threshold value of $\frac{1}{N(N-1)}$. Therefore, we can apply the SAOM to determine whether this autocorrelation is due to influence mechanisms.

6.5.1 Hypothesis 3: Do student adjust their choice of smoking to be aligned with their friend?

Inspired by section 4.3, teenagers' smoking patterns could be affected by social influence processes (e.g. the decisions of their friends). Hence, we implemented the model1 that explains both network dynamics and behavior dynamics as shown in the figure 5. Note that the model1 reached convergence(the convergence t-ratio is in absolute value smaller than 0.1 and the overall maximum convergence ratio is smaller than 0.2).

By the figure 6, the parameter for "same sex" is significant and positive, affirming our conclusion regarding hypothesis 2 about the existence of gender homophily. It's interesting to note that reciprocity is also significant and positive, indicating that teenagers tend to reciprocate friendship nominations. Regarding hypothesis 3, the parameter accounting for smoking behavior is significant and positive (p-value of 0.012 and an estimate value of 3.272), which implies that students indeed change their smoking habits to be more similar to their friends. Therefore, hypothesis 3 is accepted.

```
> model1
Estimates, standard errors and convergence t-ratios

                                          Estimate   Standard   Convergence
                                                       Error      t-ratio
Network Dynamics
   1. rate constant friendship rate (period 1)  8.8000  ( 0.6943   )   -0.0630
   2. rate constant friendship rate (period 2)  7.6400  ( 0.5736   )    0.0098
   3. eval outdegree (density)                 -3.0916  ( 0.0859   )    0.0327
   4. eval reciprocity                          2.4715  ( 0.0866   )    0.0724
   5. eval same sex                             0.9623  ( 0.0915   )    0.0489
   6. eval smokingbeh alter                     0.0638  ( 0.0787   )   -0.0080
   7. eval smokingbeh ego                       0.0036  ( 0.0829   )    0.0085
   8. eval smokingbeh similarity                0.6018  ( 0.1815   )   -0.0083

Behavior Dynamics
   9. rate rate smokingbeh (period 1)           4.1527  ( 1.9264   )    0.0777
  10. rate rate smokingbeh (period 2)           3.7427  ( 1.5179   )    0.0378
  11. eval smokingbeh linear shape             -3.2207  ( 0.6272   )    0.0569
  12. eval smokingbeh quadratic shape           2.7260  ( 0.3532   )    0.0392
  13. eval smokingbeh average similarity        3.2716  ( 1.3067   )   -0.0530
  14. eval smokingbeh indegree                  0.1479  ( 0.1822   )    0.0348
  15. eval smokingbeh outdegree                 0.0369  ( 0.2153   )    0.0384
  16. eval smokingbeh: effect from sex         -0.0097  ( 0.3058   )    0.0071

Overall maximum convergence ratio:    0.1763


Total of 3522 iteration steps.
```

Figure 5: Effects and convergence of model1

6.5.2 Hypothesis 4: Do popular students tend to smoke more?

A common stereotype depicted in high school movies is that some teenagers smoke more to appear "cool" and enhance their popularity. In relation to our theory, it is possible that popular students might feel compelled to smoke more to maintain their "status" or to impress their numerous friends. To investigate this potential phenomenon, we formulated a hypothesis. However, the effect "smokingbeh indegree" was found to be not significant, leading to the rejection of hypothesis 4. Therefore, we conclude that, based on our data, popular students do not necessarily engage in increased smoking behavior.

7 Discussion

Reviewing the hypotheses we proposed, we found that teenagers in secondary school adapt their smoking and drinking behaviors to align with those of their friends, as suggested by hypothesis 3. This finding aligns with the assimilative influence model by Flache et al. [6], which posits that individuals connected by structural relationships influence each other to reduce opinion differences. Similarly, Asch's line-judgment conformity experiments demonstrated that individuals often succumb to explicit social pressures, even when the consensus is incorrect [1]. These existing literatures offer a possible explanation for our findings: teenagers may conform to the behaviors of their friends to gain acceptance or avoid social critique from their peers.

Regarding the social selection process, hypotheses 1 and 2 were accepted,

	effect	theta	s.e.	p.value	sig.	t.conv
1	constant friendship rate (period 1)	8.800	0.694			
2	constant friendship rate (period 2)	7.640	0.574			
3	outdegree (density)	-3.092	0.086	0	***	0.033
4	reciprocity	2.471	0.087	0	***	0.072
5	same sex	0.962	0.091	0	***	0.049
6	smokingbeh alter	0.064	0.079	0.417		-0.008
7	smokingbeh ego	0.004	0.083	0.965		0.009
8	smokingbeh similarity	0.602	0.182	0.001	***	-0.008
9	rate smokingbeh (period 1)	4.153	1.926			
10	rate smokingbeh (period 2)	3.743	1.518			
11	smokingbeh linear shape	-3.221	0.627	0	***	0.057
12	smokingbeh quadratic shape	2.726	0.353	0	***	0.039
13	smokingbeh average similarity	3.272	1.307	0.012	*	-0.053
14	smokingbeh indegree	0.148	0.182	0.417		0.035
15	smokingbeh outdegree	0.037	0.215	0.864		0.038
16	smokingbeh: effect from sex	-0.010	0.306	0.975		0.007

Figure 6: Parameter estimates of model1

indicating that gender homophily and smoking/drinking behavioral homophily were supported by our data. Naturally, similarity is an important factor when teenagers choose their friends; the similarity between individuals fosters connections [13]. Consistent with many past studies that have identified various forms of homophily, our data revealed homophily in all three waves of measurement. These similarities promote mutual understanding, acceptance, and social reinforcement, forming a basis for stronger and more stable relationships. Social identity theory also supports these phenomena [**identity**]. Adolescents may gravitate towards friends of the same gender and with similar behaviors to reinforce their social identity and gain acceptance within their peer group. Shared behaviors like smoking and drinking can serve as group norms that enhance group cohesion and identity.

Despite successfully verifying our hypotheses, there is still potential for improvement. For instance, the fitting of model1 involved only smoking behavior and not drinking patterns. Incorporating more network effects would increase the model's complexity and prolong the training time. Additionally, it could worsen the goodness of fit, as small perturbations in the explanatory variables might cause the simulation to diverge and the model to become less interpretable. Therefore, it is essential to find a balance between the model's explanatory power and its complexity.

8 Conclusion

This paper discusses the co-evolution of teenagers' friendship networks and smoking/drinking habits, examining both social selection and social influence aspects. Our empirical testing using SAOM for this particular dataset revealed that students are more likely to form friendships with peers of the same gender and with similar drinking/smoking behaviors. Additionally, teenagers tend to adapt their smoking behaviors to align with those of their friends.

This study highlights the significant role of peer influence in shaping behaviors during a critical developmental period and sheds light on how adolescents form their friendships. It contributes to the broader theoretical understanding of homophily, social identity, social influence, and conformity among adolescents. Our findings provide empirical evidence supporting these theories and demonstrate their relevance in the context of secondary school friendship networks.

By identifying the patterns of smoking and drinking behaviors among adolescents and their friendship networks, this research can inform public health strategies aimed at reducing these risky behaviors. Policymakers can use the findings to create policies that foster positive social environments in schools, such as increasing diversity and promoting inclusivity. For future research, we aim to investigate similar patterns in diverse populations and different cultural contexts to understand the universality or variability of these findings. Another interesting avenue for exploration is how social media, online friendships, and interactions impact smoking and drinking behaviors in today's rapidly evolving technological era.

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