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Heavy Episodic Drinking on College Campuses: Does Changing the Legal Drinking Age Make a Difference?*

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ABSTRACT. Objective: This article extends the compartmental model previously developed by Scribner et al. in the context of college drinking to a mathematical model of the consequences of lowering the legal drinking age. **Method:** Using data available from 32 U.S. campuses, the analyses separate underage and legal age drinking groups into an eight-compartment model with different alcohol availability (wetness) for the underage and legal age groups. The model evaluates the likelihood that underage students will incorrectly perceive normative drinking levels to be higher than they actually are (i.e., misperception) and adjust their drinking accordingly by varying the interaction between underage students in social and heavy episodic drinking compartments. **Results:** The results evaluate the total heavy episodic drinker population and its dependence on the difference in misperception, as well as its dependence on underage wetness, legal age wetness, and drinking age. **Conclusions:** Results suggest that an unrealistically extreme combination of high wetness and low enforcement would be needed for the policies related to lowering the drinking age to be effective. (*J. Stud. Alcohol Drugs, 72,* 15-23, 2011)

ALCOHOL USE ON COLLEGE CAMPUSES continues to be a subject of concern both in terms of health consequences and social costs (National Institute of Alcohol Abuse and Alcoholism, 2002). Alcohol-related unintentional injury deaths and self-reports of driving under the influence continue to increase (Hingson et al., 2005). Recently, a group of college presidents (the Amethyst Initiative) suggested efforts to address problem drinking among college students have failed and called for a national debate on lowering the minimum legal drinking age (MLDA; McCardell, 2008). John McCardell, the director of the initiative, argues that underage students have restricted access to publicly moderated drinking environments and therefore model their drinking behavior after the excessive consumption typical of private student parties and similar venues (McCardell, 2007). In such venues, drinking is less controlled than in legal drinking establishments, with heavy drinking taking place (Harford et al., 2002). This is a social norms argument in which students who initially abstain or drink occasionally tend to adjust their drinking behavior according to what they perceive as the norm among their peers (Baer et al., 1991; Borsari and Carey, 2001; Perkins, 1997). Perceived norms are thought to influence alcohol use among college students in a two-step process (Borsari and Carey, 2001). First, personal alcohol use is compared with perceived norms, and a discrepancy may be perceived to exist. According to attribution theory, when students observe heavy drinking in a salient target group, they infer that the observed drinking behavior is common. In the second step, students match their drinking level to the perceived norm. Amethyst Initiative proponents believe that lowering the MLDA would permit all students to drink in public settings, where they would be less likely to observe heavy levels of drinking in the target group and therefore would infer responsible drinking to be the norm.

Opponents of the initiative point to the demonstrated effectiveness of raising the MLDA on reducing alcohol-related outcomes among all affected youth, as well as the higher prevalence of alcohol-related outcomes in European countries with lower MLDAs (Babor, 2008; McCartt et al., 2009). Unfortunately, lowering the MLDA to observe the consequences would represent a social experiment on college campuses where the profound negative consequences resulting from lowering the MLDA in the larger society have already been demonstrated (Wagenaar and Toomey, 2002). With little in the way of direct observational data on the campus level to support or oppose the Amethyst Initiative, a systems approach is appropriate to estimate effects for a campus. As defined by Homer and Hirsch (2006), a systems approach represents a means of characterizing an abstract system in terms of discrete, component states and then linking them with a set of differential and algebraic equations (i.e., parameters) characterizing the processes that are believed to move constituents of the system from one

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state to another. In the case of college drinking, the system is the college drinking social environment, the states are the various drinking styles on campus (we used abstainer and light, moderate, heavy episodic, and problem drinkers), and the links are the mechanisms (e.g., social interactions, social norms, individual factors) underpinning how college students transition from one drinking style to another. The model is defined mathematically and developed through the application of relevant empirical and experimental data. The appropriate models for assessing the Amethyst Initiative should be able to assess the countervailing effects of (a) reducing perceptions of heavy episodic drinking as the norm and (b) increasing overall student drinking by reducing the MLDA. To have relevance to the public debate, the approach must be applicable to a variety of campus types (e.g., commuter campuses, those found in dry counties). Such a mathematical modeling approach to college drinking was put forward in a recent paper (Scribner et al., 2009) using a compartmental approach (Jacquez, 1996; Koopman et al., 2000, 2001).

Scribner et al. (2009) adopted a compartmental model to describe a campus in terms of a set of constituent drinking types with transitions (flows) of students between the different drinking-type compartments. A set of compartmental model parameters was obtained by fitting model predictions to data on the observed compartment sizes across a set of college campuses. To model the different environmental factors—such as the number of bars and liquor stores near campus and the influences of a fraternity/sorority system—a single parameter representing the campus wetness was used to vary each of the model parameters between maximum and minimum values. Individual college campuses were assigned wetness parameters determined from fitting the available data. They found that they could make adequate predictions of drinking compartment size across a number of campuses with varying wetness. They also modeled intervention policies, such as reducing the overall alcohol availability and directly removing (and/or preventing the matriculation of) heavy episodic drinkers (HEDs).

The issues that the Scribner approach addresses are similar to those raised by the Amethyst Initiative, with particular regard to policies that reduce the proportion of HEDs. Thus, it appears that the Scribner model can be adapted to directly model the ideas motivating the Amethyst Initiative, namely the interaction between drinking age and drinking misperception. Clearly, lowering the MLDA would lead to increased access to alcohol on a campus (increased wetness). Using this approach, we want to answer the question, "How much misperception would there have to be to make this policy change beneficial?"

This article extends the Scribner model to examine the effects of reducing the MLDA on a model campus making use of the parameters previously used to fit the data (Ackleh et al., 2009). First, we discuss the extension of the Scribner model to underage and legal age drinking groups. Next, we present results for the total HED population and its dependence on the difference in misperception between underage and legal age drinkers, as well as its dependence on underage wetness, legal age wetness, and MLDA. Finally, we discuss policy implications of lowering the MLDA for a broad range of campus types.

Method

Data sources and parameter fitting

The data were obtained from the Social Norms Marketing Research Project (DeJong et al., 2006), which annually surveyed a sample of students chosen at random from each of 32 college campuses. Campuses were chosen from all four U.S. regions and matched on institution type, enrollment, and student demographics. Students were surveyed regarding number of drinks per occasion, number of drinking occasions per week, and style of drinking. Students were then categorized into one of five drinking styles (abstainer and light, moderate, heavy episodic, and problem drinkers) and stratified by year. From the stratified categorical data, compartmental models were applied using a generalized least squares fitting procedure to determine overall parameter ranges for each of the compartmental model parameters (Ackleh et al., 2009).

At every participating campus, in each of 4 consecutive years, 300 students were randomly selected to receive a survey questionnaire by mail. The overall response rate across all study years was 53.1%, comparable to the 52% response rate of the College Alcohol Study, another national survey, in its latest year (2001). Students who reported at least two of four indicators of problem drinking based on the CAGE instrument (Mayfield et al., 1974) were classified as problem drinkers, regardless of the amount or frequency of their drinking. Those who consumed more than five drinks in a single sitting on at least one occasion in the past 2 weeks were classified as HEDs. The remaining drinkers were combined into a single classification: social drinkers.

Compartmental methodology

The basic principle underlying the Scribner et al. (2009) approach is that student drinking behavior can be separated into subpopulations (compartments), each associated with a specific type of drinking behavior (abstainers, social drinkers, HEDs, and problem drinkers). To simplify the model, we combined the original light and moderate drinking compartments into a single compartment, namely "social" drinkers, ensuring that the full model will have 8 compartments rather than 10. Students occupy a particular compartment for a period of time and can make transitions to other compartments (model flow). Subsequent transitions enable a particular student, in the course of his or her college career, to pass through all or just a subset of the different drinking behaviors (compartments). The transfer of students between compartments is characterized by transitions that take into account the nature of the social interactions between students with different drinking behaviors. Each transition has a flow parameter associated with it. In the simplest case (that of an "individual's risk"), this parameter is multiplied by the number of individuals in that drinking behavior. The flow parameter may also control a nonlinear social interaction between students of two drinking behaviors (involving the product of counts of individuals in the two compartments). In the most complex case, it controls a perception term in which a social interaction is affected by the students' perceptions of either the total fraction of drinkers or the fraction of HEDs on the campus.

Flows are modeled between compartments according to what drinking behavior transitions are thought to occur on college campuses. Students in any compartment may drop out of the campus, as well as graduate from the campus. A constant campus size is maintained by matriculation into each drinking behavior based on the proportions reported from high school levels. A time series of each drinking behavior (compartment sizes—the number of students participating in that type of drinking behavior) is then obtained from the solution of a nonlinear differential equation. The right-hand side of each equation consists of a combination of linear, social interaction, and perception terms of the types described above.

The compartmental model of alcohol consumption of Scribner et al. (2009) is therefore a dynamic system, with the drinking compartment sizes determined by a set of differential equations with model parameters specified by that campus's wetness. To explore the effects of lowering the drinking age, we extended the model to include two age groups: (a) one set of compartments for the underage drinkers and (b) another set of compartments for legal age drinkers. We allowed aging from each of the underage drinking compartments to the corresponding legal age drinking compartment. We assigned wetnesses to different age groups, with different accessibility to alcohol to model the underage versus legal age students (with a larger value for the legal students), thus making use of the results from the fitting procedure of Ackleh et al. (2009). This allowed us to model the full range of behaviors seen on those campuses whose data were fit in the previous compartmental analysis.

The extension of the Scribner model to eight compartments based on student age is illustrated in Figure 1. Each underage (or legal age) compartment has a proportion $U_i(L_i)$ of the total population, where the subscripts represent drinking status, that is, abstainers (i = 1), social drinkers (i = 2), problem drinkers (i = 3), and HEDs (i = 4). The flow parameters are the following: graduation/dropout rates (d_i); individual risk rates (r_{ij}); social interactions (s_{ij}); and perception-based interactions (n_{ij}), where i, j denote the source and sink compartments, respectively. The equations for underage drinkers are the following:

$$\frac{dU_1}{dt} = -d_1^U U_1 - n_{12}^U \left(\frac{\sum_{i=2}^{4} \left(U_i + L_i\right)}{\sum_{i=1}^{4} \left(U_i + L_i\right)} \right) U_1 - s_{12}^U U_1 (U_2 + L_2) + r_{21}^U U_2 + r_{31}^U U_3 - \lambda_1 U_1 + c_1 \sum_{i=1}^{4} (d_i^U U_i + d_i^L L_i) \quad (1)$$

$$\frac{dU_2}{dt} = -d_2^U U_2 + n_{12}^U \left(\frac{\sum_{i=2}^{4} \left(U_i + L_i\right)}{\sum_{i=1}^{4} \left(U_i + L_i\right)} \right) U_1 + s_{12}^U (U_2 + L_2) U_1 + s_{42}^{underage} (U_4 + L_4) U_2 - r_{21}^U U_2 - r_{23}^U U_2 - r_{24}^U U_2 + r_{42}^U U_4 - \lambda_2 U_2$$
$$+ c_2 \sum_{i=1}^{4} \left(d_i^U U_i + d_i^L L_i\right) \quad (2)$$

$$\frac{dU_3}{dt} = -d_3^U U_3 - r_{31}^U U_3 + r_{23}^U U_2 + r_{43}^U U_4 - \lambda_3 U_3 + c_3 \sum_{i=1}^{4} (d_i^U U_i + d_i^L L_i) \quad (3)$$

$$\frac{dU_4}{dt} = -d_4^U U_4 - s_{42}^{underage} U_2 (U_4 + L_4) - r_{42}^U U_4 - r_{43}^U U_4 + r_{24}^U U_2 - \lambda_4 U_4 + c_4 \sum_{i=1}^{4} \left(d_i^U U_i + d_i^U L_i\right) \quad (4)$$

We have introduced an aging parameter, λ_i, denoting the rate at which members of underage compartment i move to the corresponding legal age compartment. The superscripts to the flow parameters indicate that they are determined by the wetness of the underage group. We allow for continuous dropout and graduation of students. This loss is compensated by a continuous enrollment apportioned to the different drinking groups by the coefficients c_i (which sum to 1). In each of the underage group equations, the rate of enrollment is equal to the product of c_i and the total count of dropout/graduation across all drinking and age groups.

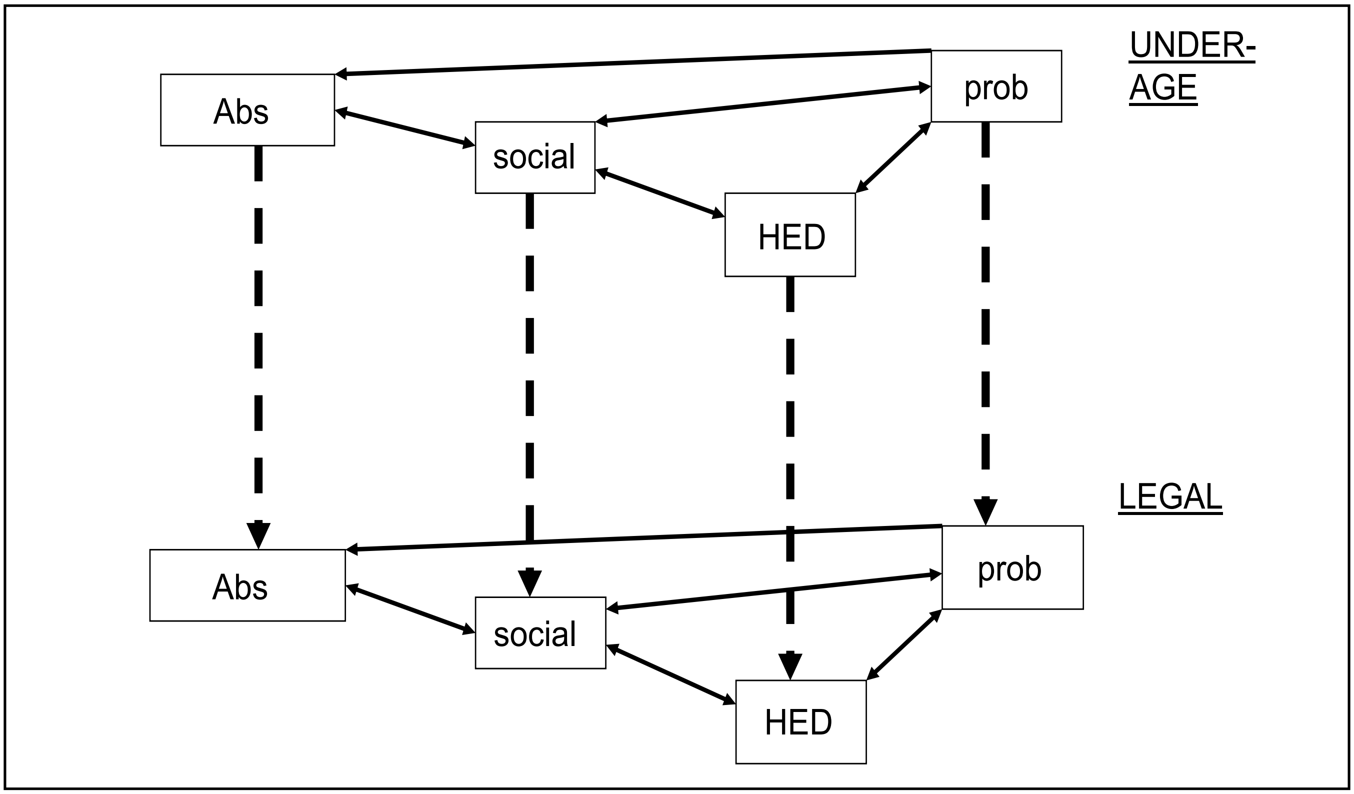

FIGURE 1. Schematic of the two-dimensional model with separate compartments for underage and legal students. Solid lines denote flows existing in the previous model, whereas dashed lines denote "aging" flows. Abs = abstainer; HED = heavy episodic drinker; prob = problem drinker.

Our largest departure from the four-compartment model is in the nonlinear interactions. To investigate the effects of student perceptions of the levels of drinking on campus, we made adjustments to the nonlinear interaction terms that control transitions from the social drinking category into the HED category. In the present model, the social and perception terms for an underage abstainer or underage social drinker depend on *all* the drinkers in the behaviors to which they may transition. For example, in the single perception term controlled by n_{12}, the underage abstainers perceive the members of all of the drinking compartments in both underage and legal age drinking groups. Likewise, for the social terms controlled by s_{12} and s_{24}, the underage abstainers and social drinkers interact with all social drinkers and HEDs, respectively—again summed across underage and legal age groups. Those students leaving the abstainer and social compartments as a result of social or perception terms arrive in the drinking category of the same age group—students may interact with those in another age group, but they only change age group by aging. Finally, we have split the s_{24} coefficient controlling the social drinker to HED by age group (indicated with a superscript) to allow for different levels of misperception in underage and legal age social drinkers.

We similarly constructed compartmental equations for legal age students (again, superscripts on the flow parameters indicate that they depend on the wetness of the legal age group):

$$\frac{dL_1}{dt} = -d_1^L L_1 - n_{12}^L \left(\frac{\sum_{i=2}^{4} \left(U_i + L_i\right)}{\sum_{i=1}^{4} \left(U_i + L_i\right)} \right) L_1 - s_{12}^L L_1 (U_2 + L_2) + r_{21}^L L_2 + r_{31}^L L_3 + \lambda_1 U_1 \tag{5}$$

$$\frac{dL_2}{dt} = -d_2^L L_2 + n_{12}^L \left(\frac{\sum_{i=2}^{4} \left(U_i + L_i\right)}{\sum_{i=1}^{4} \left(U_i + L_i\right)} \right) L_1 + s_{12}^L (U_2 + L_2) L_1 + s_{42}^{legal} (U_4 + L_4) L_2 - r_{21}^L L_2 - r_{23}^L L_2 - r_{24}^L L_2 + r_{42}^L L_4 + \lambda_2 U_2 \tag{6}$$

$$\frac{dL_3}{dt} = -d_3^L L_3 - r_{31}^L L_3 + r_{23}^L L_2 + r_{43}^L L_4 + \lambda_3 U_3 \tag{7}$$

$$\frac{dL_4}{dt} = -d_4^L L_4 - s_{42}^{legal} L_2 (U_4 + L_4) - r_{42}^L L_4 - r_{43}^L L_4 + r_{24}^L L_2 + \lambda_4 U_4 \quad (8)$$

The interaction terms follow the reasoning used in the underage terms—students who transition from a low drinking category to a higher drinking category in the legal age group from social or perception terms are influenced to do so by heavy drinking students of all ages. Recruitment into a legal age compartment occurs solely by aging from the corresponding underage compartment. As a check of the model, we sum the compartment sizes in each group to obtain totals for the underage and legal age compartments of: $U_{TOTAL} = \sum_{i=1}^{4} U_i$ and $L_{TOTAL} = \sum_{i=1}^{4} L_i$. We find

$$\frac{dU_{TOTAL}}{dt} = -\frac{dL_{TOTAL}}{dt} = \sum_{i=1}^{4} (d_i^L L_i - \lambda_i U_i) \quad (9)$$

For uniform dropout/graduation and aging rates across drinking behaviors, the totals reach an equilibrium of $U_{TOTAL} = d_L / (d_L + \lambda)$ and $L_{TOTAL} = \lambda / (d_L + \lambda)$. Therefore, the ratio of the legal age to underage student count in the eight-compartment model is simply $L_{TOTAL} / U_{TOTAL} = \lambda / d_L$, and we could set the drinking age on a campus by fixing the ratio of aging rate to the legal age dropout/graduation rate λ / d_L. Assuming that the 4 student years reflect the age groupings 18-19, 19-20, 20-21, and 21 and older, a drinking age of 21, 20, or 19 corresponds to λ / d_L of 1/3, 1.0, and 3.0, respectively. We also took the underage dropout rate to be one third of the legal age dropout/graduation rate. Finally, we obtained the changes in the levels of heavy episodic drinking on campuses by solving the system of differential equations to get the HED totals. To simplify the drinking age problem, we focused on the difference in HED totals with an MLDA of 19 compared with an MLDA of 21. We were therefore interested in the sign and magnitude of the quantity:

$$\delta = U_4 (\lambda / d_L = 3) + L_4(\lambda / d_L = 3) - (U_4(\lambda / d_L = 1/3) + L_4 (\lambda / d_L = 1/3)) \quad (10)$$

This overall difference in net HED totals arising from a reduction in MLDA is discussed in the next section as a function of both misperception and wetness.

Results

We solved the aforementioned eight-compartment model differential equations using the Model Transition and Sensitivity Analysis software (Koopman et al., 2000, 2001). The parameters for the underage and legal age groups were drawn from the four-compartment fitting procedure of Ackleh et al. (2009) and have the same functional dependence on wetness (Table 1)—the age groups differ only in their wetness. We defined a "wet" campus as one in which both the underage and legal age groups have moderate to high values of wetness and a "dry" campus as one in which both values are relatively low. We further distinguished those campuses in which the *difference* between underage and legal age wetness was large—in such campuses, underage drinkers are prevented from entering drinking establishments; therefore, they are termed "high-enforcement" campuses. At the opposite end were campuses in which underage drinkers can readily enter drinking establishments and can more easily obtain alcohol. Thus, the wetness difference between legal and underage groups was small; therefore, we labeled them "low-enforcement" campuses.

The perception difference between underage and legal age drinkers was modeled by allowing the underage social interaction between social drinkers and HEDs to differ from the term in the legal age interaction (after allowing for different group wetness) by a scaling factor that represents a "misperception difference" (equivalent to $s_{42}^{underage} / s_{42}^{legal}$ in the notation of the eight-compartment equations). It can be seen from Table 1 that the fitted four-compartment values of s_{42} are positive for the whole range of wetness, indicating a net flow from HEDs to social drinkers (Ackleh et al., 2009). If the underage drinkers believe there are more HEDs compared with what legal age drinkers believe, then the flow from HEDs to social drinkers will be reduced for the underage group and may even change sign. Therefore, we modeled increasing misperception on the part of underage drinkers by reducing the misperception difference from that of legal age drinkers, allowing this misperception parameter to take negative values.

In Figures 2 and 3, we show results (with color legend included) of the difference, δ, in HED totals arising from a reduction in MLDA (expressed as percentages of the total

Table 1. Parameters from the four-compartment model used to parameterize the separate underage and legal age groups according to their individual wetness. "Dry" and "wet" refer to the set of values of the parameters that apply for a wetness of 0 and 1, respectively.

Variable	Dry	Wet
s12	0.1179	37.659
s42	4.1587	3.089
r31	4.7324	4.4485
r23	0.42068	1.1702
r24	2.3492	11.339
r42	5.7418	5.34
r43	1.1022	0.87091
r21	0.80373	−0.033466
n12	0.64939	14.517

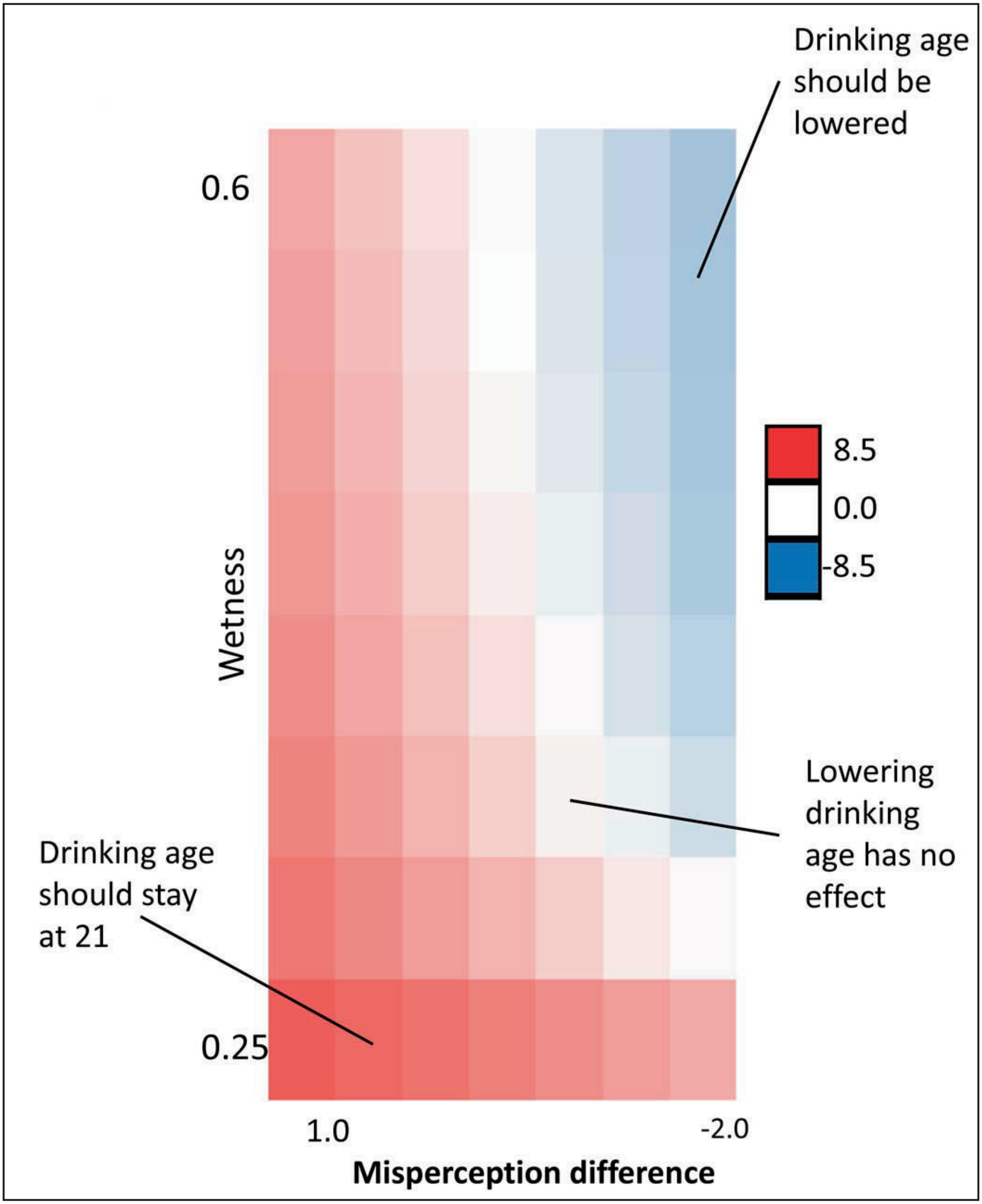

FIGURE 2. Schematic color map showing δ (net drop in heavy episodic drinker totals) upon lowering the drinking age from 21 to 19 years as a function of the wetness of the legal age group and the misperception difference. Regions are marked with distinct policy implications.

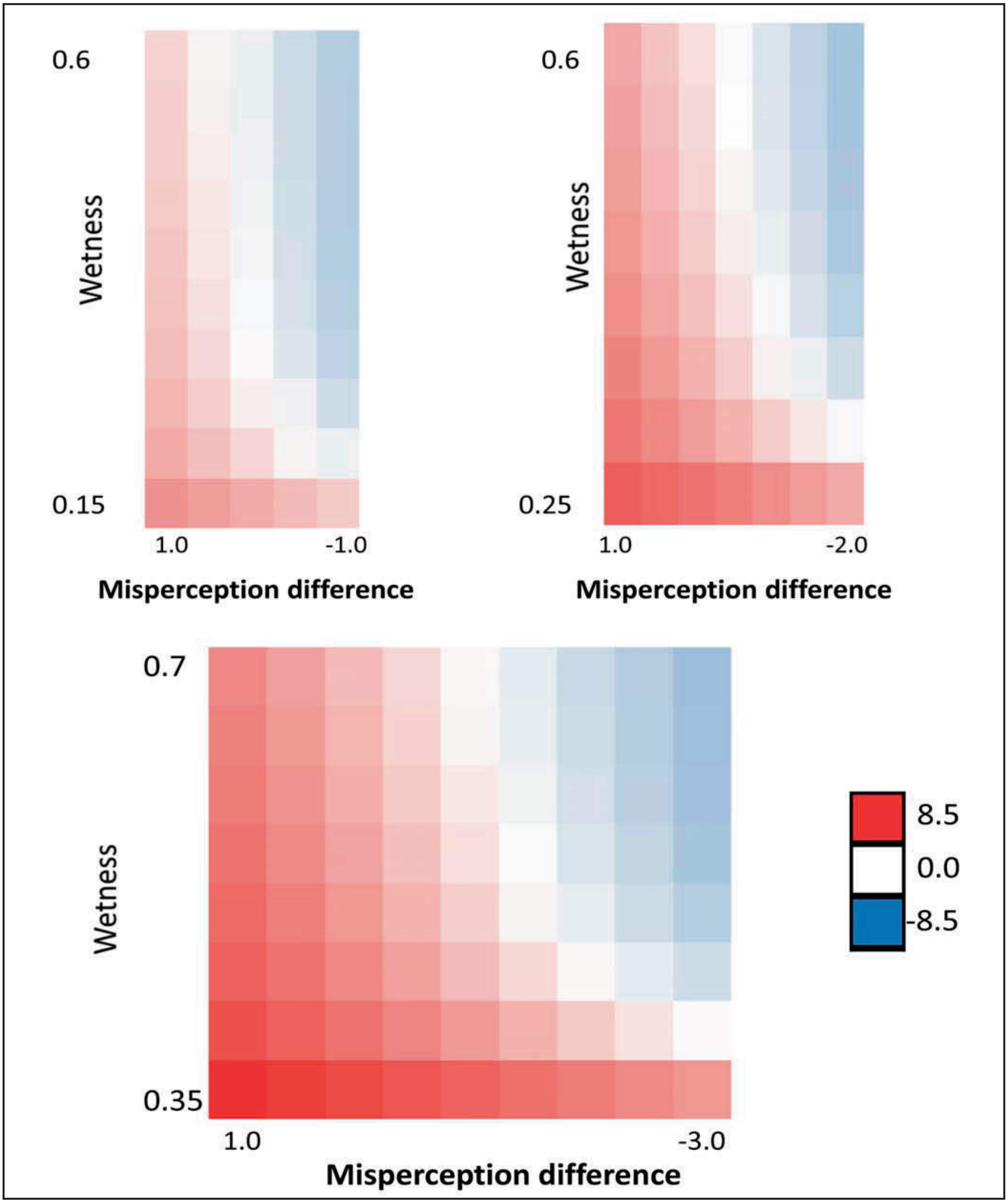

FIGURE 3. Color map showing δ (net drop in heavy episodic drinker totals upon lowering the drinking age from 21 to 19 years) as a percentage of the total student population. Wetness of the legal age group and the misperception difference are displayed along the axes. The wetness difference between underage and legal age groups is in clockwise order 0.1, 0.2, and 0.3, corresponding to campuses with low, intermediate, and strict levels of enforcement of drinking policies, respectively.

number of students on the campus) as functions of both the legal age group wetness and of the misperception difference across different levels of campus enforcement. Figure 2 illustrates how a policy maker might use such results to decide whether changing the legal drinking age might lead to a reduction in the number of HEDs on his or her campus. Blue regions on the figures have fewer HEDs when we reduce the MLDA from 21 to 19 years; that is, the net change is negative. In blue regions, the gains from lowering misperception outweigh the consequences of increased alcohol availability that would result from lowering the MLDA. The opposite is true for red regions. In the red regions, it would not be beneficial to lower the minimum drinking age. The blue and red regions are separated by a critical boundary (white) in which the increase in wetness offsets reductions in misperception resulting from a lower MLDA. The policy maker would determine where on the figure his or her particular campus falls, as well as the misperception difference that would be required to offset the effects of lowering the MLDA. From this, the policy maker could then decide whether a lower MLDA would benefit his or her campus.

Figure 3 illustrates campuses with different levels of enforcement (i.e., varying differences in wetness between underage and legal age groups). We retained the same scale so that the degree of color intensity reflects the magnitude of the HED gain or loss, δ, allowing inferences to be drawn about the relative effectiveness of the policy change across different campus types. Figure 3 (top left) illustrates low-enforcement campuses in which the difference in wetness is 0.1. Here, a campus having a legal age wetness of 0.2 and up would benefit from a lower MLDA when the misperception difference lies between 0 and −1.0. In this range, the underage group's misperception is large relative to legal age drinkers, such that the net flow from underage HEDs to underage social drinkers is negated or even reversed. For low-enforcement settings, the campuses that would benefit the most from lowering the MLDA are those with legal wetness near 0.6. This corresponds to a wet campus with low enforcement.

For medium-enforcement campuses (Figure 3, top right) where the wetness difference is 0.2, a larger misperception difference (amounting to a reversal in sign) is needed to achieve benefits from reducing the MLDA, because the critical boundary has been pushed to lower values of the misperception difference. For high-enforcement campuses with a wetness difference of 0.3 (bottom), the critical boundary is pushed toward even lower values of misperception difference. For high-enforcement campuses with legal wetness as high as 0.7, what is required is not only a change in the sign of the underage HED–social drinker flow but also an increase in magnitude. For dry campuses with *any* level of enforcement (Figure 3, bottom panel), HED totals always increase. Dry campuses would require unrealistically large reversals in underage misperceptions to benefit from a lower MLDA.

A cautionary note emerges on examining the overall size of the change in HED fractions obtained in Figure 3. Even for campuses that would benefit from reducing the MLDA, namely wet with a low level of enforcement, the reduction in HED fraction is ~2.3% for a misperception difference of −1. However, a policy maker on such a campus could risk an increase in the HED fraction of 1% if the misperception effect turns out to be minimal. The risks become more of an issue on drier campuses—a campus with a wetness difference of 0.2 could possibly show a decrease in heavy episodic fraction of 3% if the misperception difference is extremely large (−2) but would show an increase of 3% if the misperception effect is not present. For campuses in the bottom of Figure 3 with strong enforcement levels, the consequences of reducing the MLDA but having no misperception difference present can be even larger, with HED fractional increases of 4%-8% on the very driest campuses.

Discussion

We extended an earlier four-compartment model for college drinking (Ackleh et al., 2009; Scribner et al., 2009) to examine the consequences for heavy episodic drinking of lowering the drinking age on college campuses. We modeled the effects of a variable drinking age by increasing the number of compartments from four to eight to allow for separate but interacting underage and legal age groups (each with their own four-compartment processes). Relative population sizes in the two groups are controlled by altering the aging rate between the two groups. The legal and underage groups are assumed to have different availability of alcohol ("wetness"), and the model parameters for each group are derived from the model parameters fitted in the earlier, four-compartment analysis. Parameter values encompass the full range of campuses based on data from the previous study. We also included an extra parameter controlling the difference between the heavy drinker–social drinker flows in the two groups that is expected to arise from increased misperceptions in the underage group, modeling the effect emphasized by authors of the Amethyst Initiative. We solved the eight-compartment model to obtain equilibrium values of the HED totals in underage and legal age groups and studied how the HED totals change when the drinking age is lowered from 21 to 19 years.

One limitation of our approach is that compartments are homogenous and do not allow an individual to occupy two compartments at once. The resolution of drinking behavior in compartments can be changed by increasing the number of compartments and subdividing social drinkers into lights and moderates, as in Scribner et al. (2009). However, unless another approach has additional interaction parameters that show very different dependence on wetness to those in the present model, we expected the conclusions regarding "misperception versus wetness" to be the same as in the present model. In fact, Ackleh et al. (2009) and Scribner et al. (2009) found that the interaction parameters in the five-compartment model had a similar dependence on wetness. Another limitation is that transitions and social interactions are modeled deterministically as continuous processes. One could relax this assumption using a stochastic formulation. Equilibrium levels might change because deterministic and stochastic approaches to nonlinear systems do not yield identical results. A further objection is that we neglected "learning" processes in which individuals alter their "misperception" behavior after repeated transitions through different compartments. To address this would require data that measure repeated individual responses over an extended period. These topics are left to future study. Finally, the empirical data used to parameterize the initial model represent self-report data from college students collected annually. Consequently, the model is prone to the same biases that plague self-report data, and the predictions made represent a summary measure of drinking over the course of an entire academic year.

Overall, we found that, for a lowering of the MDLA to be effective, a campus would already have to be "wet" and have poor levels of enforcement (a campus that fails to prevent underage students from accessing alcohol). However, there would also have to be such a level of underage misperception that the interaction between social drinkers and HEDs would be the reverse of that expected for legal age students. On "drier" campuses with either low or high levels of enforcement, the misperception that would be required is several times larger. In fact, data on frequency of alcohol use (Perkins et al., 1999) suggest that misperceptions occur most markedly on campuses in which abstainers are the majority, whereas on campuses where alcohol use is more frequent, the perceived use is more in line with actual use. However, our model shows that, to be effective, lowering the MDLA on dry campuses requires much larger levels of misperception than on wet campuses. A policy maker would have to be confident that a large degree of misperception is present and that the fractional reductions in heavy episodic drinking are worth the risk of being mistaken in order to justify reducing the drinking age. Without data supporting such high levels of misperception, we do not find it likely that lowering the drinking age will reduce HED totals. Our results suggest that an unrealistically extreme combination of high wetness and low enforcement would be needed for the Amethyst Initiative policies to be effective.

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