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Forecasting the Effect of the Amethyst Initiative on College Drinking

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Abstract

Background—A number of college presidents have endorsed the Amethyst Initiative, a call to consider lowering the minimum legal drinking age (MLDA). Our objective is to forecast the effect of the Amethyst Initiative on college drinking.

Methods—A system model of college drinking siumlates MLDA changes through (1) a decrease in heavy episodic drinking (HED) due to the lower likelihood of students drinking in unsupervised settings where they model irresponsible drinking (misperception), and (2) an increase in overall drinking among currently underage students due to increased social availability of alcohol (wetness).

Results—For the proportion of HEDs on campus, effects of large decreases in misperception of responsible drinking behavior were more than offset by modest increases in wetness.

Conclusions—For the effect of lowering the MLDA, it appears that increases in social availability of alcohol have a stronger impact on drinking behavior than decreases in misperceptions.

Keywords

Amethyst Initiative; Modeling; College; Heavy Episodic Drinking; Misperception

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Introduction

College drinking is one of the most significant and complex public health problems today. Heavy drinking among college students remains a pervasive problem that places students at considerable risk for a variety of negative outcomes, including date rape, academic problems, traffic accidents, and health problems (Hingson, Heeren, Winter, and Wechsler, 2005; Wechsler and Nelson, 2008). Alcohol use is embedded in the college lifestyle, resulting in enormous social, economic, and health consequences among some of the nation's finest students (Task Force on College Drinking, 2002). Heavy episodic drinking is generally conducted in private, among peers, and college students engage in the behavior in much higher proportions than do other young adults (Schulenberg, et al., 2001; Carey, Scott-Sheldon, Carey, and DeMartini, 2007; Substance Abuse and Mental Health Services Administration, 2006; Timberlake, et al., 2007).

Interventions to reduce the negative outcomes associated with college drinking have been mixed. For example, reeducation programs targeting misperception of drinking norms remain a popular intervention. Social norms researchers have found that college students routinely misperceive the level of alcohol use among their peers (Baer, Stacy, and Larimer, 1991; Perkins, Haines, and Rice, 1991) and liberal perceptions of social norms for peer drinking are consistently shown to be strong predictors of alcohol use among college students (Baer, Stacy, and Larimer, 1991; Perkins, Haines, and Rice, 1991; Reis and Riley, 2000; Baer and Carney, 1993, Perkins, et al., 1999; Babor, Aguirre-Molina, Marlatt, and Clayton, 1999; Thombs, Wolcott, and Farkash, 1997). Rather than address the population level factors that lead to misperception of social norms in the first place, Social Norms Marketing (SNM) interventions attempt to reeducate students by correcting their misperceptions of their peers' behavior in hopes of changing individual behavior. The results of these interventions have been equivocal (Thombs, Wolcott, and Farkash, 1997; Haines and Spear, 1996; Werch, et al., 2000; Wechsler, et al., 2003; Toomey, Lenk, and Wagenaar, 2007; DeJong, et al., 2006).

The limited effectiveness of college drinking interventions has led to calls to reexamine the MLDA. One of these, called the Amethyst Initiative, asks chancellors and presidents of universities and colleges across the country to sign on to a call asking elected officials to revisit the 21 year old drinking age. So far over 100 chancellors and presidents have signed on. The Amethyst Initiative statement argues that the 21 year old drinking age is not working. Underage students are legally prohibited from purchasing and possessing alcohol and the majority continue to drink. In addition, the statement argues the rampant flaunting of the drinking laws by students has led to a “culture of dangerous binge drinking” on many campuses. John McCardell, the original author of the initiative, has described the mechanism by which this culture has evolved. He argues that because of the 21 MLDA underage students are precluded from drinking in supervised settings (e.g., bars, school sponsored parties). As a result, they are more likely to drink in unsupervised settings (e.g., off campus parties) where there are fewer constraints on excessive drinking. He concludes that in these settings underage students who are new to drinking develop misperceptions of the normal drinking behavior and binge drinking tends to be viewed as normal (McCardell, 2008). This argument is consistent with literature that demonstrates misperception of drinking norms predicts individual drinking (Baer, Stacy, and Larimar, 1991; Perkins, Haines, and Rice, 2005). Social norms theory argues that the effect of misperceptions is rooted in a psychological attribution process in which the individual tends to perceive the drinking actions of others as reflective of their individual drinking temperament and align their behavior accordingly (Perkins, 1997; Prentice and Miller, 1993), proponents suggest that the MLDA of 21 years of age is the problem. Critics of the Amethyst Initiative argue that lowering the MLDA will increase the availability of alcohol for both social and home consumption, and therefore increase drinking among the entire population with disastrous results (Babor, 2008).

Lowering the current MLDA represents an enormous social experiment with potentially major consequences. While there is considerable evidence indicating the harms associated with lowering the MLDA with regard to the general population (Wagenaar and Toomey, 2002), there is little in the way of observational evidence (Kypri, et al., 2006) to either support or oppose the specific hypotheses regarding student drinking behaviors embedded in the Amethyst initiative. A systems approach is one method of providing a forecast for the effects of a policy change prior to carrying out interventions based on that policy. Public health researchers are beginning to see the opportunities of moving from a purely inferential approach of experimental design and data analysis to a more mechanistic, systems approach (Homer and Hirsch, 2006). In particular, the social and economic cost of suboptimal policy decisions can potentially be mitigated by an increased understanding of the potential consequences that a systems model can provide.

Materials and Methods

We have developed a systems model, referred to as SimHED (Ackleh, et al., 2009; Scribner, et al., 2009), to simulate a college campus student population structured by drinking behavior and drinking age. The model, a continuous dynamical systems compartmental model derived using epidemiological reasoning, is provided in detail in the Appendix. The compartmental structure involves two levels of structure in age, namely underage (U) and legal age (L), as well as four drinking styles associated with college drinking, namely abstainers (*1*) social drinkers (*2*), problem drinkers (*3*), and heavy episodic drinkers or HEDs (*4*). Abstainers are defined as individuals who do not drink. Social drinkers are individuals who drink more frequently than abstainers but do not belong to the other two compartments. Problem drinkers are those who report at least two out of four indicators of problem drinking based on the CAGE instrument (Mayfield, McLeod, and Hall, 1974), regardless of the amount or frequency of their drinking. Heavy episodic drinkers are individuals who consume more than five drinks in a single sitting on at least one occasion in the past two weeks. In this manner, the state of the system at any given time is defined by 8 numbers, $U_1,U_2,U_3,U_4,L_1,L_2,L_3,L_4$, which are the number of individuals in each of the four drinking style compartments for the underage drinkers (U_1,U_2,U_3,U_4) followed by the corresponding numbers for the legal age drinkers (L_1,L_2,L_3,L_4).

Individuals move from underage to legal age purely by aging. We assume that the aging process itself does not directly change the drinking style of the individual, so that transition from the underage to legal age compartments preserves the drinking style. The drinking style transition model includes three types of parameters that control transfers between the four drinking style compartments: individual risk (Wechsler, Dowdall, Davenport, and Castillo, 1995, Presley, Meilman, and Leichliter, 2002), social interactions (Reifman, Watson, and McCourt, 2002; McCabe, et al., 2005), and social norm misperception (Perkins, et al., 1999; Borsari and Carey, 2001).

The individual risk model handles transitions that depend only on individual factors (e.g., mood, developmental transitions, individual traits). This component of the system involves a fraction of individuals with a particular drinking style transitioning to a different drinking style over a period of time. These transitions are modeled by terms of the form $r_{ij}N_i$ (in which N represents U or L, r models the fraction of those individuals transitioning, and the subscript ij represents the transition out of drinking style i into drinking style j). Since the movement is from i to j, this term is a positive term in the j equation and a negative term in the i equation.

Social interaction transitions depend on individuals from two separate groups coming into contact with one another, much like an epidemiological model of disease transmission. That is, an individual with a certain type of drinking style convinces another individual with a different drinking style to change behavior. We model these transitions by terms of the form $s_{ij}N_iN_j$, proportional to the number of pairings available among the two different drinking styles. In this case, the movement may be in either direction, i.e., from i to j or vice versa. So, $s_{ij}N_iN_j$ represents a net movement between the two compartments i and j, and thus s_{ij} may be negative.

Social norms/misperception transitions occur due to perception of the level of a particular drinking behavior. These movements occur in two situations: when abstainers become light drinkers because they perceive an exaggeratedly large number of drinkers on campus, and when social drinkers become HEDs because they perceive an exaggeratedly large number of HEDs. Situation a) is modeled by the term $n_{12}N_1M\left(\frac{\sum_{k=2}^{4}U_k+L_k}{\sum_{k=1}^{4}U_k+L_k}\right)$ and situation b) is modeled by the terms $n_{i5}N_iM\left(\frac{U_4+L_4}{\sum_{k=1}^{4}U_k+L_k}\right)$, where i can be either 2 or 3. Again, N represents either U or L here, an underage (U) or legal age (L) drinking style, as the changes in drinking style are assumed to occur within an age group. The function M is the misperception function, modeling how badly the students overestimate the fraction of individuals undertaking the role model behavior (either the fraction of drinkers or the fraction of HEDs). Were M the identity function, student perception would be entirely accurate. Research in social norms suggests (Reis and Riley, 2000) that misperception is greatest when the model behavior is least prevalent and that misperception decreases as the model behavior increases. For example, in an analysis of the National College Health Assessment, 59.9% of students overestimate the drinking norms of their peers at parties by three or more drinks on campuses where abstinence is the norm. Where six drinks is the actual norm, 31.5% of students overestimate by three or more drinks (Perkins, Haines, and Rice, 2005). For these reasons we have chosen the functional form $M(x)=\sqrt{\varepsilon+(1-\varepsilon)x^2}$ whose graph is illustrated in Figure 1.

The hyperparameter ε controls the level of misperception: as $\varepsilon \to 0$ the amount of overestimation goes to 0, and *M* becomes the identity function. We use the term “hyperparameter” here to distinguish from the basic transition rate parameters in the model and to emphasize that those rate parameters depend on ε.

The campus alcohol environment (i.e., level of campus wetness) is an additional hyperparameter, *w*, which modifies the transfer rates between compartments as a function of campus wetness. Each rate parameter r_{ij}, s_{ij}, n_{ij} depends linearly on the wetness. For example, $r_{23}=r_{23}^{0}(1-w)+r_{23}^{1}w$, so that a completely “dry” campus, *w*=0, has rate parameter r_{23}^{0}, and a completely “wet” campus, *w*=1, has rate parameter r_{23}^{1}.

A version of the model without age structure has been successfully calibrated to survey data obtained from 32 campuses across the United States in the Social Norms Marketing Research Project, SNMRP (DeJong, et al., 2006; Ackleh, et al., 2009; Scribner, et al., 2009). We have reasonable estimates of the “wet” and “dry” rate parameter values, the wetness levels for each of the 32 campuses, and the misperception levels. Table 1 contains parameter estimates for the wet and dry rate parameters.

The wetness hyperparameters range from 0.05 to 0.55 in the 32 schools from the SNMRP data. Wetness correlates (R^2 = 0.30) with alcohol outlet density, a common measure of availability, but clearly other phenomena are involved, such as enforcement and campus social environment. However, lowering the MLDA would dramatically affect the effective alcohol outlet density for underage students. We estimated the misperception hyperparameters for the SNMRP campuses, and these values range from nearly 0 to 0.25.

We are interested in the exploration of the interplay between misperception and availability. In particular, the Amethyst Initiative's hypothesis is that a reduction in misperception and attendant improper role model choices will lead to a reduction in HED behavior. Toward that end, we consider a hypothetical college population behavior averaged over a ten year period, and we conduct a series of experiments. We assume that the wet and dry rate parameter values are the same for the under age and legal age groups; however, we take the legal age group to have higher wetness (greater availability) and lower misperception levels. We conducted a series of computer simulation experiments that we report here.

Results

We begin our exploration by considering a campus with medium wetness of 0.30, applicable to the legal age students, who also have a small amount of misperception (ε =0.05). In order to examine the effect of misperception, we consider a number of simulated “treatment” scenarios in which we assume a range of effects on the wetness and misperception parameters for the underage population and observe the resulting drinking behavior.

Our first simulation involves the assumption that the wetness hyperparameter for the underage population is the same as for the legal age (w=0.30), but that the misperception is at a higher level (ε =0.25). Our treatment is assumed to reduce the misperception from 0.25 down to 0.05, the level of the legal age students, with 100% treatment implementation

(Figure 2 upper panel). The x-axis in the upper panel Figure 2 denotes this linear change of misperception, where 0% implementation corresponds to ε =0.25 and 100% to ε =0.05. We can see that the reduction in Heavy Episodic Drinkers is relatively small. We should note that it is not clear that the legal age population would actually have less misperception than the underage population; however, such an assumption leads to a slightly conservative estimate on heavy episodic drinking.

A different approach might be to change the wetness parameter for the underage students. Our second simulation, in the lower panel of Figure 2, shows the fraction of HEDs in the legal and underage compartments as we reduce wetness in the underage group from 0.30 (0 percent treatment on the x-axis) down to 0.00 (100 percent treatment). Again, the legal age students have a small misperception parameter (ε =0.05) while the misperception of the underage students is at a high level (ε =0.25). One can see in the lower panel of Figure 2 that this treatment has a much stronger impact on the HED fraction than does the reduction of misperception.

Neither of these simulations captures the actual effect of the Amethyst Initiative's MLDA reduction. One might expect that wetness for the underage population is somewhat less than it is for the legal age population (exactly how much is of course a difficult matter to resolve) while the amount of misperception is greater for the underage population. We have conducted a number of simulations in which wetness and misperception for the underage population are changed simultaneously. As a first illustrative example, we continue with the hypothetical campus having wetness of 0.30 and misperception of 0.05 for the legal age students. We have also simulated a wet campus (w=0.55). We assume in this example that the underage population has a wetness parameter of half that of the legal age population, and a misperception parameter of 0.25, while the misperception parameter is at the high end of those we have inferred from SNMRP data. The treatment is to increase the underage wetness to that of the legal age group, while reducing the misperception to 0.05, so that at the end of the treatment, the legal age and underage students have the same parameters.

In Figure 3, we show the effect of simultaneously increasing the wetness and decreasing the misperception in the underage population. In each of the simulated experiments (both moderate and wet), the underage population goes from half the wetness of the legal population to fully as wet, while simultaneously going from high misperception (0.25) to the low level of the legal age population (0.05). In each of the three panels, the qualitative trend is the same: HED drinking among underage students is increased.

With any computer simulation model of a real-world phenomenon, but most especially with the highly challenging modeling problems of social systems, the prediction of events that are out of the scope of observation must be viewed with some skepticism. We have endeavored to calibrate and validate our model as accurately as possible (Ackleh, et al., 2009), and we have also conducted a large number of simulation studies to examine the dependence on assumptions about the legal age population, dropout and recruitment rates, and other parameters. Such sensitivity analyses of the model to its parameters are a necessary step for developing confidence in the resulting predictions. We have found across a wide spectrum of such analyses that the structure of the basic findings presented here is remarkably consistent.

Discussion

Limitations

It is of course a risky exercise to attempt to predict possible behavior based on inferred parameterizations. Rather than viewing these results as quantitative predictions of the actual levels of drinking that will occur under an MLDA change, we prefer to interpret the model output in terms of the trends and joint behavior as wetness index and misperception are changed simultaneously. The inescapable conclusion is that the misperception must be very great among the underage population and very significantly reduced by allowing the underage population to drink in order to compensate for the increased availability of drinking venues to the underage population. Indeed, further studies are required to quantify with accuracy how these parameters might actually change in the presence of an MLDA reduction. We do, however, interpret our simulations to date as pessimistic for the Amethyst Initiative's proposal that an MLDA reduction will have beneficial consequences for college drinking.

Conclusions

The preliminary insights provided by this model suggest that a reduction in the MLDA may not produce the desired reduction in heavy episodic drinking that is the goal of the Amethyst Initiative's strategy, based on the Initiative's reasoning about why “21 is not working.”(20). The analysis we have conducted suggests that effects of a reduction in misperception from the largest observed values to the lowest is overcome by a 25 percent increase in campus wetness. One might expect a much larger increase in wetness from the increased physical availability of alcohol associated with making the entire college population, rather than approximately half, to be of legal drinking age.

Acknowledgments

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We dedicate this paper to the memory of our friend and colleague, Dr. Jawaid Rasul, who passed away shortly after the completion of this work.

Appendix

The eight-compartment set of equations is given by

$$\frac{dU_1}{dt}=-d_1U_1-n_{12}f\left(\frac{\sum_{i=2}^{4}(U_i+L_i)}{\sum_{i=1}^{4}(U_i+L_i)}\right)U_1-s_{12}U_1(U_2+L_2)+r_{21}U_2+r_{31}U_3-\lambda_1U_1$$

$$\frac{dL_1}{dt}=-d_1L_1-n_{12}f\left(\frac{\sum_{i=2}^{4}(U_i+L_i)}{\sum_{i=1}^{4}(U_i+L_i)}\right)L_1-s_{12}L_1(U_2+L_2)+r_{21}L_2+r_{31}L_3+\lambda_1U_1$$

$$\begin{aligned}\frac{dU_2}{dt}= & -d_2U_2+n_{12}f\left(\frac{\sum_{i=2}^{4}(U_i+L_i)}{\sum_{i=1}^{4}(U_i+L_i)}\right)U_1\\ & +s_{12}(U_2+L_2)U_1\\ & +s_{42}(U_2+L_2)U_4\\ & -n_{24}f\left(\frac{(U_4+L_4)}{\sum_{i=1}^{4}(U_i+L_i)}\right)U_2\\ & -r_{21}U_2-r_{23}U_2-r_{24}U_2+r_{42}U_4-\lambda_2U_2\end{aligned}$$

$$\begin{aligned}\frac{dL_2}{dt}= & -d_2L_2+n_{12}f\left(\frac{\sum_{i=2}^{4}(U_i+L_i)}{\sum_{i=1}^{4}(U_i+L_i)}\right)L_1\\ & +s_{12}(U_2+L_2)L_1\\ & +s_{42}(U_2+L_2)L_4\\ & -n_{24}f\left(\frac{(U_4+L_4)}{\sum_{i=1}^{4}(U_i+L_i)}\right)L_2\\ & -r_{21}L_2-r_{23}L_2-r_{24}L_2+r_{42}L_4+\lambda_2U_2\end{aligned}$$

$$\frac{dU_3}{dt}=-d_3U_3-r_{31}U_3+r_{23}U_2+r_{43}U_4-\lambda_3U_3$$

$$\frac{dL_3}{dt}=-d_3L_3-r_{31}L_3+r_{23}L_2+r_{43}L_4+\lambda_3U_3$$

$$\frac{dU_4}{dt}=-d_4U_4-s_{42}U_4(U_2+L_2)+n_{24}f\left(\frac{(U_4+L_4)}{\sum_{i=1}^{4}(U_i+L_i)}\right)U_2-r_{42}U_4-r_{43}U_4+r_{24}U_2-\lambda_4U_4$$

$$\frac{dL_4}{dt}=-d_4L_4-s_{42}L_4(U_2+L_2)+n_{24}f\left(\frac{(U_4+L_4)}{\sum_{i=1}^{4}(U_i+L_i)}\right)L_2-r_{42}L_4-r_{43}L_4+r_{24}L_2+\lambda_4U_4$$

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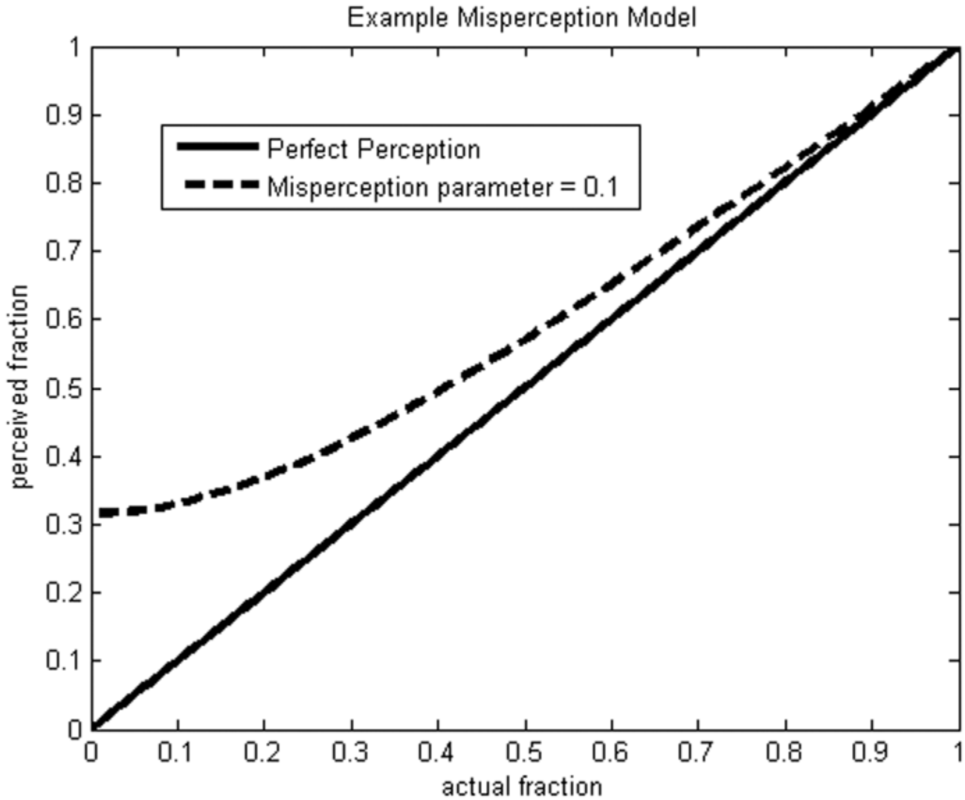

Figure 1.
Example misperception function.

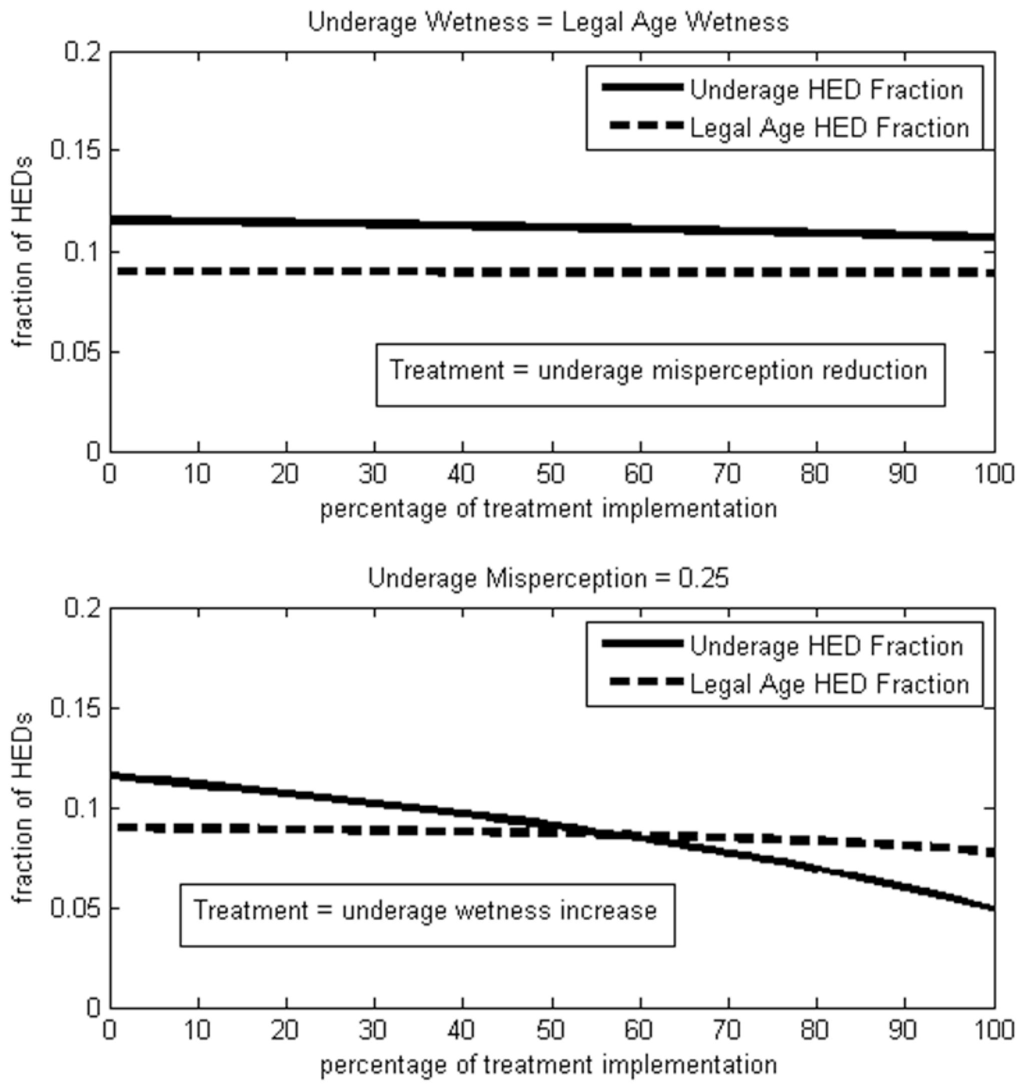

Figure 2.

HED fraction as a function of simple one-variable treatments. Upper panel shows the effect of reducing misperception from 0.25 to 0.05. Lower panel shows the effect of lowering wetness from 0.30 to 0.00.

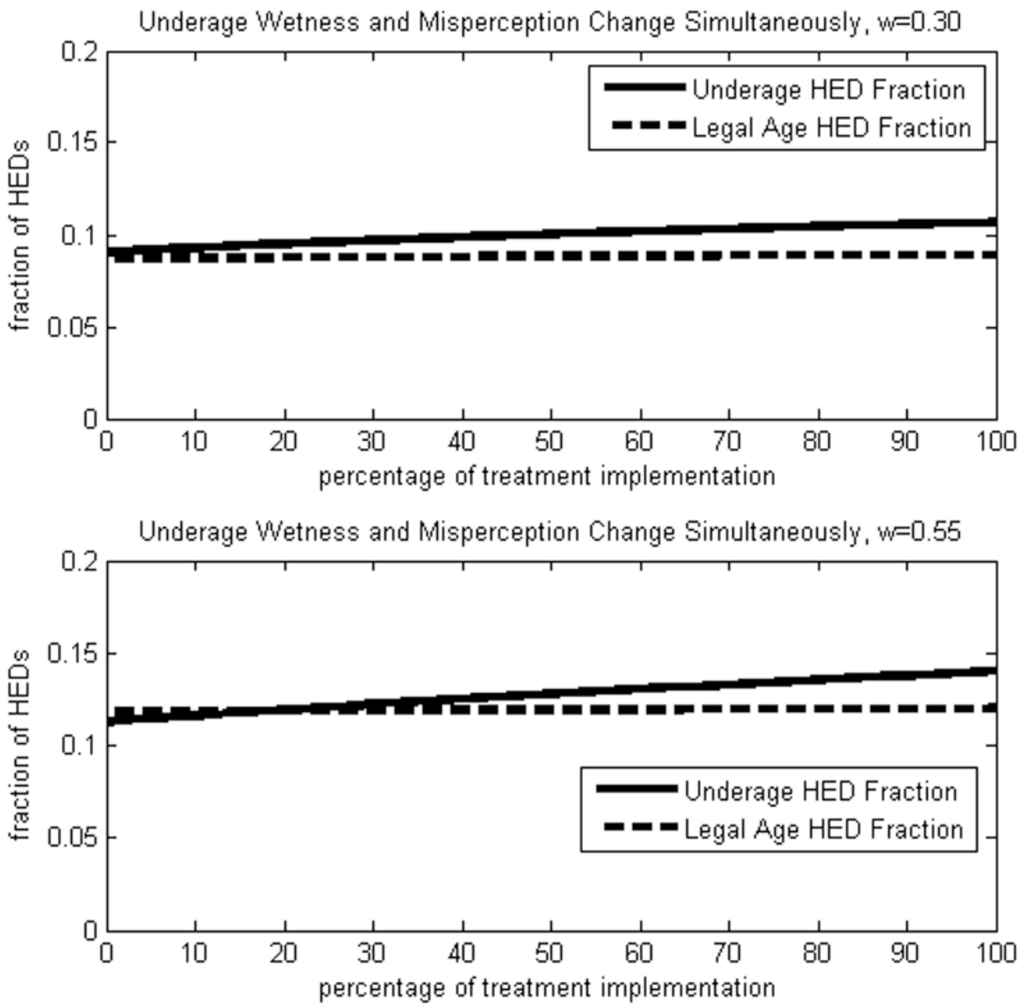

Figure 3.

HED fractions as a function of changing underage wetness and misperception. The upper panel shows a campus with moderate wetness (w=0.30) among the legal age students; the lower panel shows a wet campus.

Table 1

Bounds for the rate parameters as estimated from SNMRP data.

Parameter Name	Value at w=0	Value at w=1
s12	0.0170	19.1313
s42	4.2113	3.9486
r31	4.6484	4.6133
r23	0.2538	0.3971
r24	1.2860	6.8722
rR42	6.3111	6.2014
r43	1.5545	1.5776
r21	0.58-0	0.1807
r12	0.5006	8.0899
r24	2.6021	4.3106