ANALYSIS OF THE SPREAD OF ALCOHOL CONSUMPTION AMONG STUDENTS THROUGH AGENT-BASED MODELS

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ABSTRACT

Alcohol abuse is a critical issue in schools worldwide, with students starting to drink at younger ages. Key factors such as social pressure, household conditions, and emotional stability significantly influence student drinking behavior, often leading to compulsive drinking. This study investigates how peer influence contributes to compulsive drinking among students and explores preventive measures.

To explore these interventions, we utilized agent-based modeling to simulate alcohol consumption dynamics among students. Each student is modeled as an agent with attributes like susceptibility to peer pressure and drinking status. The model, implemented in NetLogo, follows a discrete-time process where agents move and interact, updating their behavior based on peer influence.

Recovery workshops were tested to evaluate their impact on reducing compulsive drinking. Specifically, when the initial percentage of binge drinkers was set to 20% and the social influence radius was increased to 7, nearly all students from groups 1 to 4 became binge drinkers at an accelerated rate. However, implementing recovery workshops where 50% of binge drinkers reduced their alcohol intake led to a visible slowdown in compulsive drinking rates, significantly mitigating the spread.

These results highlight the importance of early, targeted interventions in schools to transform societal drinking patterns, promoting a healthier, more stable student population. This research provides valuable insights for policymakers and educators working to combat underage drinking and its social consequences.

I. INTRODUCTION

Adolescence represents a critical period for the development of alcohol consumption behaviors, with binge drinking emerging as a prevalent concern among this demographic (Wang et al. 2015). This behavior presents significant health risks, including alcohol poisoning, accidents, mental health disorders and chronic diseases (Alcohol Use and Your Health, 2024). Understanding how binge drinking spreads within adolescent social networks is crucial for developing effective interventions.

Agent-based models (ABMs) offer a valuable approach to studying how individual behaviors like binge drinking propagate through social networks. By simulating interactions in a school environment, these models allow us to explore the influence of peer pressure and social dynamics on drinking behavior.

This study simulates the spread of binge drinking using an ABM implemented in NetLogo, following the ODD (Overview, Design concepts, and Details) protocol to ensure transparency and reproducibility. Through this approach, we aim to better understand how peer pressure drives binge drinking among adolescents and assess the impact of workshops in curbing this behavior.

The paper is structured as follows: section II presents the relevant literature, section III describes the model and section IV details the implementation on NetLogo. Sections V and VI focus on the model analysis and experimentation. Finally, sections VII and VIII provide conclusions and recommendations, contributing to evidence-based strategies for preventing binge drinking in schools.

II. LITERATURE REVIEW

The articles contribute valuable data for establishing the attributes of simulated individuals and the behavioral logic behind becoming compulsive drinkers.

Article 1, “Alcohol Use among Adolescent Youth: The Role of Friendship Networks and Family Factors in Multiple School Studies,” explores the co-evolution of friendship ties and alcohol use behavior among adolescents. Using data from the National Longitudinal Study of Adolescent to Adult Health, the study found that both peer selection and peer influence significantly impacted friendship choices and adolescent drinking behavior. Adolescents tended to choose friends with similar drinking habits, and their friends’ behavior influenced their own alcohol use (Wang et al. 2015).

Article 2, “An Agent-Based Social Network Model of Binge Drinking Among Dutch Adults,” employs agent-based social network models to examine binge drinking behavior among Dutch adults. The study discovered that simple social rules, such as selecting similar peers, being prompted to drink if others do, and considering the context, were sufficient to predict binge drinking behavior. It highlighted that the nature of interactions, rather than just the identity of the individuals involved, plays a crucial role in binge drinking behavior, with peer influence and social dynamics being essential factors

(Giabbanelli and Crutzen 2013).In this article, the authors explore how responses to a social questionnaire can explain the influence of peer behavior on adult actions. Based on the number of 'yes' responses, individuals can be divided into distinct groups.

These studies differ in their research locations (the United States and the Netherlands), the age groups modeled (adolescents and adults), and the aspects considered in modeling the phenomenon.

NetLogo, a widely-used platform for agent-based modeling, was employed to create the simulation for this study. It allows for the modeling of complex social systems where agents interact based on defined rules (Wilensky 1999). In this research, NetLogo was used to build a custom model from scratch to simulate binge drinking behavior. Each agent in the simulation follows behavioral rules inspired by the findings in the literature previously mentioned.

III. MODEL DESCRIPTION

A. Purpose

This agent-based model is designed to explore how binge drinking behavior can spread among students in a school setting. It aims to identify the key mechanisms that influence adolescents to engage in binge drinking and to assess the impact of workshops on reducing this behavior. By simulating individual student interactions and their susceptibility to peer influence, the model provides insights into the formation and change of drinking norms over time. The ultimate goal is to offer a valuable tool for researchers and policymakers to develop more effective prevention and support programs tailored to the needs of adolescent populations.

B. Entities, state variables, and scales

In this agent-based model, the primary entities are the students within a school environment, represented as agents in the simulation. Each student agent is characterized by several state variables that define their behavior and interactions. These variables include:

- **binge-drinker?**: A boolean indicating whether the student is a binge drinker.
- **group**: An integer (0 to 4) representing the frequency of alcohol consumption in the past year.
- **yes_answers**: An integer reflecting the number of affirmative responses to questions about alcohol consumption.
- **influence**: A numerical value representing the student's susceptibility to peer influence regarding drinking behavior.
- **perception**: An integer denoting the number of students within the student's perception radius.
- **drinkers-near**: An integer representing the number of binge drinkers within the perception radius.
- **yes_change**: A boolean indicating whether the student's influence increases to a maximum level under certain conditions.
- **radius**: A spatial attribute representing the perception radius, which defines the area within which each student can perceive and be influenced by the behavior of others.

The model operates in discrete time steps, where each tick represents a unit of time, such as a day or a week, depending on the specific context of the study. Spatially, the model utilizes a continuous 2D plane where agents move and interact, defined by the xcor and ycor coordinates within the NetLogo environment, which represent the school environment. Agents move within this space based on random turns and forward steps, allowing the model to examine how binge drinking behavior spreads through social interactions over time and space, taking into account individual attributes and peer influences.

C. Process overview and scheduling

At each time step, agents engage in sequential processes, beginning with random movement throughout the environment. Subsequently, each agent updates its binge drinking status based on its perception of nearby agents and their influence. This synchronous updating ensures consistency in the state variables across the population after each iteration. By structuring the model in this manner, it adheres to a clear and replicable scheduling protocol, enabling straightforward implementation.

D. Design concepts

The model is grounded in social influence theories, specifically focusing on how peer pressure and social perception affect binge drinking behavior among college students. Emergence is a key aspect, with the prevalence of binge drinking in the population emerging from individual interactions and social influences. Adaptation is represented through agents' decisions to start binge drinking based on their perception of nearby drinkers and their susceptibility to influence, which varies according to their group. The objectives of the agents are implicit, aiming to replicate observed behaviors linked to social conformity and peer influence. Sensing is localized, with agents perceiving the number of binge drinkers within a certain radius. Interaction among agents is direct, as they influence each other through their presence and binge drinking status. Stochasticity is introduced in the initial assignment of group membership and the decision-making process regarding binge drinking initiation. Collectives are implicit, as groups of agents with similar drinking behaviors emerge based on social influence. Finally, observation is facilitated by collecting data on the number of binge drinkers and their distribution across different groups over time to analyze the model's dynamics and outcomes.

E. Diagrams

We now present class diagrams, which offer a visual representation of the model, including its state variables, procedures, and entities. In addition to this, we provide the execution flow of the model through a UML activity diagram, offering

further insight into the internal processes and interactions within the model.

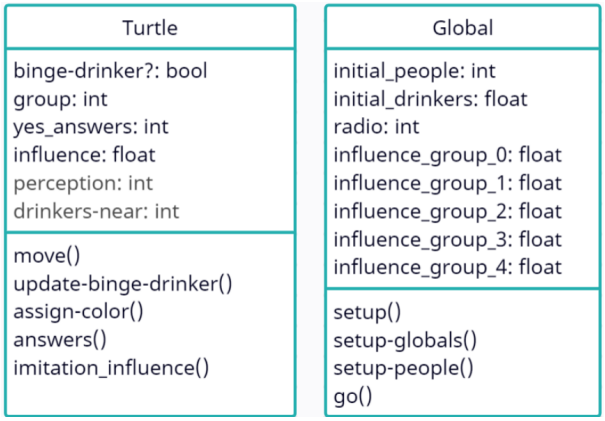

Figure 1: Model's UML class diagram.

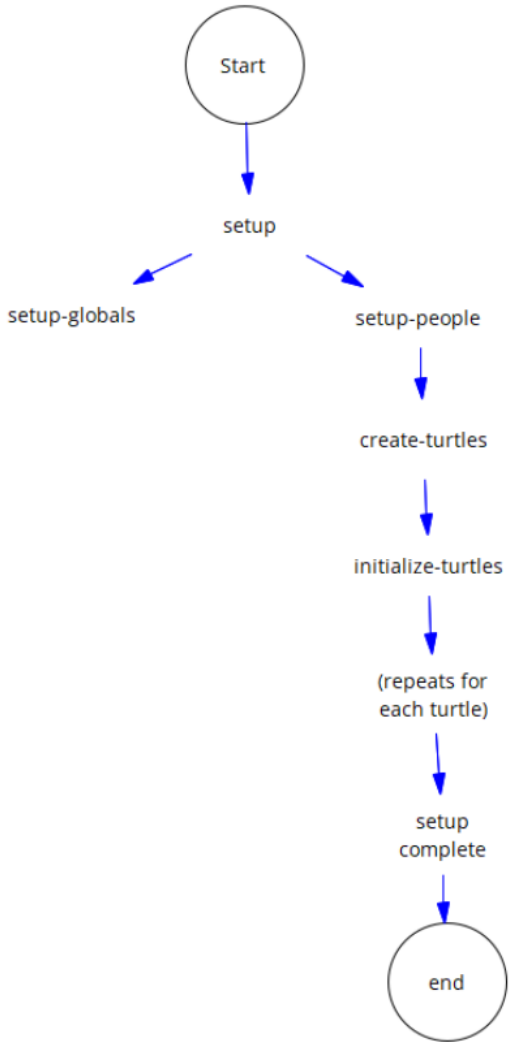

Figure 2: Model's UML activity diagram 1.

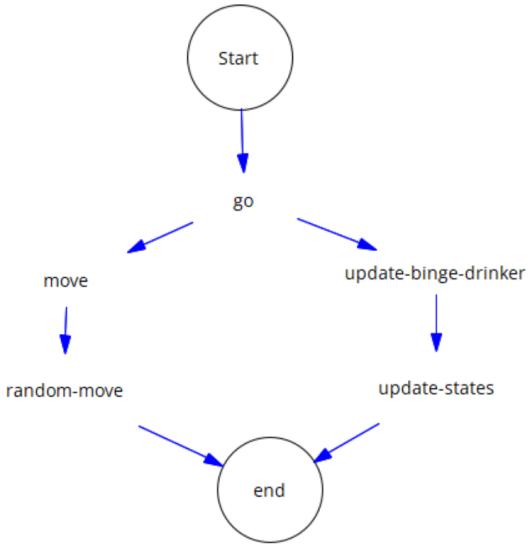

Figure 3: Model's UML activity diagram 2.

F. Initialization

At the initialization stage of the simulation, the model world begins at time t = 0 with a defined initial state. Initially, the model consists of a population of individuals, each representing a student within the simulated community. The number of individuals and their characteristics are determined based on predefined parameters set by the modeler. These parameters dictate the distribution of individuals across the five categorized groups, with group 4 representing students who are most inclined to engage in binge drinking behavior due to having the highest number of positive responses in the survey categories of enhancement, social, coping, and conformity. The exact values of their state variables, such as their group assignment, yes_answers, influence, perception, and drinkers-near, are set either deterministically or stochastically according to the model specifications. The initialization process may vary among simulation runs to capture the variability and uncertainty inherent in real-world scenarios.

G. Submodels

The submodels in the simulation represent various processes involved in the dynamics of binge drinking behavior within the population. One submodel governs the movement of individual agents within the simulated environment, implemented through random rotations and forward movements. Another submodel updates the binge drinker status of each agent based on their perception of drinkers nearby and their susceptibility to influence, with parameters including the radius of perception and the threshold for becoming a binge drinker. Additionally, submodels handle the assignment of initial characteristics to individuals, such as their group membership and responses to survey questions, which are stochastically determined based on predefined probabilities. These submodels were designed to capture key aspects of binge drinking dynamics, drawing on insights from social influence theories and empirical studies. Parameters for each submodel, such as perception radius and

influence threshold, were chosen based on empirical findings and calibrated to ensure the model's behavior aligns with observed patterns of binge drinking behavior.

IV. IMPLEMENTATION ON NETLOGO

A. INPUT DATA

In the model, each turtle has several attributes, including whether it is a binge drinker (binge-drinker?), its drinking frequency group (group), the number of affirmative responses to a drinking-related questionnaire (yes_answers), its susceptibility to peer influence (influence), its perception of the prevalence of binge drinking in its vicinity (perception), and the number of nearby binge drinkers (drinkers-near).

The setup procedure initializes the simulation by clearing the world, setting up global variables, creating turtles, and resetting the simulation ticks. During the setup-people procedure, turtles are created and randomly positioned, with a fraction of them initialized as binge drinkers. Non-binge drinkers are assigned values for yes_answers and influence, which are determined based on their responses to a questionnaire and their assigned group, respectively. The assign-color procedure visually differentiates turtles by their binge drinking status and group, with non-binge drinkers being colored according to their group and binge drinkers colored red.

The model's main loop, defined in the go procedure, includes moving the turtles randomly, updating their binge drinking status, and incrementing the simulation ticks. Turtles move randomly each tick to simulate social interactions. The update-binge-drinker procedure models peer influence on binge drinking behavior. It calculates the number of nearby turtles (perception) and nearby binge drinkers (drinkers-near). If the number of nearby binge drinkers exceeds the turtle's influence threshold, the turtle becomes a binge drinker.

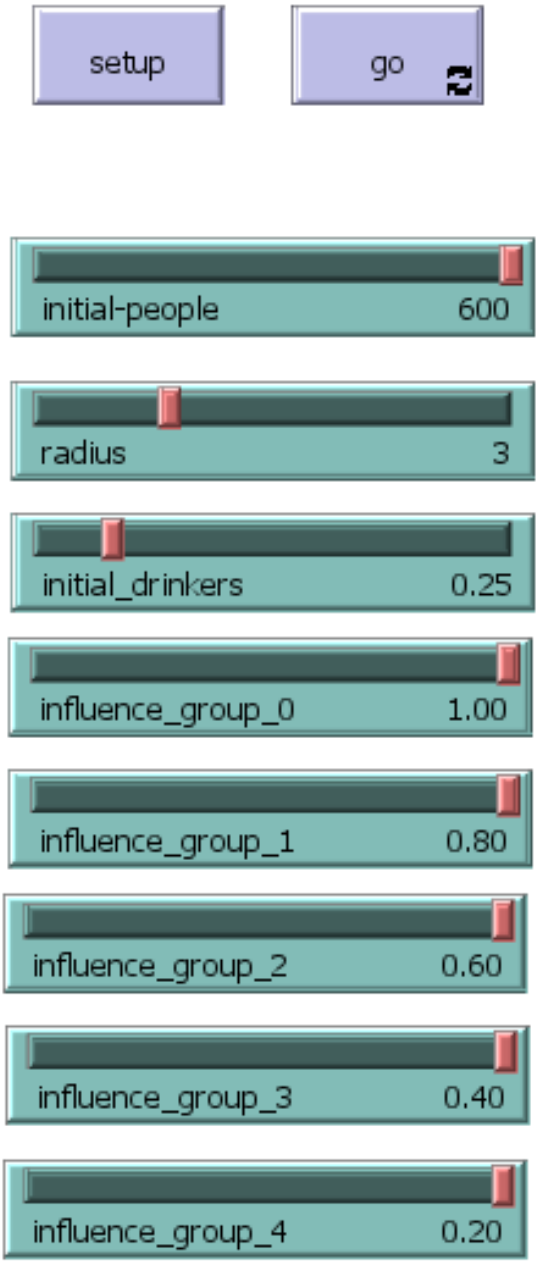

Figure 4: Baseline parameters.

B. MODEL IMPLEMENTATION

The implementation of the model on Netlogo is designed with clarity and ease of use in mind. The interface features two main buttons, "Setup" and "Go". The "Setup" button initializes the model with the desired conditions, while the "Go" button starts the simulation, allowing users to observe the dynamics of the system. The interface includes sliders to adjust the initial number of students, the radius within which students can influence each other, and the influence parameters for each of the five drinking behavior groups. This intuitive setup ensures that users can easily configure the simulation according to their specific needs without complex instructions.

The results are presented clearly through three graphs. The first graph, "Binge drinker students," tracks the overall number of students who become binge drinkers throughout the simulation. The X-axis represents time steps, while the Y-axis reflects the number of binge drinkers. The second graph, "Students per group," depicts the distribution of students across for defined drinking groups at each time step. Here, the X-axis represents the group number, and the Y-axis shows the number of students in each group. The third graph, "Students in group 0," zooms in on the population of students in Group 0. The X-axis again represents time steps, while the Y-axis shows the number of students pertaining to that group.

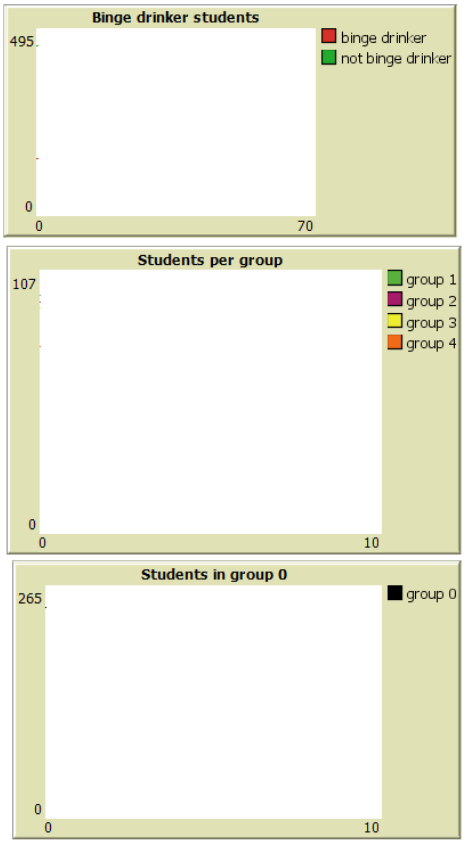

Figure 5: Baseline graphs.

Subsequently, agents are visually represented using icons, with different colors employed to distinguish between groups. Group 0 is the color blue, group 1 is the color green, group 2 is the color magenta, group 3 is the color yellow and group 4 is the color orange.

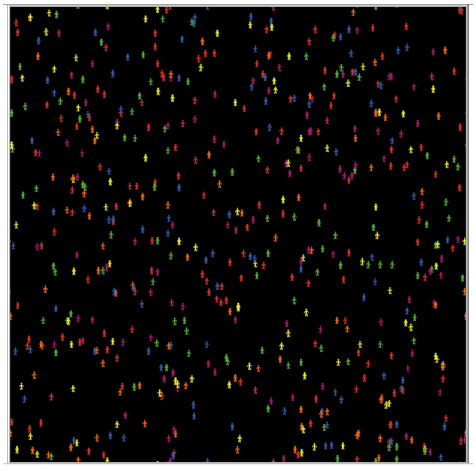

Figure 6: Baseline agents visualization.

V. MODEL ANALYSIS

A. Results

When the radius has a value of 1, the initial amount of students is 600, 20% of the students are binge drinkers and all the sliders are at their maximum amount of influence, the time required for everyone to become binge drinkers increases significantly, while most of the students become binge drinkers except those belonging to the groups 0 and 1. The total amount of binge drinkers and the total amount of non binge drinkers does not change extremely fast over time.

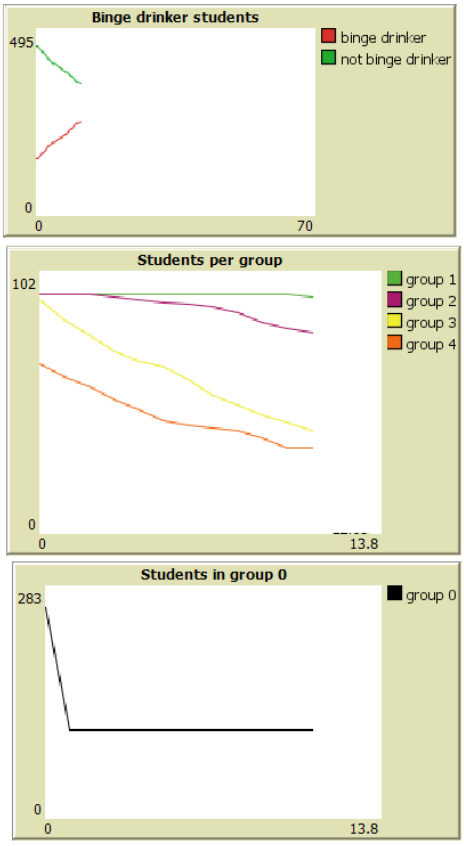

Figure 7: System behavior under variation in radius to 1, 600 students, 20% binge drinkers and until tick 11.

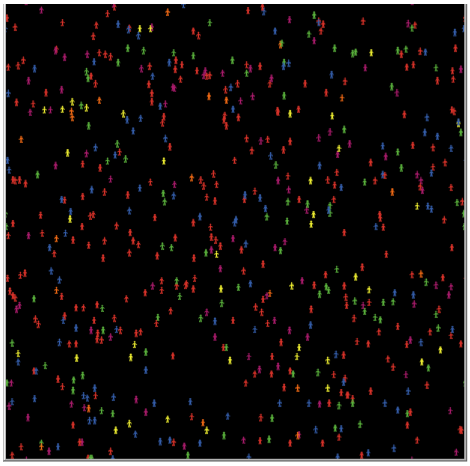

Figure 8: Visual representation under variation in radius to 1, 600 students, 20% binge drinkers and until tick 11.

When the radius is adjusted to 7, the initial amount of students is 600, 20% of the students are binge drinkers and all the sliders are at their maximum amount, most students become binge drinkers faster, except those belonging to group 0.

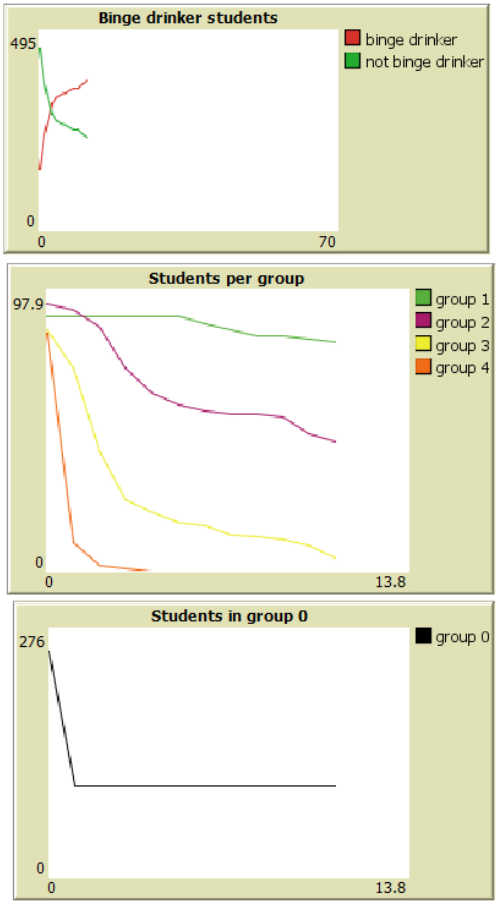

Figure 9: System behavior under variation in radius to 7, 600 students, 20% binge drinkers and until tick 11.

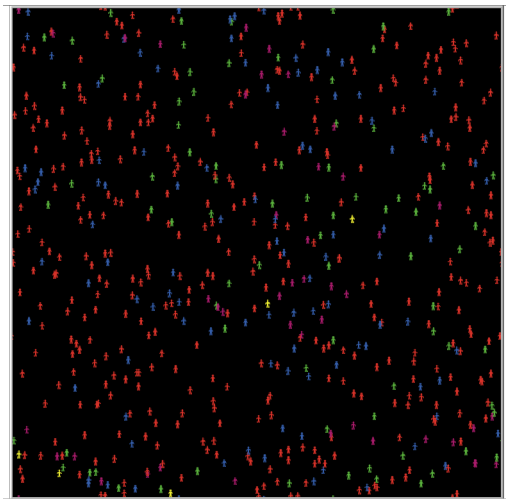

Figure 10: Visual representation under variation in radius to 7, 600 students, 20% binge drinkers and until tick 11.

If we lower to the minimum the parameters of influence for each group, keep the radius at 5 and the initial amount of binge drinkers at 20%, we can observe how all of the students become binge drinkers extremely quickly.

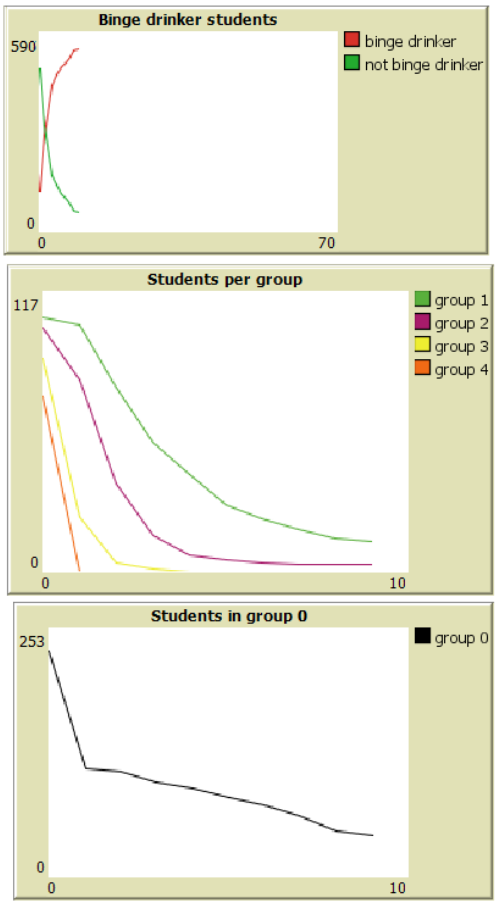

Figure 11: System behavior when lowering the parameters of influence and the radius to 5 until tick 11.

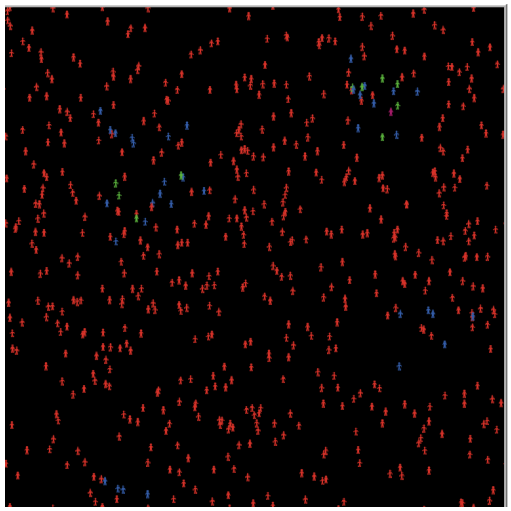

Figure 12: Visual representation when lowering the parameters of influence and the radius to 5 until tick 11.

When running the model with 600 students and 80% of binge drinkers at the beginning and a radius of 1, most students become binge drinkers quickly

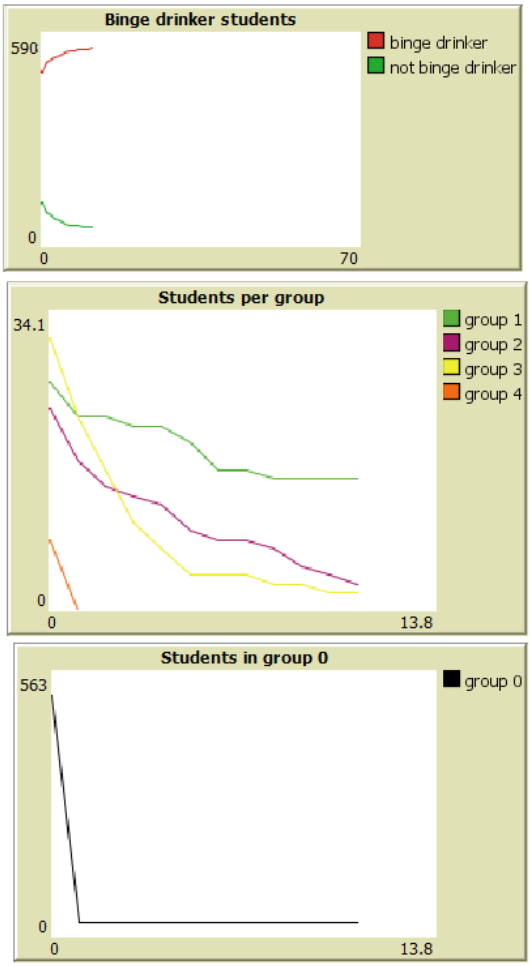

Figure 13: System behavior under variation in radius to 1, 600 students, 80% binge drinkers and until tick 11.

Figure 14: Visual representation under variation in radius to 1, 600 students, 80% binge drinkers and until tick 11.

When running the model with 600 students and 80% of binge drinkers at and a radius 8, all of the students become binge drinkers extremely quickly.

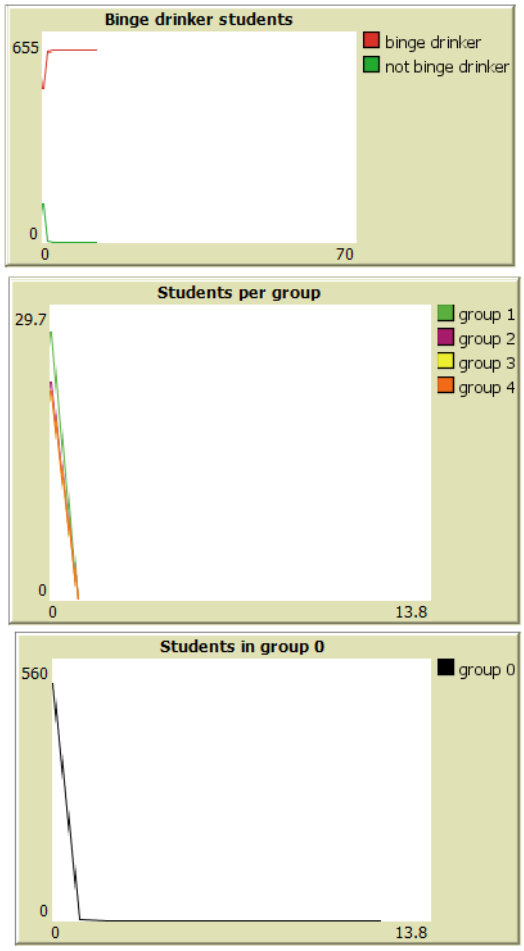

Figure 15: System behavior under variation in radius to 8, 600 students, 80% binge drinkers and until tick 11.

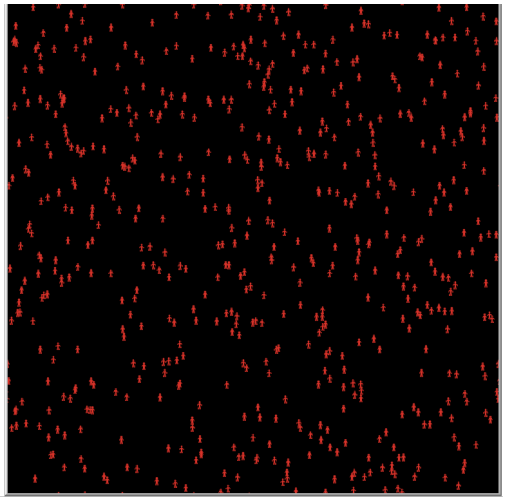

Figure 16: Visual representation under variation in radius to 8, 600 students, 80% binge drinkers and until tick 11.

It should be noted that if we modify initial people, we can observe different behaviors. For example, if the model starts with only 200 people, the interaction of the agents becomes slightly slower. This is because with fewer people in a very close radius upon selecting the subject, there may not be a high number of binge drinkers in their circle. Consequently, the agent may need to be analyzed repeatedly to update its status and indicate whether or not it is a binge drinker.

B. Sensitivity and uncertainty analysis

Next, we will make small adjustments to certain parameters to observe the model's behavior. To do this, we will keep the parameters consistent with the baseline model, while varying one parameter at a time.

First, we will adjust the initial percentage of binge drinkers to 45%.

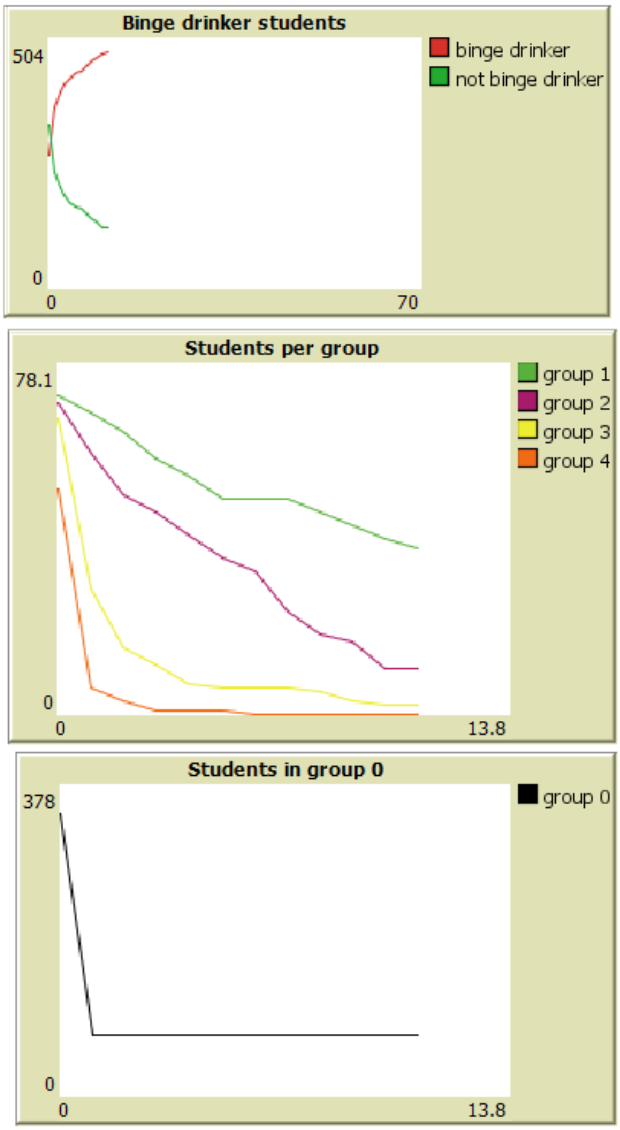

Figure 17: System behaviour when initial binge drinkers is 45%.

Next, we will adjust the same parameter to 50%.

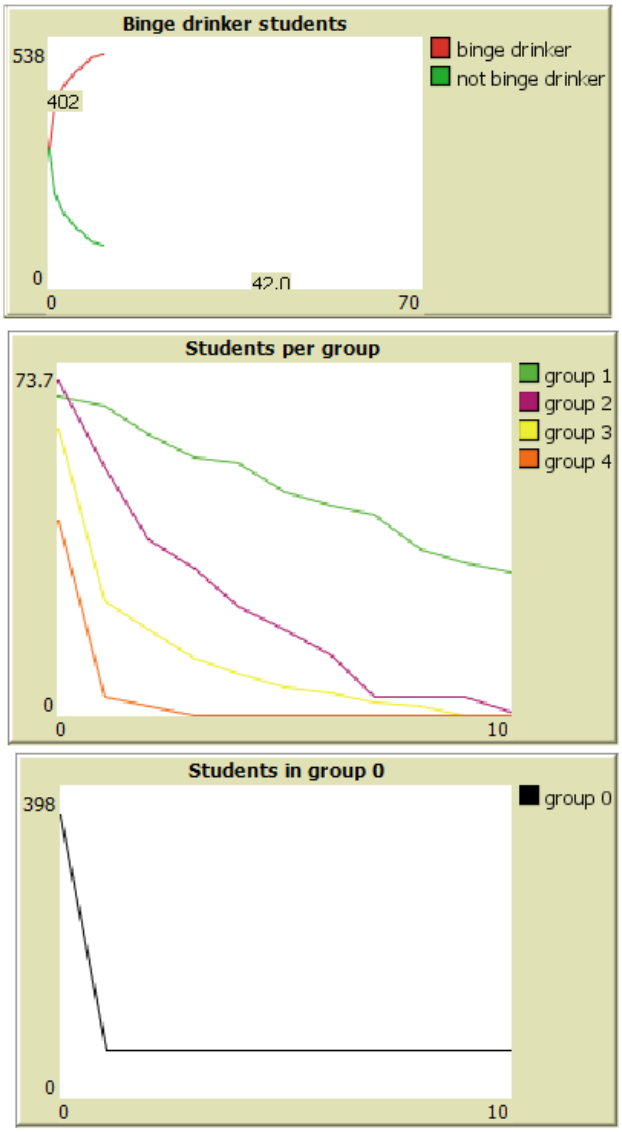

Figure 18: System behaviour when initial binge drinkers is 50%.

Finally, let us examine the behavior when the parameter is set to 55%.

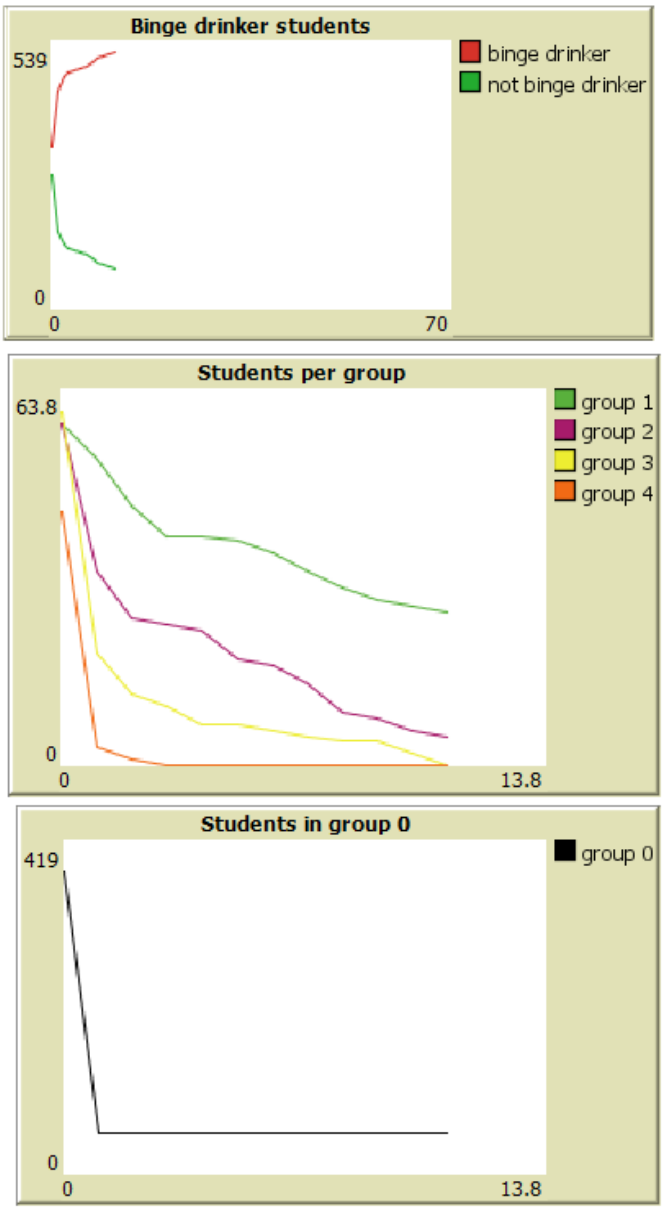

Figure 19: System behaviour when initial binge drinkers is 55%.

Next, we will introduce changes to the parameter influence_group_1, while keeping all other parameters consistent with the baseline model. First, we will adjust the parameter influence_group_1 to 70%.

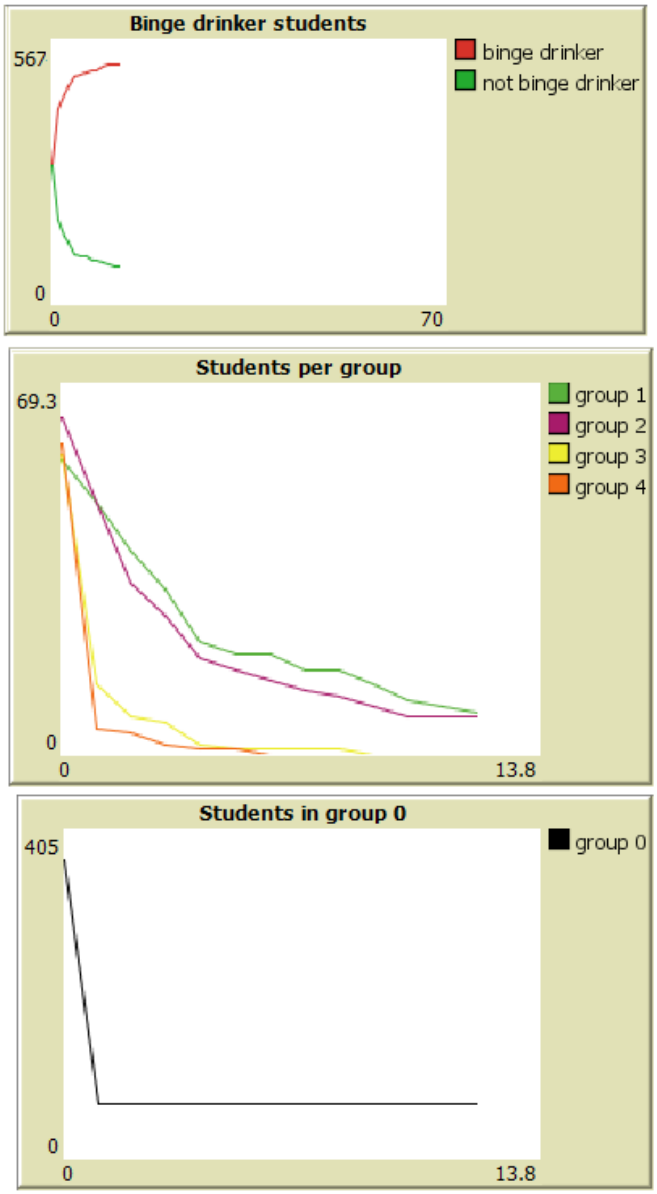

Figure 20: System behaviour when influence_group_1 is 70%.

Next, we will adjust the same parameter to 75%.

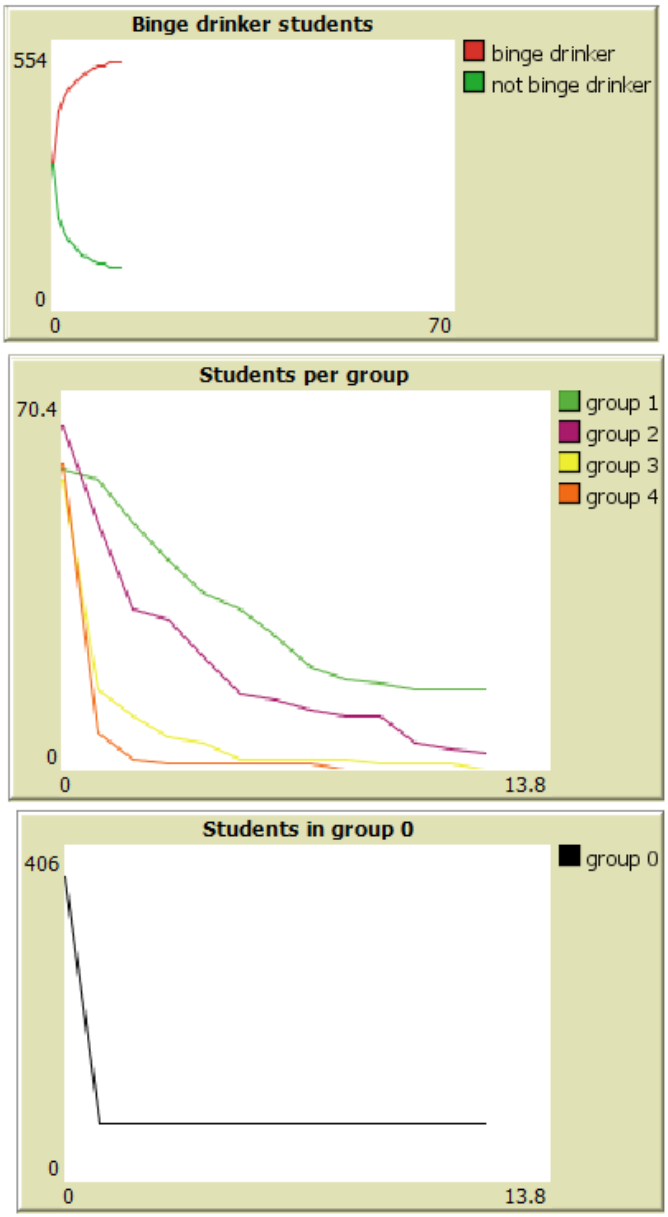

Figure 21: System behaviour when influence_group_1 is 75%.

Now, let us change the parameter influence_group_3, the results are shown below. First, we will adjust the parameter influence_group_3 to 30%.

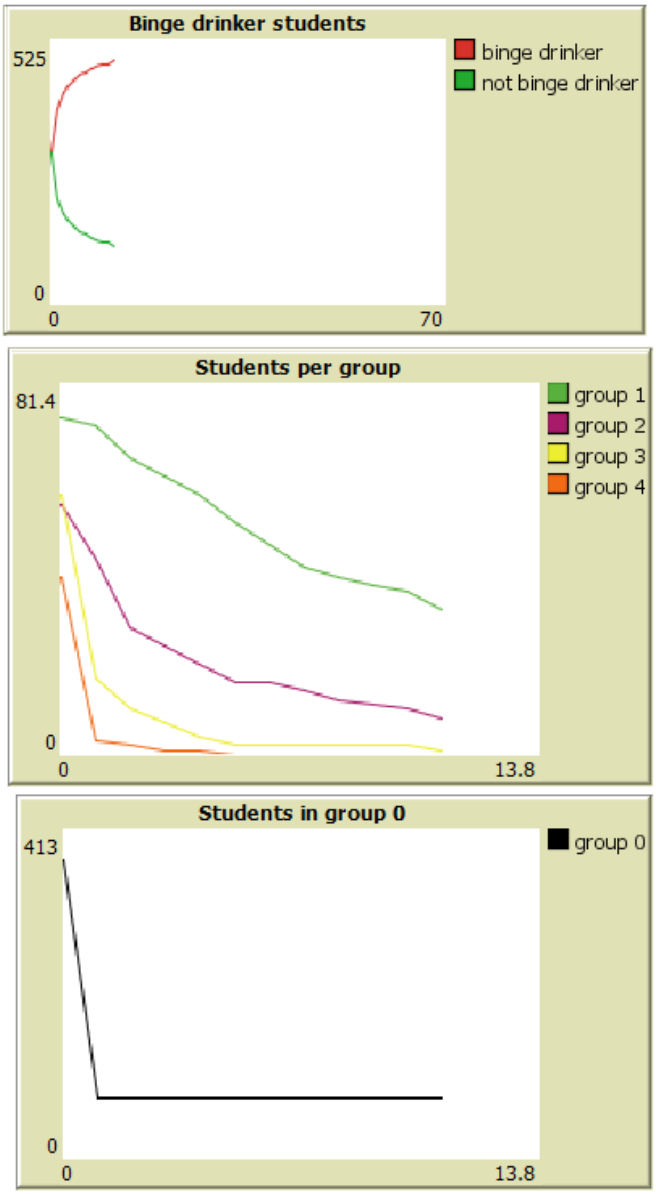

Figure 22: System behaviour when influence_group_3 is 30%.

Then, we will adjust the parameter influence_group_3 to 35%.

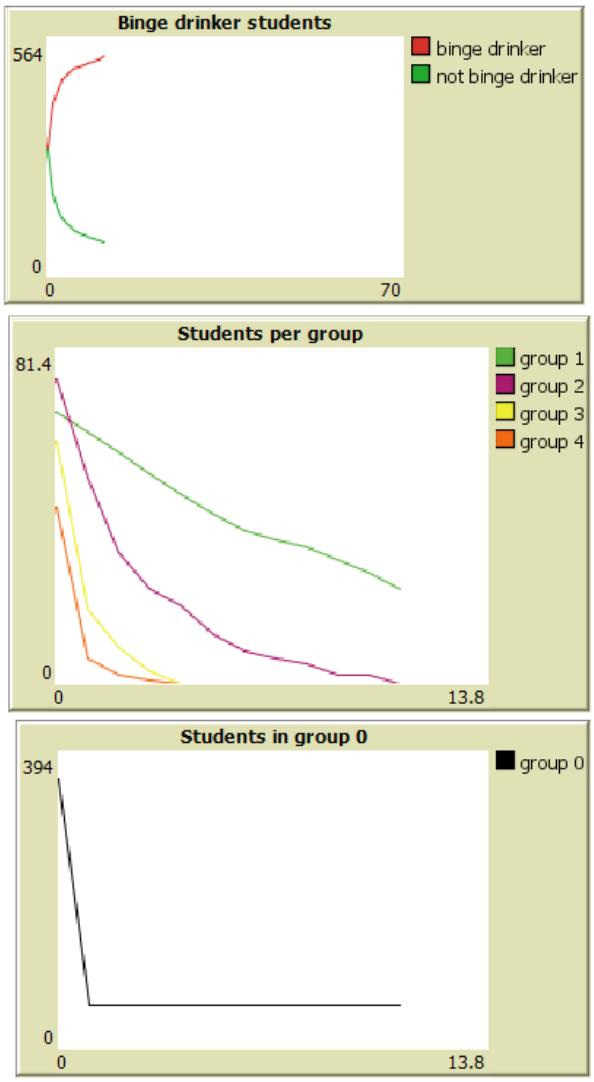

Figure 23: System behaviour when influence_group_3 is 35%.

After observing these graphs, we note that the model is not sensitive to small changes in parameters such as the initial number of compulsive drinkers and group influence. This can be inferred from the fact that we see the same group behavior dynamics.

VI. EXPERIMENTATION

In the baseline model, students' behavior is analyzed based on a series of questions to determine their level of alcohol consumption. Students are classified into groups from zero to four, based on their susceptibility to alcohol. Additionally, a group of compulsive drinkers is identified. By analyzing a randomly selected student in relation to their circle of friends, the number of compulsive drinkers in their vicinity is assessed to predict if the student will become a compulsive drinker.

In the experimentation, measures are implemented to mitigate the significant increase in compulsive drinkers. In this model, educational workshops are conducted to raise awareness about the risks of excessive alcohol consumption. These workshops target both compulsive drinkers and those in the influence groups, encouraging them to reduce their alcohol intake.

A. *Workshop targeted to students in the different groups*

This model incorporates a slider called "slider percentage yes_change," which allows to adjust the percentage of students who decide to decrease their drinking levels. When a student decides to reduce their drinking levels due to the adverse effects of being a compulsive drinker, they are considered part of group 0, which has a high resistance to alcohol influence. When 50% of the students reduce their drinking levels, the increase of compulsive drinkers is not as fast as the baseline model.

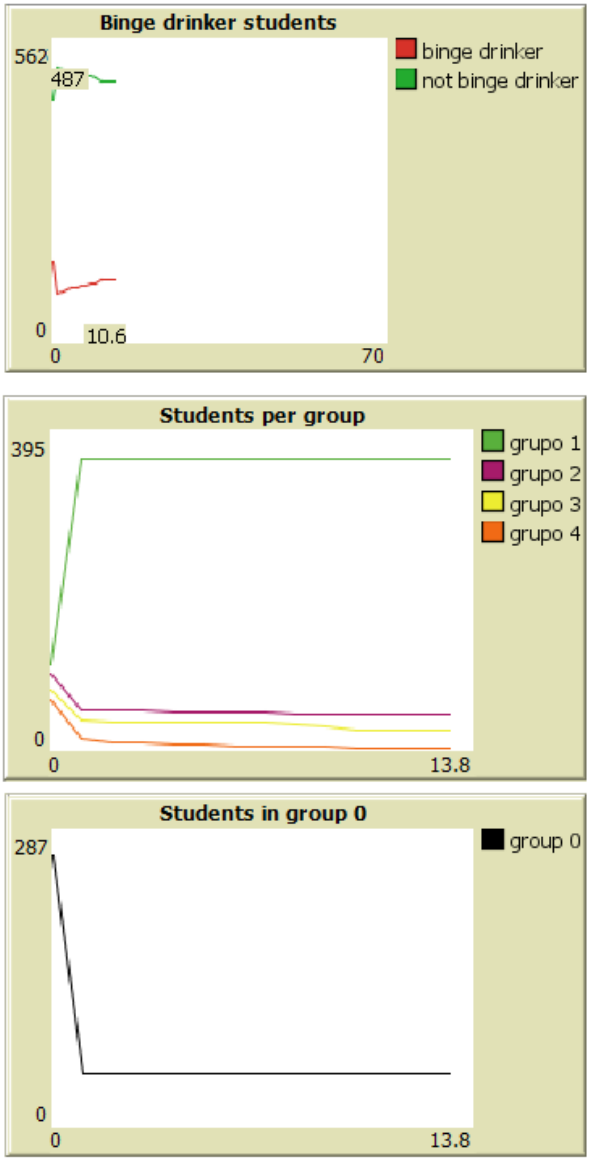

Figure 24: System behaviour when recovery is set to 50%.

Figure 25: Parameters of experiment for recovery set to 50%.

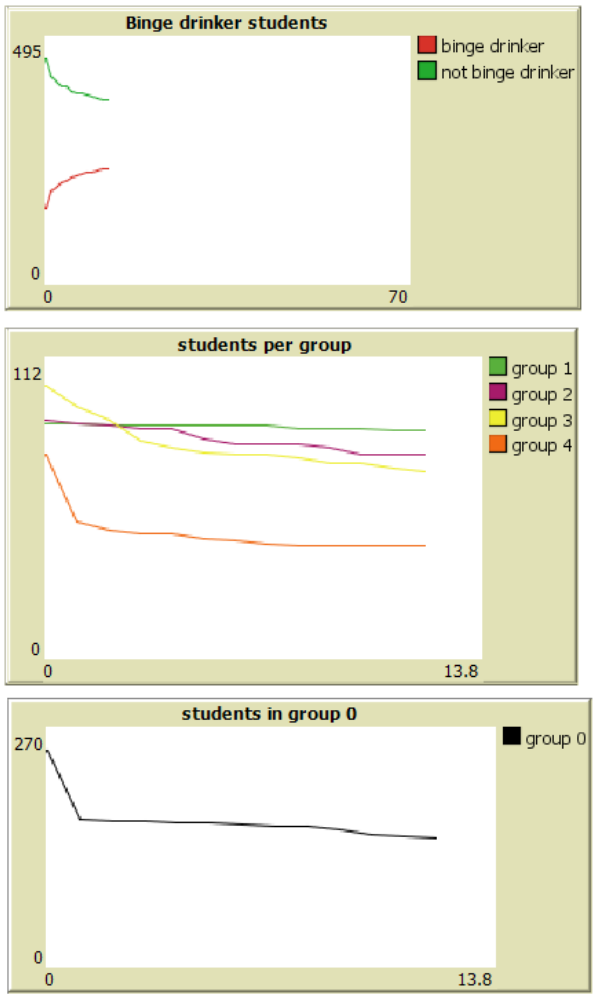

Figure 26: System behaviour when students set to 50%.

B. Workshop targeted to binge drinkers

This model incorporates a slider called "slider percentage recovered," which allows for adjusting the percentage of compulsive drinkers who successfully recover from addiction after attending the workshops. Students who recover from addiction are then classified into group 1. When 50% of binge drinkers recover from their addiction the number of students in groups 2, 3, and 4 decreases as shown in the graphs.

Figure 27: Parameters of experiment for students set to 50%.

As the effectiveness of the workshops increases, the number of students who recover from addiction also rises, which in turn reduces the number of students who become binge drinkers due to peer influence. Depending on the parameter settings, the results will vary, allowing schools to use this model to simulate how their student population might respond to the implementation of such workshops, helping them plan more effective interventions.

VII. CONCLUSIONS

The agent-based model developed in this study provides evidence that supports our hypothesis: peer influence plays a significant role in the spread of binge drinking behavior among students. The model highlights that small increases in the perception radius substantially accelerate the spread of binge drinking. In real-life terms, this increase reflects direct contact with peers who influence and normalize alcohol consumption through various means, such as peer pressure, the desire for social inclusion (drinking to feel accepted), or fear of social exclusion (being ostracized for not drinking). Events like school parties and celebrations where students commonly consume alcohol, as well as exposure to social media platforms like Facebook, Instagram, and YouTube, and the influence of trends, media representations in music, TV shows, and movies, further exacerbate the spread. These platforms often misportray drinking, encouraging natural curiosity and, in some cases, rebellion against parental restrictions. Moreover, the model demonstrated the critical role of recovery workshops in reducing binge drinking rates. The effectiveness of these workshops is essential, as early intervention can mitigate the impact of peer pressure. Schools must implement timely and targeted workshops to significantly reduce the prevalence of binge drinking, promoting healthier behaviors among students. Overall, our findings emphasize the need for structured prevention programs to combat the complex dynamics of adolescent alcohol consumption.

VIII. RECOMMENDATIONS

Based on the model's insights, we recommend implementing early, targeted interventions in schools to curb the spread of binge drinking among students. Educational workshops should be designed to not only raise awareness about the risks of excessive alcohol consumption but also to equip students with strategies to resist peer pressure. Additionally, support programs for current binge drinkers should be established to facilitate their recovery and reintegration into healthier social circles. Policies should focus on creating a supportive environment that encourages positive behavior change and reduces the stigma associated with seeking help for alcohol-related issues. Furthermore, ongoing research and model refinement are essential to adapt interventions to the evolving social dynamics within student populations.

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