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The normative underpinnings of population-level alcohol use: an individual-level simulation model

Charlotte Probst, (PhD)[1], **Tuong Manh Vu, (PhD)**[2], **Joshua M. Epstein, (PhD)**[3,4], **Alexandra E. Nielsen, (PhD)**[5], **Charlotte Buckley, (PhD)**[6], **Alan Brennan, (PhD)**[2], **Jürgen Rehm, (PhD)**[1,7,8,9,10,11], **Robin C. Purshouse, (PhD)**[6]

1)Institute for Mental Health Policy Research, Centre for Addiction and Mental Health (CAMH), 33 Russell Street, Toronto, ON M5S 2S1, Canada

2)School of Health and Related Research, University of Sheffield, 30 Regent St, Sheffield, S1 4DA, UK

3)College of Global Public Health, New York University, 665 Broadway, New York, NY 10012, USA

4)Santa Fe Institute, 1399 Hyde Park Road, Santa Fe, New Mexico 87501, USA

5)Alcohol Research Group, Public Health Institute, 6001 Shellmound St, Emeryville, CA 94608, USA

6)Department of Automatic Control and Systems Engineering, University of Sheffield, Mappin Street, Sheffield, S1 3JD, UK

7)Dalla Lana School of Public Health, University of Toronto, 155 College Street, Toronto, ON, Canada, M5T 3M7

8)Campbell Family Mental Health Research Institute, Centre for Addiction and Mental Health, 33 Russell Street, Toronto, ON, Canada, M5S 2S1

9)Institute of Medical Science, University of Toronto, Faculty of Medicine, Medical Sciences Building, 1 King's College Circle, Toronto, ON, Canada, M5S 1A8

10)Department of Psychiatry, University of Toronto, 250 College Street, Toronto, ON, Canada, M5T 1R8

11)Institute of Clinical Psychology and Psychotherapy & Center of Clinical Epidemiology and Longitudinal Studies (CELOS), Technische Universität Dresden, Chemnitzer Str. 46, 01187 Dresden, Germany

Abstract

Background: By defining what is 'normal', appropriate, expected and unacceptable, social norms shape human behavior. However, the individual-level mechanisms through which social norms impact population-level trends in health-relevant behaviors are not well understood.

Data availability
The code of the model will be made available in an open-source repository.

Conflicts of interest
None.

Aims: To test the ability of social norms mechanisms to predict changes in population-level drinking patterns.

Methods: An individual-level model was developed to simulate dynamic normative mechanisms and behavioral rules underlying drinking behavior over time. The model encompassed descriptive and injunctive drinking norms and their impact on frequency and quantity of alcohol use. A micro-synthesis initialized in 1979 was used to represent plausible demographic developments over the 20 year simulation period based on a representative synthetic US population. Three experiments were performed in order to test the modelled normative mechanisms.

results: Overall, the experiments showed limited influence of normative interventions on population-level alcohol use. An increase in the desire to drink lead to the most meaningful changes in the population's drinking behavior. The findings of the experiments underline the importance of autonomy, i.e., the degree to which an individual is susceptible to normative influence.

Conclusion: The model was able to predict theoretically plausible changes in drinking patterns at the population level through the impact of social mechanisms. Future applications of the model could be used to plan norms interventions pertaining to alcohol use as well as other health behaviors.

Keywords

Alcohol use; social norms; individual-level simulation modelling

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INTRODUCTION

Social norms are implicit rules that shape human behavior and interactions by defining what is socially appropriate, expected, and unacceptable. In this study we examined the ways in which social norms affect health behavior focusing on alcohol use as a specific health behavior example (Greenfield & Room, 1997). We present a formal, mechanism-based individual-level simulation model of social drinking norms that can be used to investigate and explain population-level dynamics in alcohol use as well as other health behaviors.

Room (1975) defined social norms in the context of alcohol use as follows: "A norm is a cultural rule or understanding affecting behavior which is to a greater or lesser degree enforced by sanctions. […] By 'cultural' I mean that a norm is not of an individual or a private understanding between people interacting with one another but is a relatively permanent rule shared by a class of individuals who may not ever have met each other" (page 363). In the psychosocial tradition, two main normative components are generally distinguished: *injunctive norms*, referring to the *perceived acceptability* and *descriptive norms*, referring to the *perceived prevalence* of a specific behavior (Cialdini, Kallgren, & Reno, 1991). As operationalized in our model, these two social normative components shape personal attitudes, decision making and drinking behavior (Borsari & Carey, 2001; Borsari & Carey, 2003; Lac & Donaldson, 2018).

The first empirical studies of descriptive drinking norms (perceived prevalence) were published by Perkins and Berkowitz who found that college students' drinking was influenced by the perception of their peers' drinking behavior (Perkins & Berkowitz, 1986). Later research confirmed their initial findings (O'Grady, Cullum, Tennen, & Armeli, 2011; Stappenbeck, Quinn, Wetherill, & Fromme, 2010; Wardell & Read, 2013). Notably, the degree to which the observer's behavior is influenced by others, increases with the similarity with the reference group (Larimer et al., 2009; Larimer et al., 2011; Lewis et al., 2011; Neighbors et al., 2010; Rinker & Neighbors, 2014). However, the perceived descriptive drinking norm is an *inaccurate* representation of the actual drinking behavior in the reference group, as it has been shown to be biased by the observer's own drinking pattern (Bertholet, Gaume, Faouzi, Daeppen, & Gmel, 2011; Borsari & Carey, 2003; Cunningham, Neighbors, Wild, & Humphreys, 2012).

Injunctive norms (perceived social opprobrium) were also found to affect alcohol use behavior (Neighbors, Lee, Lewis, Fossos, & Larimer, 2007; Neighbors, Lindgren, Knee, Fossos, & DiBello, 2011; Paschall, Grube, Thomas, Cannon, & Treffers, 2012). For example, Keyes, Schulenberg, O'Malley, and et al. (2012) found that a 5% increase in the disapproval of weekend-binge drinking in a given cohort was associated with 12% decreased odds of alcohol use in the past year. Overall, injunctive norms were found to be more restrictive towards woman's compared to men's drinking (Greenfield & Room, 1997).

Rimal and Real (2005) attempted to formalize normative influences on drinking behavior in the Theory of Normative Social Behavior. The latter theory posits that the influence of descriptive norms on individual drinking behavior is mediated by three normative mechanisms, namely (I) injunctive norms, (II) outcome expectations and (III) group identity. (I) In accordance with the postulates of the Theory of Reasoned Action, individuals are assumed to be motivated to comply with *injunctive norms* by an intrinsic want to avoid social opprobrium (see also Ajzen & Fishbein, 1980). (II) Positive or negative *outcome expectations* related to alcohol consumption can be guided by a person's own experiences or by consequences observed in others. (III) Finally, the *group identity* determines the relevant reference group based on the number of shared characteristics. The current study used a modified version of the latter theoretical concepts (Figure 1) as the basis for the individual-level simulation model.

The generation of such a model requires translation of theoretical concepts into behavioral rules and mechanisms. A number of previous agent-based, mechanistic simulation models have investigated the dynamics of social norms (Epstein, 2001; Hollander & Wu, 2011; Mahmoud, Ahmad, Yusoff, & Mustapha, 2014; Neumann, 2008). However, most of these models used small groups of agents and focused on the dynamics of norms rather than on the resulting behaviors. Meanwhile, Holder (1998) included a representation of social norms for alcohol use behaviors as part of the 'SimCom' system dynamics model, which was applied to the study of driving-under-the-influence interventions across several US counties and states.

The behavioral mechanisms model presented in this study build most strongly on the work by Verhagen (2001). Verhagen proposed that the agent's behavior is influenced by three sub-models: the individual model, representing the agent's own desire toward the behavior; the descriptive group model, representing observed behaviors; and the injunctive group model, representing perceived behavioral expectations. The agent's propensity to disregard social norms and follow her 'own' intentions and desires is captured in an autonomy parameter (Müller, Rao, & Singh, 1999; Verhagen, 2001): "The degree to which the group norms are applied in the agent's decision making is dependent on the degree of autonomy the agent has with respect to the group—autonomy meaning the freedom of choosing to not comply with the norms" (p. 299; Verhagen, 2001).

In the context of alcohol use, the 'own' intentions and desires to drink comprise different individual-level drivers of drinking behaviors that are not in the focus of the current study, such as neurobiological predispositions (Koob, 2003; Tabakoff & Hoffman, 2013), outcome expectancies (Anthenien, Lembo, & Neighbors, 2017; Young, Oei, & Knight, 1990) and other motives (Kuntsche, Knibbe, Gmel, & Engels, 2005). The *desire to drink* referenced in the current study can hence be understood as an umbrella term of individual drivers of drinking behavior that are separate from the social norms.

In the current study we integrated the theoretical frameworks, previously proposed mechanisms, and available empirical evidence into a parsimonious, individual-level simulation model. In other words, we attempted to examine, to what degree individual-level mechanisms could explain more macro-level phenomena in drinking behavior. The modelled normative mechanisms were tested on three examples using the following hypotheses:

- An intervention targeting heavy drinkers in order to lower the perception bias in perceiving the descriptive norm will lead to lower levels of alcohol use in the population (Neighbors, Larimer, & Lewis, 2004).
- If the desire to drink increases in a subgroup of the population due to an external event such as high unemployment in men in the context of an economic crisis (de Goeij et al., 2015), alcohol consumption and heavy drinking will increase not only in the 'affected' subgroup but in similar social groups as well.
- A public campaign to discourage drinking and change injunctive norms related to any alcohol use, will lead to decreases in the prevalence of drinking in the population (Young et al., 2018).

METHODS

Overview

The conceptual social norms model is implemented as a mechanism-based, individual-level simulation model. The model uses the social mechanisms approach proposed by Hedström (2005) as a framework with two entities: individuals (micro-level entities) and drinking norms (macro-level entities). The smallest time unit of the model is one day. An overview of the model processes and their scheduling is shown in Figure 2. Experiments were performed in order to test the modelled normative mechanisms on three examples. Box 1 contains definitions of the technical concepts used in this study.

The individual

Each individual has the following properties: age and gender; indicators of past 12 month alcohol use including quantity and frequency of drinking; autonomy; desire to drink; and perceived descriptive and injunctive norms. The last three properties are operationalized to be quantifiable for the k^{th} drink.

Behavioral decision making

To drink or not to drink—The individual's decision making regarding alcohol use on a given day is based on a simple behavioral rule brokering aspects of the individual's own desire to drink alcohol and her perceived drinking norms. For each individual i the disposition d to consume drink number k is given by the following function, starting with $k = 1$.

$$d_i(k) = u_i(k) * a_i + (\sqrt{I_i(k) * D_i(k)}) * (1 - a_i) \quad [1]$$

The individual's desire to drink u (as in utility) is weighted by the individual's autonomy a. The normative component (comprising injunctive norm I and descriptive norm D), are weighted by the additive inverse of autonomy. The individual's desire to drink, the perceived injunctive and descriptive norms, and autonomy all range between 0 and 1, binding the disposition to the same interval. It should be noted that the exact structure of the implemented mechanism remains subject to further development, with equation [1] representing only one conceptualization of the possible model structure. In parallel work, we have used machine learning methods to identify other potential representations of this mechanism, identifying tentative trade-offs between interpretability and goodness-of-fit to empirical data (Vu et al., 2019).

As a numerical example, suppose individual Peter (18 years old) has a desire to drink $u_{peter}(1)$ of 0.350 on any given day and he gives equal weight to his own desire to drink and to normative expectations, with an autonomy, a_{Peter}, of 0.500. The normative aspects pertaining to his age and gender assign acceptability of 0.020 (injunctive norm, $I_{Peter}(1)$) and 0.025 (descriptive norm, $D_{Peter}(1)$) to having a drink on a given day. As per equation [1] Peter's resulting disposition $d_{Peter}(1)$ to have a drink is $0.350 * 0.500 + \left(\sqrt{0.020 * 0.025}\right) * (1 - 0.500) = 0.186$. Within the model his disposition to drink alcohol is compared to a randomly sampled threshold between 0 and 1, similar to the *Agent_Zero* framework by Epstein (2013). In the long run, Peter will decide to drink on approximately 19% of days. Of course, his drinking then affects other individuals under the same algorithm, e.g., through changes in the descriptive norm.

How much to drink—Peter's autonomous desire to drink and the operative drinking norms on drinking frequency regulate decision making about any vs. no alcohol use on a given day. This will tell us how *often* Peter decides to drink, but not how *much*. Once an individual decides to drink on a given day, decisions regarding subsequent drinks, i.e., how much that individual consumes, depend on the norms and the desire to drink for each additional drink. The respective injunctive norms refer to the acceptability to drink *2, 3… k* drinks in the context of a drinking occasion. Similarly, the descriptive norms refer to the mean level of alcohol consumption in a drinking occasion and the variation therein across relevant others. An individual's desire regarding quantity is operationalized using a normal distribution, with a mean and standard deviation of the desired number of drinks. The desire for the k^{th} drink is calculated as one minus the cumulative density distribution for k drinks. Let's say Peter already had his first drink and has to decide if he will have another one. Peter desires to drink four drinks (±1) per occasion, this means that Peter's desire to have the next drink without accounting for normative influences, would be at 0.99 for having a second drink, 0.85 for a third, 0.50 for a fourth drink, and so on.

Drinking norms

The drinking norms are specific to the individual's age and gender. The injunctive norm $I(K)$for k=1 represents the accepted frequency of drinking per se. Conditional on having entered a drinking occasion, the acceptability of $k > 1$ drinks is based on a decreasing exponential function, the idea being that, by and large, extremely heavy drinking is less acceptable than light consumption (see equation [8], Web Appendix). Gender-differences for injunctive norms are informed by secondary survey data from the 1979 National Alcohol Survey (calculations by author; for background information see Greenfield & Room, 1997).

Descriptive norms $D(k)$for k=1are based on the *daily* prevalence of alcohol use, for age/gender reference groups. The current model uses a total of 18 reference groups (man/woman x eight age groups). Descriptive norms for $k > 1$ are based on the observed mean and standard deviation of the number of drinks per drinking occasion for each reference group (see equation 3, Web Appendix).

The individual's perception of norms—Before making decisions about alcohol use, the individual 'checks in' with the descriptive and injunctive drinking norms which apply to her (Figure 2). In order to represent similarity with the age/gender reference group, each individual gives higher importance to the norms operating in a given age/gender group with which she shares more demographic characteristics. For example, Peter would disregard the norms for women aged 35–64 (no shared characteristics), give high importance to the norms for men aged 18–34 (two shared characteristics), and lower importance to norms for women 18–34 (one shared characteristic).

In the case of descriptive norms regarding the quantity consumed in a drinking occasion, the perception is biased based on the individual's own drinking behavior (Bertholet et al., 2011). This perception bias is implemented using a weighted average of (a) the true average quantity consumed in the individual's reference group and (b) the individual's own average quantity per drinking occasion. A constant 'bias factor' ε is used as the weight. Ceteris paribus, this bias promotes heavy drinking among drinkers that already drink above the average in their reference group.

In Peter's case the true average consumption of people in his reference group is two drinks per occasion (after applying the weighting based on similarity as described above). However, Peter perceives a higher level of drinking because he is biased by his own level of consumption. With a bias factor of $\varepsilon = 0.4$ he perceives the descriptive norm regarding the 'normal' drinks per drinking occasion as

$0.4 * 3.5\ drinks_{Peter} + (1 - 0.4) * 2\ drinks_{reference} = 2.6\ drinks.$

Dynamics of norms—While descriptive norms are constantly changing with drinking behavior in the population over time, two explicit feedback loops are implemented for changing injunctive norms, derived from the work of Holder (1998). These norm adjustments are assessed and applied for each age/gender reference group separately, making it less/more acceptable for people in this group to drink (*1, 2, … k drinks*). More details regarding the dynamics of norms are described in the Web Appendix, page 4.

Hypothesis testing

Experiment 1 was used to simulate the effects of an intervention to decrease the perception bias among heavy drinkers (defined as drinking more than the 'true' average in their reference group). To implement the experiment the descriptive norm bias factor was changed so that 95% weight was given to the true average number of drinks per occasion in the reference group and only 5% weight were given to the own average number of drinks per occasion for all heavy drinkers.

Research has shown that some external events such as the US recession can lead to increases in heavy alcohol use in specific subgroups of the population (de Goeij et al., 2015; Mulia, Zemore, Murphy, Liu, & Catalano, 2014; Richman et al., 2012). Experiment 2 was used as a high-level simulation of potential effects of such an external event causing a relatively sudden increase in the desire to drink alcohol among a certain social group. To implement this experiment, the desire to drink was increased by 25% among middle aged men (35 to 54 year of age), only.

Experiment 3 was used to simulate a public campaign to discourage drinking and change respective injunctive norms. In order to implement this experiment, the injunctive norm regarding the first drink (k=1) was decreased by 50%. All experiments were modelled to begin five years into the simulation (1984).

Implementation

The model was implemented in C++ using the RepastHPC agent based modeling platform (Collier & North, 2012). We modeled the daily drinking behavior of a closed cohort of 1000 individuals for 20 years (1979 to 1999), collecting cohort statistics and population-level drinking behaviors annually. Seven outputs were collected: prevalence of current drinking in the past 12 months; average grams of pure alcohol consumed per day among current drinkers in the past 30 days; average number of drinking days in the past 30 days among current drinkers; and number of drinking days with 5+ drinks in the past 30 days among current drinkers (HED).

A sociodemographic micro-synthesis was used to populate the individuals with characteristics age, gender and drinking history in the model (Brennan et al., in preparation). The micro-synthesis was representative of the population of the United States in 1979 and contained individuals aged 12 to 80 informed by the National Survey on Drug Use and

Health (United States Department of Health, Human Services, National Institutes of Health, & National Institute on Drug Abuse, 2015), the Panel Study of Income Dynamics (University of Michigan & Survey Research Center, 2018) and the US Census 1980 (Manson, Schroeder, Van Riper, & Ruggles, 2018). The desire to drink was based on the individual's drinking history so that the desire to drink of each individual would roughly correspond to his/her drinking history (e.g., individuals with a very low frequency of alcohol use would be assigned a very low desire to drink on any given day).

The autonomy of each individual was assigned by sampling from a beta distribution. The hyper-parameters of the beta distributions were specified through the *calibration* procedures, described below. In order to allow for differences in the autonomy by gender and drinking status, shifting factors were introduced and exposed to the calibration.

All simulation scenarios were repeated 10 times to investigate variation due to stochastic processes (such as sampling the drinking threshold). The resulting standard error across simulation runs was used to calculate confidence intervals.

Calibration—The parameterization of the model followed Bayesian principles: for each of the 28 parameters (i.e., the parameter set), a prior distribution was specified. We sampled 5,000 parameter sets from the joint prior distribution using a Latin hypercube space-filling design. The model was run for each parameter set and the fitness was calculated by comparing the simulated outputs and the empirical target data. Target data were calculated using repeated cross-sections from the nationally representative National Survey on Drug Use and Health (Center for Behavioral Health Statistics and Quality, 2016). After quantifying fitness of all parameter sets, we selected the parameter set with the best fitness for hypothesis testing (for more details see Web Appendix, page 6).

RESULTS

Baseline model

The outputs of the baseline model demonstrated generative sufficiency for the calibration targets (Figure 3) with the exception of the average quantity of alcohol consumed among female current drinkers, for which the simulation model resulted in higher levels of consumption. Overall, the implemented mechanisms were deemed to have generative sufficiency in reproducing the population observed regularities. See Web Appendix, Table 1 for the baseline parameter set.

Experiment 1 – Decrease in perception bias—The results of experiment 1 in which the perception bias in heavy drinkers was reduced, did not show any meaningful changes in the drinking outcomes (Web Appendix, Figure 1). While the intervention was ineffective on the population level, intervention effects were observed on the individual level. Figure 4 shows two exemplary individuals, both of which are young men and heavy drinkers. With the start of the intervention, the perceived descriptive quantity norm decreased for both individuals. However, given the higher level of autonomy in individual A, only individual B was receptive to the intervention. As a consequence, changes in the number of HED days were observed over time in individual B (an average of 5.0 HED days per month without compared to 4.1 days with the intervention), whereas individual A showed no meaningful change in his behavior (an average of 10.2 HED days per month without vs. 10.3 days with the intervention).

Experiment 2 – Exogenously-triggered reduction in desire to drink—The results of experiment 2 compared to the baseline model are shown in the Web Appendix, Figure 2. The increase in the desire to drink among middle aged men (35 to 54 years) in 1989 led to a strong increase in the frequency and quantity of alcohol use among men. No systematic changes in the quantity or frequency of drinking were observed among women in general nor in women of the same age.

Experiment 3 – Public campaign to discourage alcohol use—The campaign to change injunctive norms regarding alcohol use on the population level lead to small decreases in the prevalence of alcohol use among both genders (Figure 5). Compared to the baseline scenario, the prevalence decreased on average by 2% and 3% after the intervention among men and women, respectively.

DISCUSSION

We present a novel parsimonious theoretical framework and a complete individual-level simulation model integrating the currently available empirical evidence. The simulated normative mechanisms were able to demonstrate generative sufficiency in a simplified setting, i.e., in a synthetic population representing a random sample of the US population and in comparison to evidence based target data. To investigate the usefulness of the simulation for hypothetical policy scenarios, three exemplary 'what-if?' scenarios were investigated in experiments.

Overall, the experiments showed limited influence of normative interventions on population-level alcohol use. An increase in the desire to drink (experiment 2) lead to the most meaningful changes in the population's drinking behavior. The latter can be explained by relatively high levels of autonomy, indicating that norms are merely one of many factors that influence drinking decisions on the individual level. Experiment 1 showed that a higher degree of 'receptiveness' towards normative influence can be considered a prerequisite to behavioral changes due to an intervention to reduce perception bias in the descriptive norm. This is in line with empirical findings showing moderating effects of the level of "self-determination" on the effectiveness of interventions to decrease the perception bias of descriptive norms (Deci & Ryan, 1985; Neighbors, Lewis, Bergstrom, & Larimer, 2006). Experiment 3 targeted the acceptability of alcohol use in general. In the context of the simulation model it was possible to single out effects on prevalence by addressing this component of the injunctive norms in particular. The experiment showed that such a campaign would lead to small decreases in the prevalence of drinking among women in particular.

Strengths and limitations

To our knowledge, this is the first individual-level simulation model to successfully investigate proposed normative *mechanisms*, and the effects of policy-relevant factors. The conceptual model is sufficiently generic to enable adaptation to behaviors besides alcohol use.

A key advantage of the generative approach is that it identifies the mechanisms that support the reasoning process of "what works for whom in what circumstances" used in intervention design (Pawson, 2002). Normative mechanisms that influence alcohol use can also be integrated with other mechanisms (e.g. relating to opportunities to drink, or coping motives driven by stress (Kuntsche, Knibbe, & Gmel, 2009) to provide additional context that can inform the effectiveness of a norm-based intervention.

A limitation of the current model is that includes only age and gender as individual characteristics. Other characteristics such as religion, race/ethnicity, and socioeconomic status are relevant with regard to injunctive norms (Kathol & Sgoutas-Emch, 2017; Meyers, Brown, Grant, & Hasin, 2017; Pedersen, Bakken, & von Soest, 2015). While it is anticipated that these characteristics will be included in future versions of the model, it is important to note that scarcity of empirical evidence on injunctive drinking norms in these subgroups poses a challenge to informing respective priors of the model.

Another limitation of the current model is that the desire to drink is set as constant. Future versions of the model could implement additional mechanisms to model incident alcohol use disorders due to physiological or psychological processes (Koob, 2003) or declines in desire to drink when transitioning into certain social roles (Kuntsche et al., 2009). While such additions may make for a more accurate representation of the 'real world', they would at the same time move away from a clean representation of one particular theory, i.e., the social norms theory.

Conclusions

Future applications of the model may be used to (a) investigate normative dynamics in alcohol use in different sociocultural contexts; (b) help generate quantitative predictions over trends in population-level alcohol use; and (c) help develop analytical procedures for policy analysis of normative interventions and related scenario planning. However, normative dynamics in alcohol use will need to be combined with other individual processes to overcome the limitations of the norms approach, and to better understand the various parameters such as desire and autonomy.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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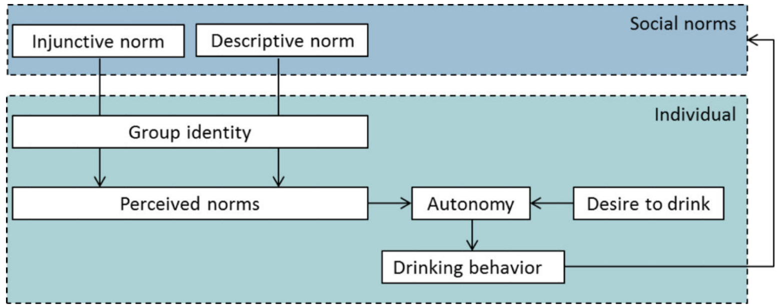

Figure 1.
Conceptual social norms model of health risk behavior on the example of alcohol use.

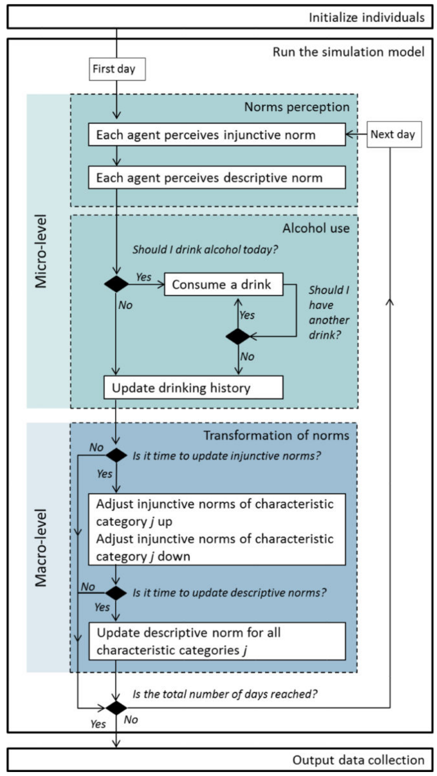

Figure 2.
Flow-chart of simulation model processes, individual-level decision making, and process scheduling.

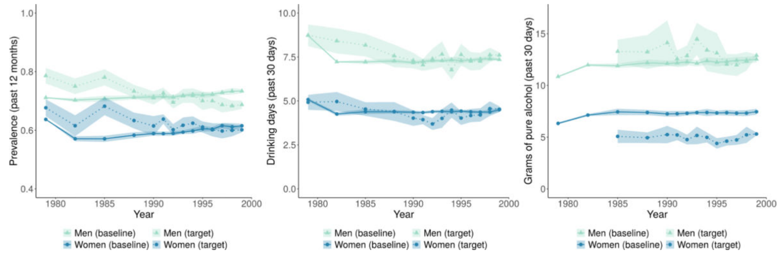

Figure 3.

Calibrated simulation model outputs (baseline model) compared to target data with 95% confidence intervals: prevalence of current drinking in the past 12 months (left); average grams of pure alcohol consumed per day among current drinkers in the past 30 days (middle) and average number of drinking days in the past 30 days among current drinkers (right) by gender. The solid line shows modelled estimates using the baseline parameter set, the dotted line shows target data used for calibration. The shaded range indicates the confidence interval (based on stochastic variation across 10 simulation runs for model outputs).

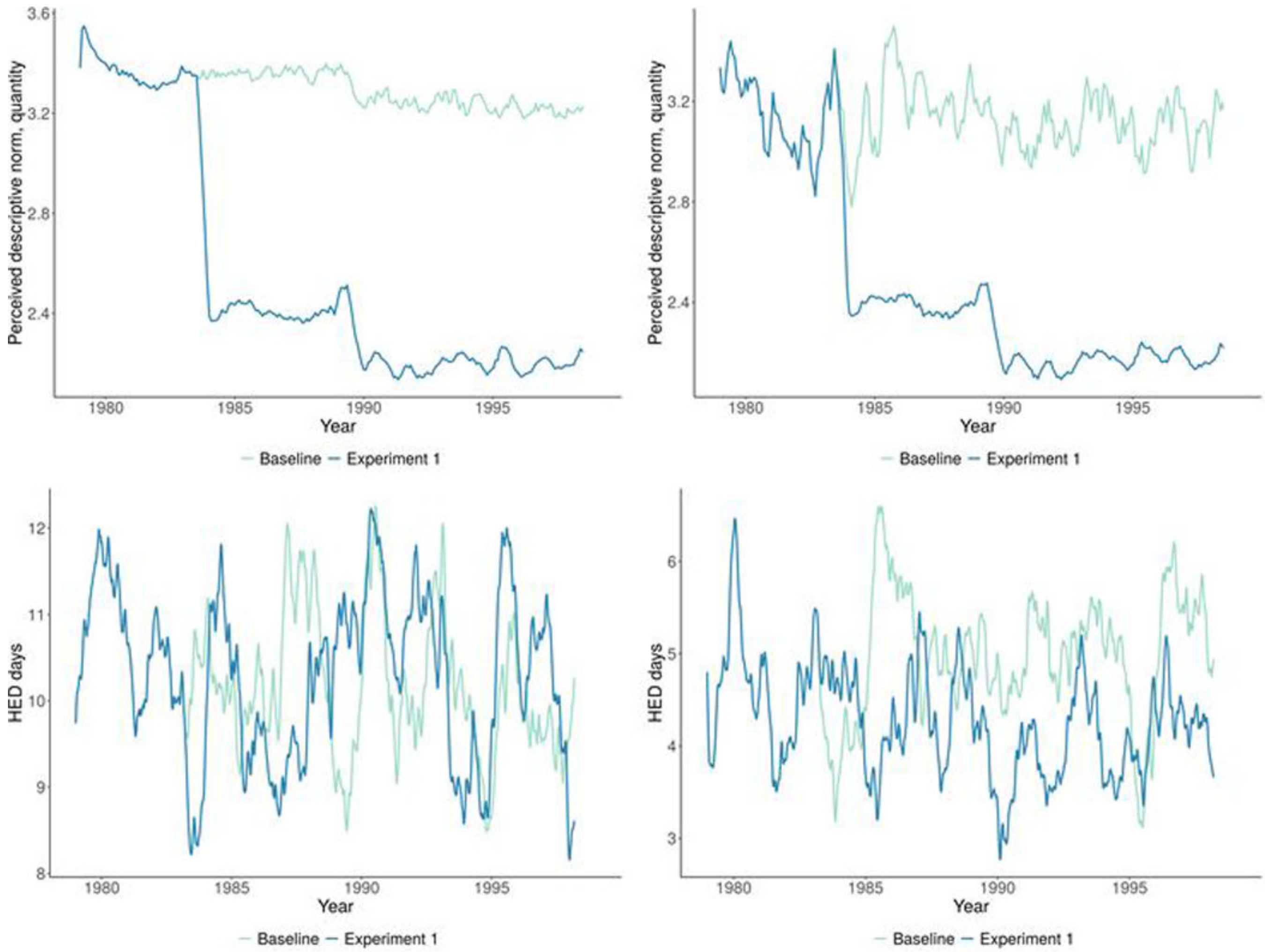

Figure 4.

Perceived descriptive norms on quantity (top row) and the number of heavy episodic drinking days (HED; bottom row) in the past 30 days in two exemplary individuals (young males, heavy drinkers). Individual A (autonomy=0.9) is shown on the left, individual B (autonomy=0.5) is shown on the right. Moving averages were used to smooth outcomes over 90 days. Norms and drinking behavior under the baseline setting and under experiment 1 (starting five years into the simulation) are shown. The latter entailed an intervention directed at heavy drinkers, aiming to decrease the perception bias regarding the level of alcohol use per occasion in relevant others, starting five years into the simulation.

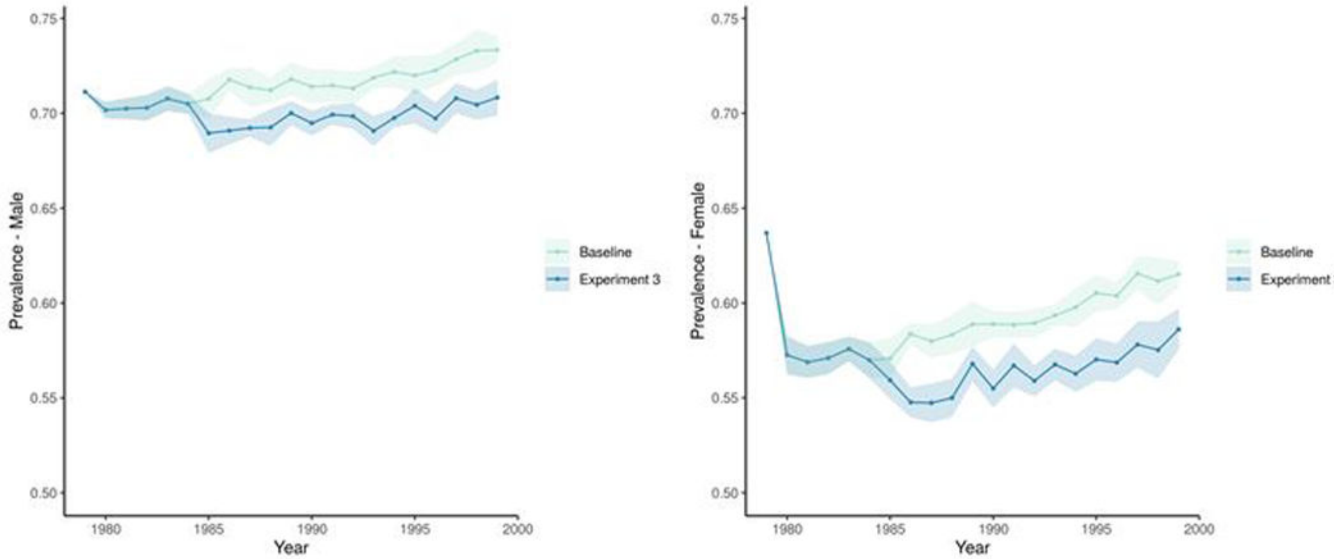

Figure 5.
Prevalence of current drinking in the past 12 months under the baseline setting compared to experiment 3. The latter entailed a public campaign targeting injunctive norms in order to discourage alcohol use, starting five years into the simulation.

Box 1:

Definitions of key modeling and simulation terms

Agent-based/ Individual level simulation model	A computer modeling method in which heterogeneous agents/individuals act (and interact) within a simulated environment according to behavior rules. Individuals, their environment, and their behavior rules are implemented in a computer program, and global population-level phenomena arise from individual actions.
Calibration	The process by which a model's input parameter values are systematically selected using repetitive sampling so that model outputs fit known empirical data.
Generative sufficiency	The ability of a calibrated individual-level simulation model to generate a macroscopic regularity (population-level phenomenon) based on a particular behavior rule set, agent population, and environment. If the behavior rules demonstrate generative sufficiency, then those rules are a candidate explanation for why the population-level phenomenon arises.
Latin hypercube sampling	A method for generating samples from the parameter space of a simulation that aims to provide good coverage of that space given a limited sample budget.
Mechanism (social mechanism)	A hypothetical causal model or behavioral rule that explains a social phenomenon based on actions and interactions of individuals.
Macro-level entity	Entities are the individuals in mechanism-based theories. Macro-level entities are social constructs that impact individuals.
Micro-level entity	Micro-level entities are individuals who may perform actions, often, individual people.
Micro-synthesis	A method to generate a representative synthetic population of a given geography. Iterative proportional fitting is used to make an individual level dataset with demographics and alcohol use behaviour fit the known socio-demographic constraints of a geographical area.
Model fitness	A statistical measure of discrepancy between model outputs and empirical data.
Parameter	A numerical variable used as input to a model, the precise value of which is not known at the outset of a simulation. The values of parameters may be changed in the process of calibration so that model outputs can be fit to empirical data.
Prior distribution	The distribution expressing prior beliefs regarding the model parameter. The distribution is used to repeatedly sample possible parameter values in the calibration process.