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Relationships of policy and place with substance use, alcohol misuse, and other risk behaviors

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RELATIONSHIPS OF POLICY AND PLACE WITH SUBSTANCE USE, ALCOHOL MISUSE, AND OTHER RISK BEHAVIORS

by

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RELATIONSHIPS OF POLICY AND PLACE WITH SUBSTANCE USE, ALCOHOL MISUSE, AND OTHER RISK BEHAVIORS

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ABSTRACT

Substance use has been linked to adverse health and social costs, including morbidity and mortality. Substance use patterns are driven not only by individual-level determinants, but also by social, political and ecological factors. Given this inter-connected web, further exploration into the interactions between individuals and their environments may help inform strategies to intervene and reduce substance use and related risk behaviors. The purpose of this dissertation was to examine the dimensions of place in determining an individual's substance use behaviors.

In the first two studies, we explored the policy dimension of an individual's environment, specifically how the state-level policy environment shapes frequency of alcohol use. We used data from the National Longitudinal Survey of Youth 1997 (NLSY97) cohort, a nationally representative, longitudinal sample of emerging adults.

In the first study, we examined associations between stringency of an individual's state-level policy environment (as measured via the Alcohol Policy Scale, APS) and past 30-day drinking and binge drinking. We found that 10-unit higher (more stringent) APS score at interview was associated with small reductions in past 30-day drinking (-0.03 drinking days, 95% Confidence Interval (CI) -0.17, 0.11) while associations were null for

past 30-day binge drinking (0.004, 95% CI -0.06, 0.06), after adjusting for individual and contextual confounders. Given interest in impacts of policy changes on drinking, we also assessed associations for cross-interview change in APS. The mean interview-to-interview (roughly 1 year) change in APS score was 0.4 (+/- 2.6, range -38.1 to 39.7). In confounder-adjusted models, a 10-unit greater increase in APS change score across an interview interval was associated with -0.15 reduced drinking days (95% CI -0.30, 0.01) while reductions in binge drinking days were smaller (-0.05, 95% CI -0.14, 0.05). For the change in APS analyses, stratification by prior (starting) APS score showed the largest reduction among those in the highest quartile of prior APS (-0.25 drinking days, 95% CI -0.57, 0.07) while those in the lowest quartile of prior APS had the largest reductions in binge drinking (-0.10, 95% CI -0.13, -0.07). Age-based stratification showed the impacts were primarily driven by years when individuals were under age 21 (under legal drinking age).

The second study of this dissertation also used data from the NLSY97 cohort, but focused on alcohol use over time rather than drinking at single time points. Specifically, our second study identified sub-groups of longitudinal drinking patterns—or trajectories—across 18 years of follow-up using latent class growth analysis. We then estimated the association between state-level policy score (APS) at baseline and trajectory group membership. For both the past 30-day drinking and past 30-day binge drinking outcomes, distinct trajectories were identified and described. For drinking days, a 5-group solution was the best fitting model. The 5 drinking-days groups were: late escalating (10.8%), normative (19.0%), high frequency (5.6%), low frequency (47.0%)

and no/infrequent use (17.7%). A 10-unit higher baseline APS score was associated with slightly higher odds of membership in the late escalating group (adjusted Odd Ratio, aOR = 1.13, 95% CI 0.98, 1.31) and reduced odds of membership in the normative group (aOR = 0.94, 95% CI 0.81, 1.10) compared with membership in the no/infrequent group. In a separate trajectory model, we identified 5 binge drinking-days groups: later onset (10.5%), high frequency (4.4%), once-a-month (34.8%), earlier onset (11.3%), and no/infrequent (39.1%). A 10-unit higher baseline APS score was not associated odds of binge drinking group membership compared to the no/infrequent comparator outcome.

For study 2 overall, we found weak associations between state-level APS at approximately age 14 and drinking or binge drinking trajectory membership. However, we also found a consistent, slight decreased odds of membership in the normative drinking days group (compared to both the no/infrequent and low frequency drinking groups) with a more stringent policy environment. Furthermore, sensitivity analyses showed APS score may decrease odds of membership in drinking day trajectory groups typified by earlier initiation of alcohol use.

In study 3, we examined a more granular environmental exposure—the neighborhood environment. Using baseline data from participants in a human immunodeficiency virus (HIV) prevention study who lived in Baltimore, we evaluated the association between neighborhood disorder and substance use behaviors. We compared neighborhood-level disorder at residential address (live/sleep neighborhood) to a more dynamic definition of exposure to neighborhood disorder based on where individuals reported spending their time engaged in specific activities (activity spaces).

Using data from a previously collected Neighborhood Inventory for Environmental Typology (NIfETy) instrument assessment, we calculated objective neighborhood disorder scores for participants (live/sleep scores and activity-weighted scores). While higher live/sleep neighborhood disorder was associated with higher prevalence of self-reported harmful alcohol use, results were imprecise (adjusted prevalence ratio, PR: 1.14, 95% CI 0.94, 1.37). We found a similar directional relationship between live/sleep disorder and injection drug use in the past 6 months (adjusted prevalence ratio: 1.03, 95% CI 0.88, 1.22). The relationship of live/sleep disorder to injection-related risk behaviors (among those who injected drugs in the past 6 months) was inconsistent. Higher live/sleep neighborhood disorder was associated with reduced prevalence of non-alcohol related treatment (among those with a history of drug use; adjusted prevalence ratio: 0.97, 95% CI 0.89, 1.07). Contrary to our hypothesis, there was little variation in results or model fit between the live/sleep and activity-weighted exposures. However, time spent in live/sleep location modified observed relationships for harmful alcohol use and injection drug use. Understanding exposure to factors such as disorder at a micro-space level (both location and time spent at a location) may help explain risk behaviors and identify priorities for intervention.

These three studies highlight state policy and neighborhood as two of the many environmental forces that influence individual substance use behaviors. A better understanding of how state-level policy and neighborhood environments influence behavior is critical to initiatives focused on substance use and related harm reduction. These findings are therefore relevant to policy makers and community advocates at both the state and local-level. These dissertation studies also highlight the complexity inherent in quantifying and assessing the impact of both policy and neighborhood exposures on individuals. Further research is needed to examine critical time periods for the influence of neighborhood and state-level policies on substance use across the life-course.

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LIST OF ABBREVIATIONS

ACASI	Audio computer-assisted self-interview
aOR	Adjusted odds ratio
APS	Alcohol Policy Scale
aRR	Adjusted risk ratio
BIC	Bayesian information criterion
CAPI.	Computer-assisted personal interviewing
C.D.C.	Centers for Disease Control
CES-D.	Center for Epidemiologic Studies depression
CI	Confidence interval
DAG	Directed acyclic graph
D.C.	District of Columbia
ER	Efficacy rating
GEE	General estimating equations
HIV	Human Immunodeficiency Virus
IR	Implementation rating
Max	Maximum
Min	Minimum
NIfETy	Neighborhood inventory for environmental typology
NLSY97	National longitudinal survey of youth 1997 cohort
NSA	Neighborhood statistical area
OR	Odds ratio

PR .... Prevalence ratio

QIC .... Quasi-likelihood under the independence model criterion

SD .... Standard deviation

SE .... Standard error

U.S. .... United States

VAOD .... Violence alcohol and other drugs

CHAPTER 1: INTRODUCTION

Excessive and frequent consumption of alcohol and other drugs increases risk of chronic disease, injury, and pre-mature death.[1,2] As substance use is a leading preventable cause of morbidity and mortality in the United States (U.S.),[1] research is needed to inform strategies to prevent and reduce initiation and frequency of substance use.

Substance use behaviors occur within a social-ecological framework where individuals are influenced by personal, interpersonal, community, societal and political factors.[3,4] As such, an individual's decision-making is highly influenced by daily exposure to a broad range of influences, including their social and physical environments that may have wide-reaching impacts on substance use behaviors. Two aspects of these environments—specifically state-level policies and neighborhood exposures—are explored in this dissertation.

In studies 1 and 2, we explored the policy dimension of the social-ecological model. Specifically, how state-level alcohol policy environment shapes individual-level alcohol use at single time periods (study 1) and over-time (study 2). Prior research has found relationships between specific alcohol policies and a broad range of alcohol-related outcomes in both adolescents and adults,[5] yet, alcohol policies are rarely implemented in isolation. For example, at the state-level, a state may have certain excise taxes (influencing the price of alcohol), minimum drinking age laws, and per se laws in place. As such, an individual will experience multiple alcohol policies at the same time when they consume alcohol. This aggregation of costs and consequences may influence alcohol use frequency more acutely than a single policy. Yet, past research often focused on specific policies omitting the overall alcohol policy environment.[6–11] Fewer studies have explored the role of the overall alcohol policy environment on alcohol use. Studies assessing the role of the collective policy environment have found that more stringent state-level alcohol policies led to lower alcohol consumption and binge drinking among adolescents[12,13] and adults. The current evidence-base focuses primarily on cross-sectional data, limiting individual-level confounder adjustment and exploration of change across time. To begin to address these gaps, study 1 evaluates the association between short-term changes in the alcohol policy environment and recent drinking frequency in a population of adolescents aging into adulthood over 12 years of follow-up. Study 2, identifies alcohol use trajectories as individuals mature from age 12–30 and explored the association between alcohol policy environment in adolescence and trajectory membership.

For the third study, another dimension of environment was considered—the neighborhood environment. The neighborhood context is a critical sphere of influence on individual behavior.[14] One aspect of a neighborhood is neighborhood disorder. Neighborhood disorder is a lack of physical and social control within a neighborhood by neighborhood residents. Neighborhood disorder has been associated with higher alcohol consumption including hazardous alcohol use,[15–21] increased injection frequency and equipment sharing among populations of persons who inject drugs.[22–25] Yet, the majority of studies assign levels of disorder to individuals based on their residential address when in reality individuals may encounter and interact with a variety of locations beyond where they live and sleep. An expanded consideration of opportunities for exposure to neighborhood disorder is warranted. Our third study compared associations between neighborhood disorder and several risk/health-seeking behaviors when one's neighborhood is defined based on (1) residential address, (2) residential address, incorporating time spent in that location and (3) activity-based locations beyond residential address.

The goal of this dissertation was to take an expanded view of the spheres that influence substance use behavior. We focus first on the state-level policy environment's associations with alcohol use frequency (study 1) and alcohol use trajectories (study 2). We then examine the complexity of the lived environment acknowledging a potential for additional exposures beyond residential address (study 3). Additional background and details for each study are included at the beginning of each chapter.

CHAPTER 2: STATE-LEVEL ALCOHOL POLICY ENVIRONMENT AND ALCOHOL USE FREQUENCY

2.1 BACKGROUND

Alcohol use and related consequences represent a major public health problem.[26] Excessive drinking practices cost the U.S. approximately 249 billion annually, including indirect economic costs, such as increased law enforcement, legal system resources, and lost productivity.[27,28] In addition, excessive drinking is estimated to cause over 90,000 pre-mature deaths a year.[26,29]

Emerging and young adulthood—the period between one's late teens and mid-twenties—is a critical life stage marked by many life transitions and milestones, including potentially moving out of childhood homes, entering the workforce, attending college, and developing deeper peer relationships. It is a time of exploration, where young people lay the foundations for their future success. Adolescents and young adults are at increased risk for consequences of alcohol use including both fatal and non-fatal injuries, risky sexual behaviors, and impacts on academic performance.[26,30] Drinking beliefs and behaviors are also established during these critical developmental periods.[31]

Research has consistently shown that people tend to drink heaviest during young adulthood.[32] During this period, individuals are much more likely to binge drink and an estimated 14.5% of young adults report average consumption exceeding the National Institute of Alcohol Abuse and Alcoholism's recommended weekly limits (14 or 7 standard drinks for men and women, respectively).[32] This age group is also at high risk for consequences of heavy drinking, including alcohol-related traffic fatalities and serious injuries related to instances of violence (i.e. suicide, homicide, intimate partner violence). Excessive drinking in adolescence and early adulthood increases risk for alcohol use disorder, and may impede educational attainment and work success[1,33] As such, policies aimed at reducing consumption and binge drinking frequency during adolescence and young adulthood may have a considerable public health impact.

Population-based alcohol policies influence availability (e.g. hours of sale, age restrictions, outlet density, advertising), cost, risk perceptions (e.g. likelihood of arrest), and alcohol consumption norms.[34,35] Prior research has found relationships between specific alcohol policies and a broad range of alcohol-related outcomes.[5,36] While such research has been critical for the evidence-base to inform policy creation and implementation, fewer studies have explored the role of the overall alcohol policy environment on alcohol use. Alcohol policies are rarely implemented in isolation. Instead, when individuals go to purchase or consume alcohol, they are often impacted by multiple alcohol policies at the same time. Individuals may perceive the aggregation of costs and consequences more acutely than a single implemented policy. Yet past research often focused on specific policies omitting the overall alcohol policy environment.[6–11] Collective policy environment studies found reduced alcohol consumption and binge drinking among adolescents[12,13] and adults[35,37,38] residing in states with more stringent alcohol policy environments. Yet, the current evidence-base focused primarily on repeated, cross-sectional data, limiting individual-level confounder adjustment and the potential to study change over time.

Exploring the role of policy environment on individual behavior over time will expand our understanding of how the policy environment contributes to behavior change. Using longitudinal data with repeated alcohol assessment from the same individuals over time offers an opportunity to explore this relationship. Within the U.S., states control and implement the majority of alcohol-related policies. The timing of policy implementation also varies across states. This variation in policy environment across states and time offers a natural experiment for assessing the association between changes in the policy environment over time on reported drinking frequency. Furthermore, individuals may experience policies differently depending on whether they are of legal drinking age. Longitudinal data allow for comparisons of policy environment effects among the same individuals across interviews when they are below and above legal age.[30,39,40]

The following study takes advantage of state-level, temporal variation in alcohol-related policies to investigate the relationship between alcohol policy environment and two alcohol consumption outcomes (past 30-day drinking frequency and past 30-day binge drinking frequency) in a national study of U.S. residents using annual assessments from 1999 to 2011 as they mature from adolescence into adulthood. The study aims were to: (1) describe the association between U.S. state-level alcohol policies and overall frequency of alcohol use and of binge drinking and (2) explore whether being of legal drinking age modifies policy-alcohol consumption associations. We hypothesized that those experiencing a stricter policy environment at interview (compared to those in less strict policy environment) would have lower past 30-day alcohol consumption and past 30-day binge drinking frequency. We further hypothesized that when we looked at change in policy score across interview intervals, those experiencing an annual increase in the strictness of the state-level policy environment would have lower past 30-day alcohol consumption frequency and past 30-day binge drinking frequency at follow-up interview. Finally, we hypothesized that the identified associations would be more pronounced when individuals were under age 21, compared to when they were 21 and older.

2.2 METHODS

2.2.1 Data sources: National Longitudinal Survey of Youth 1997

The National Longitudinal Survey of Youth, 1997 (NLSY97) is a nationally representative prospective cohort of 8,984 adolescents living in the U.S. Adolescents were age 12–16 at baseline (as of December 31, 1996). The NLSY97 was created by the Bureau of Labor and Statistics to understand the transition into the labor market and role of socioeconomic factors on major life events and behaviors, including substance use.[41]

Recruitment procedures have been described previously.[41] In brief, potential respondents were identified using stratified geographic probability sampling to ensure demographic representation (race, income, region), with an oversample of Black and Hispanic/Latinx respondents.[41] Eligible participants were born between 1980 and 1984 and resided primarily at the identified address for six months or more.[41] There were no additional eligibility criteria.

Participating adolescents were followed annually through 2011 and are currently followed biannually, with retention rates of 93% for first follow-up and 79–85% through subsequent follow-ups.[41] During interviews, trained field interviewers administered questionnaires in English or Spanish (as preferred) to participants via a validated computer-assisted personal interview instrument.[41] Prior to participants becoming head of their own households, supplemental interviews were conducted with the head-of-household for additional economic and household information. Incentives were offered for interview completion ($10–$20 depending on survey wave).[41]

As we were interested in short-term impacts of policy (both current policy and cross-interview changes in policy) on current drinking, we used a repeated measures framework where the time-scale was an interview interval (approximately 1 year). Each individual could contribute multiple observation periods as long as they were present for the interview prior (start-of-interval, time t-1) and the interview where the outcome was assessed (end-of-interval, time t). We further outline the timings and definitions for the exposures and outcomes of interest in section 2.2.3.

2.2.2 Data sources: State-Level Exposure Information

The Alcohol Policy Scale (APS) was previously developed by Naimi and colleagues to measure the U.S. state-level alcohol policy environment from 1999 to 2014.[35] The scale includes annual assessments of efficacy and implementation of 29 alcohol-related policies for all 50 states and Washington, DC (Appendix Table A2.1). Policies were identified for inclusion via the National Institute on Alcohol Abuse and Alcoholism's Alcohol Policy Information System and other data sources.[35,42] Full details on development and policy coding were previously published.[35,36] In brief, standardized and ideal descriptions of each policy were developed. Ten policy experts with relevant disciplinary specialties (e.g., law, economics, epidemiology) then independently assessed efficacy and level of implementation for each policy, within each state, for each available year.[35]

Efficacy ratings (ER) were given for four different domains of interest. Specifically, policy experts independently rated how effective on a 5-point Likert scale (1=low efficacy, 5=high efficacy) each of the 29 policies was for (1) reducing binge drinking among the general population, (2) reducing impaired driving among the general population, (3) reducing binge drinking among underage youth, and (4) reducing impaired driving among underage youth.[36] Within each domain, the mean of the panelist ratings for each policy was compiled after group discussion. For the purpose of this study, efficacy ratings for ability to reduce binge drinking among the general population (domain 1) and reduce binge drinking among youth (domain 3) were used in APS score calculations.

In addition, legislative implementation ratings for each policy were developed based on the characteristics and statutory design of a particular policy including whether or not provisions were present that would enable the particular policy to be effective, broadly applicable, and easy to enforce.[35,37] Implementation scores ranged from 0.0 (no policy present for the state in the given year) up to 1.0 (full implementation of the policy for the given state and year). Implementation scoring criteria were consistent across years and domains, but scores were allowed to vary by state and by year.

Efficacy and implementation ratings were then scored and aggregated to create two separate APS scores each with a range of 0–100 representing the stringency of the policy environment for each state in a given year: one APS score incorporated the efficacy rating for youth binge drinking—herein called “youth APS”; and the second used the efficacy rating for general population binge drinking—herein called "general population APS." This scoring and aggregation technique has been used and described in prior publications.[35,37] First, efficacy ratings were rescaled to create a maximum possible value of 1 ([ER – 1]/ 4). This re-scaled efficacy rating was then multiplied by the implementation rating. The efficacy-implementation products for each of the 29 policies were then summed to have an overall index score for each state-year:

$$APS\ Score_{state-year} = \sum_{policy=1}^{29\ policies} (ER \times IR_{state-year})$$

APS = Alcohol Policy Score for a given state and year, ER = efficacy rating for the given policy, IR = implementation rating for the policy in the given state and year

For ease of interpretation, each raw APS score was then rescaled to a theoretical range of 0–100 by dividing by the maximum possible score and multiplying by 100. Higher scores for the two APS scores (one incorporating the youth ER and one the general population ER) represent stricter alcohol policy environment within a state for the given year. The APS has been previously validated in similar populations and age groups.[35,37,43]

2.2.3 Study Variables

Exposure – Alcohol Policy Scale definitions:

- **Current year APS score (APS_t):** Individuals in the NLSY97 cohort were assigned APS scores for each year based on their state of residence at the time of interview. As aforementioned, two versions of APS score were examined: the APS score reflecting efficacy of the 29 policies to reduce binge drinking among underage youth (youth APS) and APS score reflecting efficacy of the 29 policies to reduce binge drinking among the general population (general population APS).

- **Across-interview change in participant's state APS score (**ΔAPS_t**):** We then constructed an exposure representing change in APS score across interview intervals, by subtracting current (end-of-interval, APS_t) score from prior (start-of-interval, APS_{t-1}) score. Specifically, we conceptualized that APS at the end of an interval was a combination of the policy at the prior interval plus the change across the interval ($APS_t = APS_{t-1} + \Delta APS_t$). Therefore, $\Delta APS_t = APS_t - APS_{t-1}$ such that an increase in APS across interviews was a positive value while reductions were negative.

Moderator – Legal drinking age at follow-up interview (time t): Birth and interview dates were used to construct a dichotomous (yes/no) variable indicating whether the participant was 21 or older at the interview where the outcome was assessed.

Outcomes – Alcohol Consumption at follow-up interview (time t): Two separate alcohol consumption outcomes were used:

- **Alcohol consumption frequency:** Participants were asked at each interview: "During the past 30 days, on how many days did you have one or more drinks of an alcoholic beverage?" Self-reported past 30-day frequency of drinking alcohol (range 0–30 days) was used as a marker of habitual usage.
- **Binge drinking frequency:** Binge drinking is a leading cause of alcohol-related consequences, and reducing binge drinking prevalence is a Healthy People 2030

goal.[44] To assess binge drinking frequency, participants were asked at each interview "On how many days did you have five or more drinks on the same occasion during the past 30 days? By occasion we mean at the same time or within hours of each other." Self-reported past 30-day frequency of binge drinking (range 0–30) was used to assess high-risk drinking behavior.

Covariates: Potential start-of-interval individual-level confounders for inclusion based on the literature available in the NLSY97 cohort were: age (continuous), gender (male/female), race (categorical: white; Black/African American; American Indian, Eskimo, Aleut; Asian, Pacific Islander; other, don't know, refused), Hispanic ethnicity (yes/no), living in an urban area (yes/no), Census region (categorical: Northeast, North Central, South, West), household size (continuous), parent/guardian education (whether at least one parent/guardian completed high school: yes/no), parent/guardian religiosity (yes/no, based off scored responses from a variety of questions asked of parent/guardians about importance of religion; those scoring 500 or higher out of a possible 600 on the index were considered very religious; those missing the index were coded as not very religious), total income (total annual cash receipts from all sources prior to taxes for the household 1997–2003, for family rounds 2004 interviews and later), and family poverty ratio (ratio comparing total income to the federal poverty threshold accounting for number of household residents and number of residents under age 18).[12] The top 2% for both income and family poverty ratio are top-coded to the average within this 98th percentile.

2.2.4 Statistical Analyses:

We first generated descriptive statistics for the exposures, outcomes, and covariates of interest for both the baseline analytic interval (1999–2000) and across all follow-up intervals. In order to account for the repeated measurement of individuals across survey years, we used generalized estimating equations (GEE) modeling with a negative binomial distribution and an identity link. We estimated a series of separate GEE models to assess the association between each of the continuous APS definitions (current APS and cross-interview change in APS) and our two drinking outcomes. Specifically, we estimated:

1. The effect of the current policy environment (APS_t) on past 30-day drinking outcome at interview (D_t). The target estimand was the mean difference in current drinking frequency per 10-unit higher current APS. We assessed this for each of the two APS scores—youth efficacy and general population efficacy APS—in relation to each of the two alcohol use outcomes—past 30-day drinking days and past 30-day binge drinking days.
2. The effect of change in policy environment across interviews ($\Delta APS = APS_t - APS_{t-1}$) on past 30-day drinking at follow-up interview (D_t). The target estimand was the mean difference in current drinking frequency per 10-unit greater increase in APS change. We assessed this for each of the four exposure-outcome contrasts outlined in the prior paragraph.

We assessed individual baseline and time-varying covariates as potential confounders. A directed acyclic graph (DAG) was used to illustrate initial assumptions about relations between exposure, outcome, and covariates to identify potential confounders for adjustment. Final inclusion was further contingent upon the potential confounder's association with exposure, outcome, and its influence on the APS-outcome association. Final, parsimonious models accounting for confounding were constructed based off the confounder evaluations. We present age-adjusted, baseline confounder adjusted, and fully adjusted (baseline and lagged time-varying confounders) models. Across models, we looked at the impact of a 10-unit change in exposure (a metric used in prior published literature on APS[12,37]). For all models, robust standard errors (accounting for repeated measures of individuals across interview years as well as clustering within states) and corresponding 95% confidence intervals were computed.

For both the current and change in policy analyses, we examined the role of policy at start-of-interval (APS_{t-1}; also called prior interview APS) on observed associations with drinking frequency. First, we examined correlations between prior APS and current APS and prior APS and change in APS. Next, we evaluated modification of observed current APS and change APS associations with drinking frequency stratified by prior APS quartile.

We next assessed differential effects of policy score by legal drinking age with models stratified by whether the individual was of legal drinking age at interview. In sensitivity analyses, we explored dichotomous outcomes of any drinking (>0 days) and any binge drinking (>0 days) as these were commonly used outcomes in prior APS analyses. In additional sensitivity analyses, we examined the impact of our decision to use a continuous change score (which can be both positive and negative) by assessing a three-level categorical variable of change in APS (increasing, stable, decreasing) and associations with drinking outcomes. In separate sensitivity analyses we removed those who never drank across the interval. In addition, we explored the proportion of participants who experienced a change in APS score due to moving states across intervals, as compared with those who experienced changes staying within the same state across intervals and examined the robustness of the main results subject to these uncertainties.

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2.3 RESULTS

2.3.1 Analytic sample description

Of the 8,984 individuals interviewed in 1997, 7,779 were interviewed in both 1999 and 2000 (our analytic baseline interval). Of these, 7,660 had information on state-of residence and alcohol use at both the 1999 and 2000 interviews. This formed the sample for the interview interval analyses. Specifically, any additional interview intervals (roughly one year) where an individual had information on state of residence at the start (time t-1) and end (time t) of the interview interval as well as information on alcohol use at time t were included in the sample. This led to 78,584 intervals for analysis contributed by the 7,660 individuals—roughly 10.3 observations contributed per-person out of a possible 12 years of follow-up (sample flow diagram, Figure 2.1).

In 1999, respondents were 16.9 years of age (range: 14–20; median: 17; intra-quartile range: 2). Approximately 50% of individuals were female, the majority identified as white, and 21% of participants identified as Hispanic (Table 2.1). Over a third of individuals lived in the Southern Census region at baseline (38.1%), with a little under a quarter from North Central (22.3%) and West regions (22.5%). The majority lived in an urban rather than a rural area in 1999 (75.6%). Respondent households included 4 individuals on average. Among those with income data, average household income was $48,965. The average poverty ratio was 3.0 and approximately three quarters of individuals had at least one parent/guardian who completed high school. In 1999, less than a quarter had completed high school or GED equivalent—reflecting the age range at baseline.

We next compared analytic baseline interval (1999–2000) demographics by whether the individual had an APS score above or below the median in 2000. Individuals living in states with APS scores at or above the median were more likely to be Black/African American (32.0% versus 22.6%), less likely to identify as Hispanic (10.3% versus 29.1%), more likely to live in a rural area (30.7% versus 19.7%) and have parents who completed high school (80.7% versus 73.1%), and tended to have higher household income (Table 2.1).

Across the 12 years of follow-up, age at start of interval ranged from 14–31 with an average age of 22.2 (median: 22; intra-quartile range: 6). The interview interval sample had similar distributions to the baseline sample across gender, race, Census region, urban-rural status, Hispanic ethnicity, and parental characteristics (Table 2.1).

Household size across follow-up tended to be smaller (3.6 versus 4.3 at baseline), while income and poverty ratio were higher across follow-up compared to baseline. In addition, most of the interview intervals reflected time periods where individuals had completed high school at the start of the interval (60.4%) followed by less than high school (25.8%) and completion of an Associates/Bachelor's degree or higher (12.7%). When looking at intervals where an individual experienced an increase in APS score across the interval (versus stable or decreasing), they were slightly younger and more likely to reside in Northeast (23.0% versus 15.6%) or South (51.6% versus 38.4%).

During their 2000 interviews (end of first interval), respondents reported an average of 2.5 drinking and 1.2 binge drinking days in the past 30 days (Table 2.1). Roughly a quarter of individuals reported drinking prior to age 13, and 4% never reported drinking across follow-up. In the interview interval sample, individuals average 4.1 drinking days and 1.5 binge drinking days. There were no variations in alcohol use characteristics by APS score category.

2.3.2 State-level policy variation

Youth binge drinking APS score at interview across the 12 years of follow-up was 41.7 on average (range 24.1–72.1; Table 2.2). Past interview youth-oriented APS score was similar but slightly lower and the average difference across interview periods was 0.4 with a range from -38.1 to +39.7. APS score for general population binge drinking was similar but slightly lower than the youth-oriented score. Across both score versions, APS tended to increase across years from 2000–2011 while change in APS across intervals showed less of a trend across time (Figures 2.2 and 2.3, respectively).

2.3.3 Associations between current APS (APS_t) and current alcohol use frequency

In age-adjusted models, a 10-unit higher youth binge drinking APS score (end-of-interval score, APS_t) was associated with a small decrease in drinking days in the past 30 days (-0.03 drinking days, 95% CI -0.14, 0.08; Table 2.3). Additional adjustment for baseline confounders (Hispanic ethnicity, gender, race, and parent completing high school) and time-varying educational status and census region yielded similar results -0.03 (95% CI -0.17, 0.11). Results for general population binge drinking APS score were closer to null (Table 2.3).

No association between current year APS score and the harmful use outcome—binge drinking days in the past 30 days—was found after confounder adjustment. Specifically, a 10-unit higher current youth binge drinking APS score added 0.004 binge drinking days in the adjusted model (95% CI: -0.06, 0.06; Table 2.3). APS incorporating the general population binge drinking rating results were similar to those for the youth binge drinking score.

2.3.4 Associations current APS (APS_t) and alcohol use frequency by prior interview APS (APS_{t-1})

Based on our assumptions about the associations between policy scores over time and relationships to drinking, prior year APS was a potential confounder of the current APS and alcohol use frequency associations. However, our analyses of the association between prior year APS and current drinking (Appendix Table A2.2) showed no association between prior year APS and current drinking frequency or binge drinking frequency. There was however a strong correlation between prior year APS and current

APS, and examining correlations between prior year APS and change in APS across intervals suggested that prior APS may play a role in determining current APS and magnitude of cross-interval change in APS (Appendix Figures A2.1–A2.3).

Based off these initial assessments we determined there could be variations in current APS and drinking frequency associations by prior interview APS. In the youth APS analyses, we found variations by prior APS quartile (Table 2.4). Specifically, within the 50th–75th prior APS percentile, higher current APS was associated with increases in drinking days. Conversely, the highest and lowest quartiles experienced reductions in drinking with higher APS. Results for the general population drinking APS were inconsistent (Appendix Table A2.3). For the binge drinking outcome where the overall association with APS was null, we again found a positive association between higher current APS and binge drinking days for the 50th–75th percentile of prior APS. Additionally, a decrease in binge drinking days with higher current APS we observed for the bottom 25th quartile of prior APS. Results were consistent for the general population drinking APS (Appendix Table A2.3).

2.3.5 Associations between change in APS since prior interview (ΔAPS) and current measures of alcohol use frequency

We next examined whether recent APS change was associated with drinking day frequency at follow-up interview. A 10-unit greater interview-to-interview increase in youth efficacy APS score was associated with a -0.15 reduction in drinking days (95% CI: -0.30, 0.01; Table 2.5) after adjustment for baseline and time-varying factors. Additional adjustment for start-of-interval policy score did not alter the results. Results for the general population efficacy APS were similar to the youth efficacy APS results.

For the binge drinking outcome, a 10-unit increase in the change in APS score was associated with a 0.05 reduction in binge drinking days (-0.05 binge drinking days, 95% CI: -0.14, 0.05; Table 2.5), and results were again similar with additional adjustment for prior interview APS. The general population binge drinking APS score yielded similar results to the youth APS score.

2.3.6 Associations between change in APS (ΔAPS) and alcohol use frequency by prior interview APS (APS_{t-1})

We also explored associations by start-of-interval policy score. The scatterplot of change in APS by start-of-interval APS suggested the magnitude of change in score varied by starting APS (Appendix Figure A2.3). In stratified analyses, the APS change and drinking frequency outcome results were directionally consistent across start-of-interval APS quartiles with the highest APS quartile (75th percentile and above) seeing the largest reductions (Table 2.6). Results were fairly consistent when looking at the general population APS score (Appendix Table A2.4).

For the binge drinking outcome, we saw slightly different results. The overall weak, negative association between change in APS and binge drinking appeared to be driven by those from lower starting quartiles—in particular the bottom 25th percentile. While results may be sensitive to positivity assumption violations at the extremes of the distribution, it is also possible that there is a threshold for when change can impact binge drinking and that the greatest benefits could be seen among less stringent starting policy environments. When examining the general population binge drinking version of the APS score, both the lowest and highest prior APS quartiles saw reductions in binge drinking with higher APS (Appendix Table A2.4).

2.3.7 Effect modification by legal drinking status

Models exploring the association between legal drinking age at interview (age 21 at time t) showed that being of legal drinking age was independently associated with a roughly 1-day increase in drinking days (0.97, 95% CI 0.82, 1.11; Appendix Table A2.5) and a 0.25 binge drinking day increase (95% CI 0.18, 0.33).

In analyses stratified by legal drinking age, legal drinking age modified the associations for the change in youth APS score exposure (Table 2.7). More specifically, for those intervals where the individual was over age 21 at follow-up, a 10-unit greater increase in change in APS score was associated with a small reduction in drinking days (-0.05 drinking days, 95% CI -0.25, 0.15). For those intervals where individuals were under 21, there was a larger reduction in drinking days (-0.15, 95% CI -0.40, 0.09). A similar pattern was seen for binge drinking days where the change in APS score effect was driven by those under age 21 (-0.13 binge drinking days with a 10-unit greater increase in APS score change, 95% CI -0.15, -0.10). There was little effect measure modification by legal drinking age when examining current year APS score. Results for the general population binge drinking score were similar to the youth APS score (Appendix Table A2.6)

2.3.8 Sensitivity analyses

In sensitivity analyses, we examined dichotomous drinking and binge drinking outcomes (any drinking and any binge drinking in the past 30 days, respectively) via log binomial models. These dichotomous outcomes have been used in prior APS analyses. In fully adjusted models, a 10-unit higher current youth APS score was not associated with past 30-day drinking (adjusted risk ratio (aRR) 0.99, 95% CI 0.94, 1.03; Appendix Table A2.7) or past 30-day binge drinking (aRR 0.98, 95% CI 0.95, 1.01). Results were similar for the APS score incorporating general population binge drinking efficacy and for the APS change score exposure.

For the main change in APS score analyses, we had explored APS change as a continuous variable. Yet it could be that it is the overall directionality of change that is critical for drinking behavior. As such, in a sensitivity analysis, we constructed a 3-level categorical variable: decreasing (a greater than 1 standard deviation decrease in score across the interval), increasing (a 1 standard deviation or larger increase in score across interval), and stable (a less than 1 standard deviation increase or decrease across the interval). Those experiencing a decrease across the interval (compared to stable) increased drinking days by 0.27 days on average (95% CI -0.03, 0.57; Appendix Table A2.8). There was also a small increase among those with an increase in APS (compared to stable; 0.06 drinking days 95% CI -0.08, 0.19). Results for the general population APS were similar but slightly attenuated. For the binge drinking outcome, results were null (Appendix Table A2.8). Results were again consistent when examining the general population APS.

Four percent of participants never reported drinking over the follow-up period. It is possible that a "never drinker" is less impacted by the policy environment. In a sensitivity analyses, we removed intervals contributed by "never drinkers" for a sample of 75,398. Removal did not substantially alter results (Appendix Table A2.9).

Finally, we evaluated the impact of whether the resulting change in APS score across an interval was the result of a move versus a within-state shift in APS score. Of the 78,584 interview intervals, 3,957 of these were intervals where an individual moved states between interviews. In moving intervals (versus non-moving intervals), individuals were similar in age on average (22.6 versus 22.1), but tended to have smaller households (2.9 versus 3.6 members on average), drank roughly one additional day on average (5.0 versus 4.1 drinking days), and binge drank slightly more frequently (1.6 versus 1.5). Movers were also less likely to be Hispanic (14.3% versus 21.2%), more likely to be white (66.3% versus 58.1%), and have completed college (26.0% versus 14.5%). Other demographics were roughly similar across groups. While imprecise, stratified results suggested that among intervals where an individual moved states, the reduction in drinking frequency from a change in APS was more pronounced compared to intervals where individuals stayed within the same state (Appendix Table A2.10).

2.4 DISCUSSION

This study assessed the associations between state-level alcohol policy and two different aspects of alcohol consumption among a population of adolescents transitioning into adulthood across roughly 12 years of annual interviews. We found little evidence of an association between current policy environment and past 30-day drinking or binge drinking. We next examined change in alcohol policy environment across an interview interval (roughly 1 year) and the resulting drinking frequency. An increase in APS score between interviews was associated with a small decrease in drinking days at the end of the interval, and a smaller decrease in binge drinking. Across analyses, results were typically similar across the youth and general population binge drinking versions of the APS score. Stratification by legal drinking age at interview suggest results were largely driven by policy impacts on underage drinkers. While effect sizes are small and reductions may not be clinically relevant, these findings add to the literature on the role of the policy environment as a collective socio-contextual determinant of drinking throughout adolescence and young adulthood.

The current study adds to the growing literature on the alcohol policy environment in several ways. In the U.S., prior analyses using the APS have found higher APS scores were associated with reductions in youth drinking and youth binge drinking, as well as adult drinking prevalence.[12,35,37,45,46] Another policy environment score, Alcohol Policy Index, was associated with per capita alcohol consumption in 30 countries[47] as well as national youth drinking prevalence.[48] Another international study found that increased price and alcohol controls were associated with a lower prevalence of weekly drinking, but a higher prevalence of drunkenness[49]—suggesting the two drinking outcomes had different associations with policy. These prior policy environment studies used repeated cross-sectional surveys, or aggregated panel survey data. In addition, many studies focused on dichotomous outcomes (any drinking or any binge drinking) rather than drinking frequency. These differences may explain variations in the current results from prior work. However, when we examined APS association with binary drinking and binge drinking outcomes in our sensitivity analyses, we found little evidence of an effect. As such, the choice of outcome may not explain the variation in findings.

This study also attempted to evaluate the impact of changes in state-level alcohol policy environment on drinking behaviors—in this case, over approximately 1 year. To our knowledge, no studies using APS have thus far examined change in APS as a predictor of alcohol use. We found that those who experienced increases in APS across interviews had slightly lower past 30-day drinking and binge drinking at follow-up. While effect sizes were small (fraction of a day per month) and analyses of change are complex and further work is needed, these initial results emphasize potential gains in harm reduction with increasing stringency of the policy environment. Our sensitivity analyses looking at a categorized change score (decreasing, stable, increasing) further suggested that decreases in the stringency of the policy environment could lead to higher drinking at follow-up. Considering the removal of certain policy restrictions that have occurred during the COVID-19 pandemic, future research should examine impacts on drinking and related behaviors when policies are removed and the overall policy environment is weakened.

Our findings related to the role of prior policy on opportunity for change in APS are another contribution to the literature. We first stratified the current policy and drinking frequency results by policy score at prior interview. For past 30-day drinking, we found higher reduction in drinking from higher current APS within the majority of the prior APS quartiles with the exception of one of the middle quartiles encompassing the 50^{th}–75^{th} percentiles of prior APS score. The stratified results likely reflect confounding by prior APS but may also suggest fewer benefits from policy improvement among this middle quartile of prior APS. The binge drinking results within prior APS quartiles varied from the directionality seen in the drinking frequency results with results suggesting greatest benefits from higher APS among the lowest quartile of prior APS.

For change score, we again stratified our findings by prior policy score. For the association between change and past 30-day drinking frequency, the results were overall consistent across start-of-interval APS quartiles with the largest reductions in drinking occurring within the highest prior APS quartile (75th percentile and above). For the binge drinking outcome, the lowest quartile of policy scores at prior interview experienced the greatest benefits from policy score change on binge drinking. While results may be sensitive to positivity assumption violations at the extremes of the distribution, it is also possible that there is a slight threshold for how change can impact binge drinking and that the greatest benefits could be seen among less stringent starting policy environments.

Using an index to estimate the stringency of the policy environment has several advancements over the literature examining policies in isolation. Most importantly it acknowledges the complexity inherent in the policy environment where multiple policies may be implemented at a given time period. The APS in particular is also able to incorporate the current evidence-base on efficacy and implementation across a range of alcohol policies. On an advocacy level, having a broader discussion about the stringency of an alcohol policy environment may have benefits for communication with policy makers and allow for flexibility in which and how many policies may be implemented. Furthermore, it could provide justification for protecting policies already in place.

However, the use of an index raises several methodological challenges and limitations. First, there are multiple ways that a state's APS score could increase. For example, a state could implement a particularly effective policy or multiple weaker policies to come to the same score. This also raises concerns about the consistency assumption wherein different policies (though they result in the same score) could lead to different outcomes among individuals.[50] In addition, while the APS accounted for efficacy of policies, it could be that only certain policies influence drinking levels and if these policies were present across many states (even when APS scores differ), there wouldn't be variations in effects by APS. Another limitation is that while the index acknowledges multiple policies may be in place, the policies are not given any interaction and have limited additive capabilities built into the score. As such, we cannot explore whether certain policies strengthen or weaken others (i.e., do wholesale price restrictions work best when combined with higher taxes?). In spite of these limitations, the use of a policy index adds to the literature, which has largely ignored the overall policy environment. Indices such as the APS compliment research exploring the impact of specific policies.

This study has several additional limitations. First, we assumed no time-dependent confounding by any of the confounders and also assumed no feedback loop between drinking and future state of residence (and thus policy score). Alcohol consumption can impact employment, family relationships, and other important factors that may influence staying or moving over time.[51] While moving in and out of states was not common across follow-up, future research should explore and quantify this potential self-selection concern, particularly given some of the demographic and alcohol consumption differences we found between intervals where individuals moved versus those where individuals stayed. In addition, the current study attempted across analyses to account for individual and parental-level confounders, however there may be residual confounding from unmeasured confounders. In particular, we had no information on peer networks or social norms around drinking which may influence individual drinking and be shaped by state or region of residence. Another limitation is the outcomes used in this study were self-reported and thus susceptible to recall and underreporting issues. In addition, the measures were limited to a past 30-day time-scale which may not reflect the respondent's typical drinking frequency. Finally, since we focused on state-level alcohol policy, we cannot address policies implemented at the Federal or local level.

In conclusion, the policy environment—specifically changes in the state-level policy environment—play a role in current drinking levels. While the effect size may seem minor, small reductions over the critical developmental time period from adolescence into early adulthood may have benefits for the physical and mental health of individuals. Future research directions should investigate how policy may have differential impacts throughout these life stages, and also whether these policy effects work directly on the individual or through other pathways, such as by impacting social norms and overall drinking prevalence within the state.

2.5 FIGURES AND TABLES

Figure 2.1. Sample flow diagram.

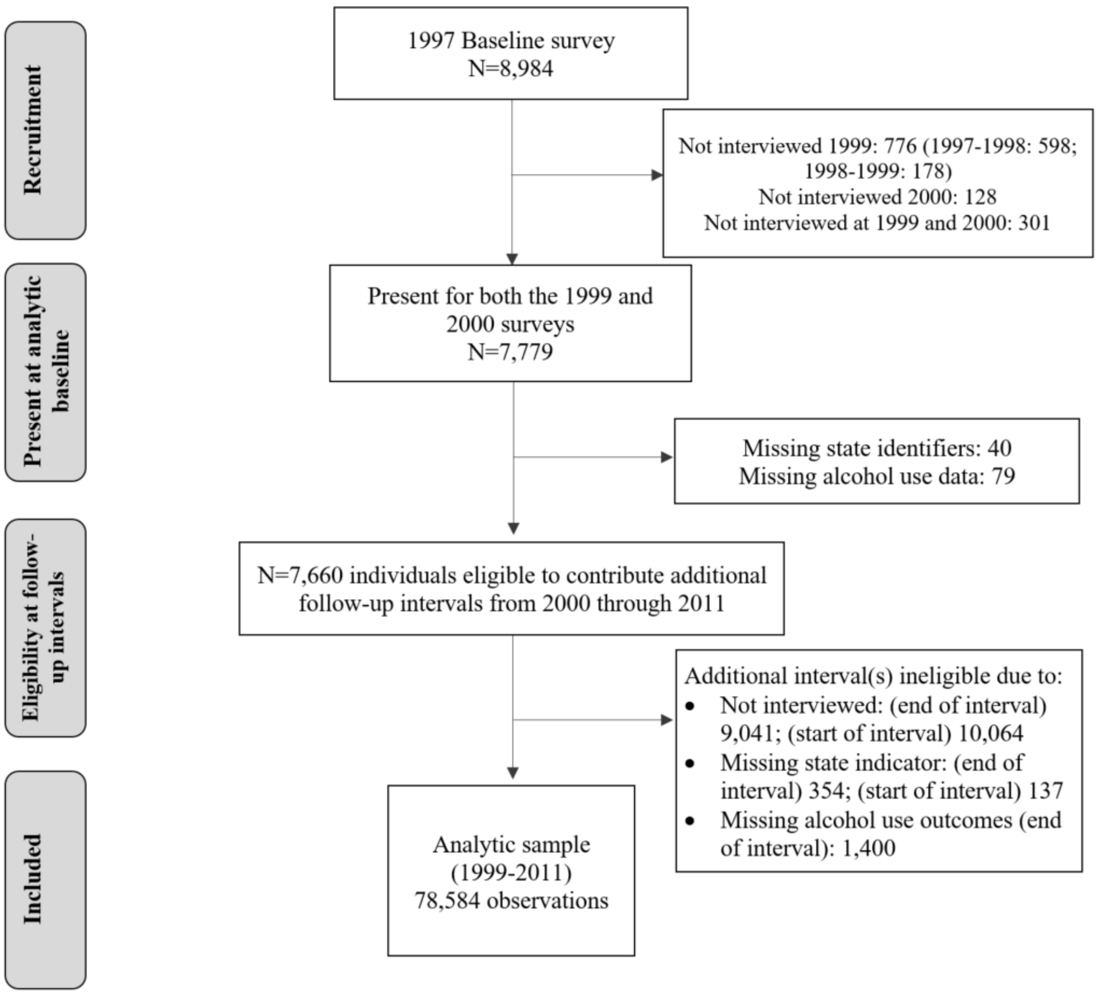
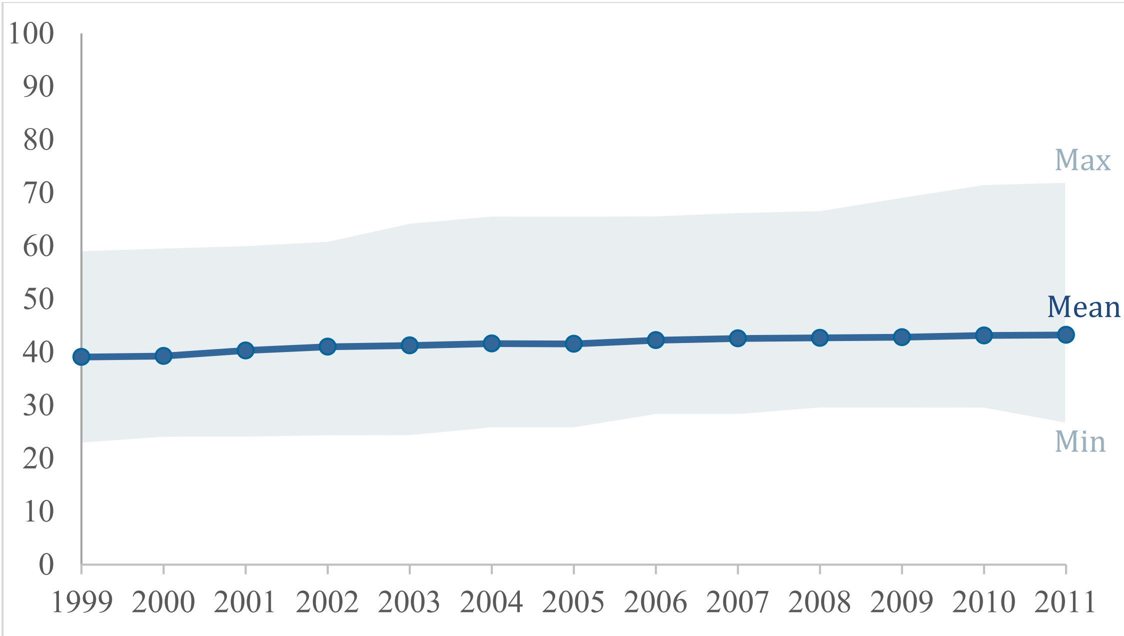
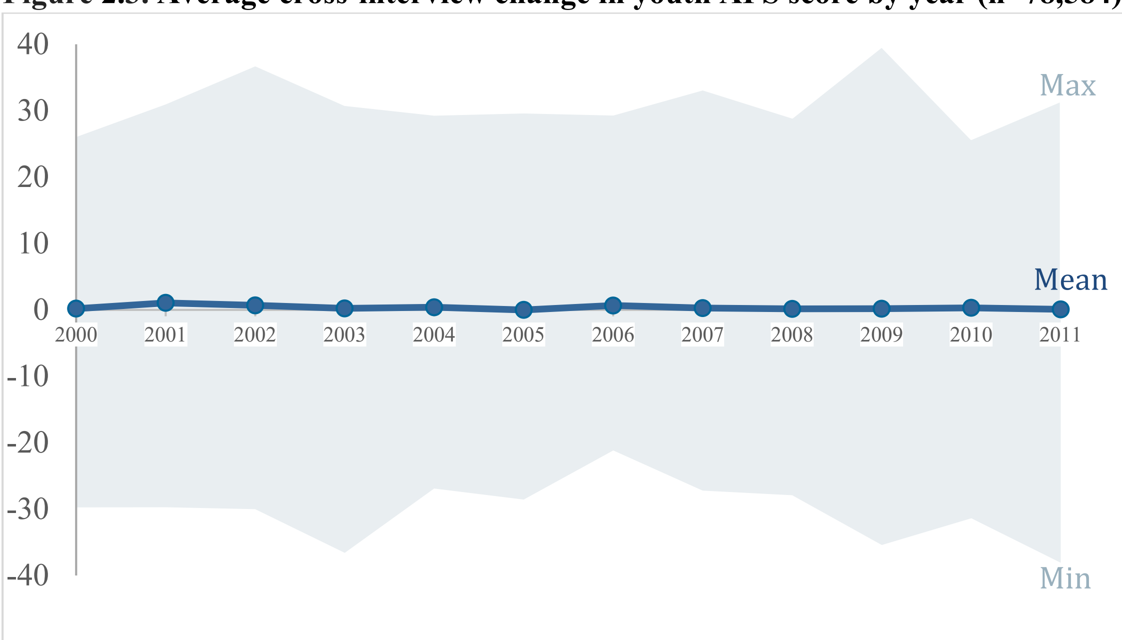


Figure 2.2. Average youth APS score by year (n=78,584)



Note: Youth APS incorporates the youth binge drinking efficacy rating. The general population APS (focusing instead on the efficacy rating for reducing general population binge drinking) average and range not shown as the values across the two APS versions are very similar

Figure 2.3. Average cross-interview change in youth APS score by year (n=78,584)



Note: Youth APS incorporates the youth binge drinking efficacy rating. The general population APS (focusing instead on the efficacy rating for reducing general population binge drinking) average and range not shown as the values across the two APS versions are very similar

Table 2.1. **Start-of-interval demographic characteristics by youth binge drinking APS (N=7,660 individuals; N=78,584 interview intervals)**

	1999–2000 Sample N=7,660			Full sample N=78,584 Interview Intervals		
	Total	**2000 APS[a] below sample median**	**2000 APS[a] above sample median**	**Total**	**APS[a] stable /decreasing across interval**	**APS[a] increasing across interval**
Sample size	7,660	4,356	3,304	78,584	72,937	5,647
Female, n (%)	3,796 (49.6)	2,179 (50.0)	1,617 (48.9)	39,877 (50.8)	37,020 (50.8)	2,867 (50.8)
Age, mean (SD)	16.9 (1.4)	16.9 (1.4)	16.9 (1.4)	22.2 (3.8)	22.2 (3.8)	21.0 (3.3)
Race, n(%)						
White	4,483 (58.5)	2,525 (58.0)	1,958 (59.3)	45,977 (58.5)	42,688 (58.5)	3,289 (58.2)
Black or African American	2,041 (26.6)	984 (22.6)	1,057 (32.0)	21,075 (26.8)	19,494 (26.7)	1,581 (28.0)
American Indian, Eskimo, or Aleut	50 (0.7)	28 (0.6)	22 (0.7)	531 (0.7)	497 (0.7)	34 (0.6)
Asian or Pacific Islander	131 (1.7)	93 (2.1)	38 (1.2)	1,342 (1.7)	1,267 (1.7)	75 (1.3)
Other[b]	955 (12.5)	726 (16.7)	229 (6.9)	9,659 (12.3)	8,991 (12.3)	668 (11.8)
Hispanic Ethnicity, n (%)	1,608 (21.0)	1,268 (29.1)	340 (10.3)	16,348 (20.8)	15,243 (20.9)	1,105 (19.6)
Census Region, n(%)						
Northeast	1,307 (17.1)	742 (17.0)	565 (17.1)	12,698 (16.2)	11,397 (15.6)	1,301 (23.0)
North Central	1,711 (22.3)	821 (18.9)	890 (26.9)	17,272 (22.0)	16,413 (22.5)	859 (15.2)
South	2,919 (38.1)	1,510 (34.7)	1,409 (42.7)	30,914 (39.3)	27,998 (38.4)	2,916 (51.6)
West	1,723 (22.5)	1,283 (29.5)	440 (13.3)	17,700 (22.5)	17,129 (23.5)	571 (10.1)
Rural,[c] n(%)	1,871 (24.4)	857 (19.7)	1,014 (30.7)	15,962 (20.3)	14,894 (20.4)	1,068 (18.9)
Household size, mean (SD)	4.3 (1.6)	4.4 (1.7)	4.2 (1.5)	3.6 (1.7)[d]	3.6 (1.7)	3.6 (1.8)
Income ($), mean (SD)[e]	48,965 (54,220)	46,269 (52,105)	52,358 (56,614)	57,216 (58,852)	57,493 (58,871)	53,433 (58,463)
Poverty ratio, mean (SD)[f]	3.0 (3.5)	2.9 (3.5)	3.2 (3.4)	3.4 (3.5)	3.4 (3.5)	3.2 (3.5)

Highest grade completed, n(%)[g]						
Less than high school	5,827 (76.1)	3,322 (76.3)	2,505 (75.8)	20,234 (25.8)	18,520 (25.4)	1,714 (30.3)
High school	1,832 (23.9)	1,033 (23.7)	799 (24.2)	47,450 (60.4)	44,133 (60.5)	3,317 (58.7)
Associates/ Bachelor's	1 (0.0)	1 (0.0)	0 (0.0)	10,009 (12.7)	9,441 (12.9)	568 (10.1)
Graduate degree	0 (0.0)	0 (0.0)	0 (0.0)	892 (1.1)	843 (1.2)	48 (0.9)
Parent/ guardian high school, n (%)	5,851 (76.4)	3,186 (73.1)	2,665 (80.7)	60,273 (76.7)	55,951 (76.7)	4,322 (76.5)
Parent/ guardian very religious,[h] n (%)	1,919 (25.1)	1,073 (24.6)	846 (25.6)	20,176 (25.7)	18,713 (25.7)	1,463 (25.9)
Alcohol use						
Drinking days,[i] mean (SD)	2.5 (4.8)	2.5 (4.9)	2.5 (4.8)	4.1 (6.2)	4.1 (6.2)	4.2 (6.2)
Binge days,[i] mean (SD)	1.2 (3.1)	1.1 (3.1)	1.2 (3.1)	1.5 (3.6)	1.5 (3.6)	1.5 (3.7)
Started drinking before 13	1,961 (25.6)	1,102 (25.0)	859 (26.0)	19,985 (25.4)	18,519 (25.4)	1,466 (26.0)
Age at first drink, mean (SD)[j]	15.5 (4.0)	15.5 (4.0)	15.5 (4.1)	15.6 (4.0)	15.6 (4.0)	15.5 (4.0)
Non-drinker over follow-up, n (%)	334 (4.4)	190 (4.4)	144 (4.4)	3,186 (4.1)	2,954 (4.1)	232 (4.1)

APS=Alcohol Policy Scale, SD=standard deviation

[a] Based on the youth-binge drinking APS score

[b] Includes don't know and refused

[c] Those missing urban-rural status (n=229; 2,694 interview intervals) were coded as urban

[d] 3 years missing household size at prior interview

[e] 5,408 individuals were missing household income in 1999; in the full sample 21,552 intervals were missing household/family income at prior interview

[f] 5,434 individuals were missing poverty ratio in 1999; in the full sample 21,682 intervals were missing poverty ratio at prior interview

[g] Completion at prior interview. Those missing educational status (n=3; 193 interview intervals) were coded as completing less than high school

[h] Based on religiosity index (0–600; derived from questions related to religion asked of parent/guardian at baseline). Scores of 500+ were designated as "very religious"

[i] End-of-interval values

[j] Among those who drank over follow-up (n=7,326; 75,398 interview intervals)

Table 2.2. APS descriptive statistics by score version (n=78,584 interview intervals)				
	Mean (SD)	**Minimum**	**Maximum**	**Median**
Youth APS score				
Current score	41.7 (6.7)	24.1	72.1	40.4
Prior interview score	41.4 (6.7)	24.0	71.7	40.1
Cross-interval change in score	0.4 (2.6)	-38.1	39.7	0.03
General population APS score				
Current score	40.6 (7.6)	23.2	68.4	40.1
Prior interview score	40.3 (7.7)	23.0	67.3	39.1
Cross-interval change in score	0.4 (2.8)	-36.0	38.4	0.02

APS=Alcohol Policy Scale, SD=standard deviation
Note: Both APS versions include ratings for all 29 state-level alcohol policies. Youth APS incorporates the youth binge drinking efficacy rating. The general population APS incorporates the efficacy rating for reducing general population binge drinking)

Table 2.3. Associations between current APS and past 30-day drinking and binge drinking frequency at interview (n=78,584 intervals)

	Youth binge drinking APS			**General population binge drinking APS**		
	Beta[a]	95% CI		Beta[a]	95% CI	
Drinking days in the past 30 days						
Age-adjusted	-0.03	-0.14	0.08	0.01	-0.09	0.10
Adjusted Model[b]	-0.03	-0.17	0.11	0.02	-0.05	0.12
Binge drinking days in the past 30 days						
Age-adjusted	-0.03	-0.10	0.04	-0.01	-0.07	0.05
Adjusted Model[b]	0.004	-0.06	0.06	0.01	-0.04	0.06

[a] Mean difference in past 30-day drinking outcome at interview with a 10-unit higher APS score at interview (APS_t)
[b]Adjusted for start-of-interval age, Hispanic ethnicity, gender, race (dichotomous: white, other race), parent completed high school, grade completed at start-of-interval (3-level: less than high school, high school, associates/ bachelors or higher), and start-of-interval census region (4-level: Northeast, North Central, South, and West)

Table 2.4. Associations between current youth APS and drinking outcomes by prior interview APS (n=78,584 intervals)

	Current APS range	**Past 30-day drinking**	**Past 30-day binge drinking**
		Beta[a, b] (95% CI)	Beta[a, b] (95% CI)
Overall	24.1 – 72.1	-0.03 (-0.17, 0.11)	0.004 (-0.06, 0.06)
By prior interview APS quartile			
75th percentile and above (prior APS 44.5 or higher)	24.1 – 72.1	-0.28 (-0.54, -0.02)	0.01 (-0.14, 0.15)
50th – 75th percentile (prior APS 40.1 up to 44.5)	24.1 – 72.1	0.18 (-0.29, 0.65)	0.25 (0.01, 0.50)[c]
25th – 50th percentile (prior APS 36.9 up to 40.1)	24.1 – 69.3	0.06 (-0.31, 0.43)	-0.05 (-0.27, 0.18)
25th Percentile and lower (prior APS <36.9)	24.1 – 69.3	-0.09 (-0.36, 0.19)	-0.10 (-0.25, 0.04)

[a] Mean difference in past 30-day drinking outcome at interview with a 10-unit higher APS score at interview (APS_t)
[b]Adjusted for start-of-interval age, Hispanic ethnicity, gender, race (dichotomous: white, other race), parent completed high school, grade completed at start-of-interval (3-level: less than high school, high school, associates/ bachelors or higher), and start-of-interval census region (4-level: Northeast, North Central, South, and West)
[c] Adjusted for age, Hispanic ethnicity, gender as fully adjusted failed to converge

Table 2.5. Associations between cross-interview change in APS and past 30-day drinking and binge drinking frequency at interview (n=78,584 intervals)

	Youth binge drinking APS			**General population binge APS**		
	Beta[a]	95% CI		Beta[a]	95% CI	
Drinking days in the past 30 days						
Age-adjusted	-0.08	-0.22	0.07	-0.06	-0.19	0.08
Adjusted Model 1[b]	-0.15	-0.30	0.01	-0.15	-0.28	-0.01
Adjusted Model 2[c]	-0.16	-0.35	0.03	-0.13	-0.28	0.02
Binge drinking days in the past 30 days						
Age-adjusted	-0.01	-0.10	0.08	0.001	-0.08	0.08
Adjusted Model 1[b]	-0.05	-0.14	0.05	-0.05	-0.13	0.02
Adjusted Model 2[c]	-0.04	-0.15	0.07	-0.04	-0.12	0.04

[a] Mean difference in past 30-day drinking frequency outcome at interview with a 10-unit higher interview-to-interview change in APS score (ΔAPS)
[b] Model 1: Adjusted for start-of-interval age, Hispanic ethnicity, gender, race (dichotomous: white, other race), parent completed high school, grade completed at start-of-interval (3-level: less than high school, high school, associates/ bachelors or higher), and start-of-interval census region (4-level: Northeast, North Central, South, and West)
[c] Model 2: Model 1 + start-of-interval policy

Table 2.6. Associations between change in youth APS and drinking outcomes by prior interview APS score (n=78,584 intervals)

	Current APS range	**Past 30-day drinking**	**Past 30-day binge drinking**
		Beta[a,b] (95% CI)	Beta[a,b] (95% CI)
Overall	-38.1, 39.7	-0.15 (-0.30, 0.01)	-0.05 (-0.14, 0.05)
By prior interview APS quartile			
75th percentile and above (prior APS 44.5 or higher)	-38.1, 25.7	-0.25 (-0.57, 0.07)	0.02 (-0.12, 0.16)
50th – 75th percentile (prior APS 40.1 up to 44.5)	-19.5, 31.5	-0.18 (-0.64, 0.29)	0.04 (-0.17, 0.26)
25th – 50th percentile (prior APS 36.9 up to 40.1)	-14.0, 31.7	-0.05 (-0.46, 0.35)	-0.05 (-0.28, 0.19)
25th Percentile and lower (prior APS <36.9)	-12.1. 39.7	-0.13 (-0.40, 0.14)	-0.10 (-0.13, -0.07)[c]

[a] Mean difference in past 30-day drinking frequency outcome at interview with a 10-unit higher interview-to-interview change in APS score (ΔAPS)
[b] Adjusted for start-of-interval age, Hispanic ethnicity, gender, race (dichotomous: white, other race), parent completed high school, grade completed at start-of-interval (3-level: less than high school, high school, associates/ bachelors or higher), and start-of-interval census region (4-level: Northeast, North Central, South, and West)
[c] Grade completion and census region removed from adjustment as full model failed to converge

Table 2.7. Associations between youth APS and drinking outcomes stratified by legal drinking age (n=78,584 intervals)

	<age 21 N=22,338			>= age 21 N=56,246		
	Beta	95% CI		Beta	95% CI	
Drinking days in the past 30 days						
Current year youth APS score[a, b]	-0.04	-0.17	0.09	0.04	-0.12	0.19
Change in youth APS score[a, d]	-0.15	-0.40	0.09	-0.05	-0.25	0.15
Binge drinking days in the past 30 days						
Current year youth APS score[a, b]	-0.01	-0.07	0.05	0.01	-0.07	0.08
Change in youth APS score[c, d]	-0.13	-0.15	-0.10	0.02	-0.09	0.14

[a] Adjusted for Hispanic ethnicity, gender, race (dichotomous: white, other race), parent completed high school, start-of-interval census region, start-of-interval educational attainment
[b] Mean difference in past 30-day drinking outcome at interview with 10-unit higher APS at interview (APS_t)
[c] Adjusted for Hispanic ethnicity, gender, race (dichotomous: white, other race), parent completed high school; clustering by state removed as models failed to converge
[d] Mean difference in past 30-day drinking outcome with a 10-unit higher increase APS change across interval (ΔAPS)

CHAPTER THREE: STATE-LEVEL ALCOHOL POLICY ENVIRONMENT IN ADOLESCENCE AND TRAJECTORIES OF ALCOHOL USE INTO EARLY ADULTHOOD

3.1 BACKGROUND

In the prior chapter of this dissertation, analyses focused on the association between the state-level policy environment and short-term changes in alcohol use. Foundational to those analyses are the within-person patterns of alcohol use over time. Understanding longer term alcohol use patterns—or trajectories—may highlight critical time periods for intervention.

Growing evidence suggests that a stronger alcohol policy environment, rather than the mere presence or absence of single policies, is associated with reduced binge drinking and lower rates of underage traffic fatalities.[12,13,35,37] As mentioned in chapter 2, the majority of this work relied on cross-sectional panel analyses. In addition, very little research has explored the role of the policy environment on drinking trajectories over time.[52]

Adolescence is a developmental time period when the policy environment and other external factors such as peer networks or advertising may influence how frequently and consistently one engages in alcohol use.[33,52,53] Early initiation and frequent, harmful alcohol use in adolescence have been linked to similar use in adulthood.[1,33] A deeper understanding of the relationship between the policy environment and individual drinking trajectories may highlight sub-groups for early intervention and help policy makers advocate for policies that shift individuals toward lower harm use patterns.

The drinking trajectory from late adolescence into adulthood is one of increasing and then decreasing use.[54–57] This population average trajectory reflects increases in alcohol use typically associated with maturing and increased independence. Yet, methods that focus on this average trajectory assume individuals will change alcohol use similarly and in the same direction across time, with variation only in the degree of change between individuals (sometimes called monotonic heterogeneity).[58,59] Many developmental and behavioral phenomena follow a multinomial pattern where both the direction and the intensity of the slopes vary between individuals.[58,60] In these instances, a focus only on a sample's average trajectory and deviations from the average masks important variation across individuals. Prior research has found substantial heterogeneity in drinking trajectories.[52,55–57,61–63]

Several methods are available to explore individual trajectories, with mixed models and latent class growth models being the most commonly used.[58,64] While mixed models allow exploration of change over time accounting for individual-level correlation, the possibility to explore within-group differences is limited to measured variables included within the model (i.e. demographics).[60,64] In contrast, latent growth curve modeling—an extension of mixed models and closely related to structural equation modeling—generates groups of individuals with similar trajectories with no a priori assumptions about the variables that influence trajectory membership and shape.[60]

While prior research has documented drinking trajectories within samples of young people in the U.S.,[52,55–57,61–63] few have explored the link between alcohol-related policies and drinking trajectories.[52] Little is known about the relationship between the collective alcohol policy environment and drinking trajectories. The National Longitudinal Survey of Youth 1997 (NLSY97) cohort offers a unique opportunity to explore drinking trajectories within a large sample of U.S. residents who have had annual interviews from approximately age 12 through until age 30.

The aims of the current study were to (1) identify overall trajectories for the frequency of (a) drinking and (b) binge drinking from mid-adolescence to early adulthood in a nationally representative U.S. population and (2) estimate the association between adolescent state-level policy environment and trajectory membership probability. In particular, we were interested in whether those maturing in less stringent policy environments were more likely to follow trajectories defined by earlier, more frequent alcohol consumption. We hypothesized that trajectories of drinking frequency in this cohort would include abstainers, early starters, those who began and escalated frequency of use near the legal drinking age, and de-escalators (those who start drinking early and then reduce frequency over time). We expected similar groups when examining binge drinking. In addition, we hypothesized those exposed to less stringent state-level policy environments would be more likely to follow drinking trajectories suggestive of early and frequent use compared with individuals exposed to stricter policy environments in mid-adolescence.

3.2 METHODS

3.2.1 Study population and design

Similar to chapter 2, the current study sample included participants from the NLSY97 cohort. Additional background on this cohort including recruitment and data collection procedures can be found in the methods section of chapter 2. For the current study, the years used for the analysis were expanded slightly, with baseline alcohol assessments in 1997 and follow-up assessments through 2015 (annual through 2011, biannually in 2013 and 2015). Within these assessment years, the population was aging from roughly 12 to 30 years of age. Analytic sample inclusion criteria were: (1) available data on baseline drinking and state-of-residence, (2) drinking behavior reported from at least 1 additional interview, and (3) available baseline demographic and covariate information.

3.2.2 Variables for trajectory modeling – Age at interview and drinking frequency

Age at interview: Age at interview (rounded down to a whole number) was used as the unit of time for the trajectory modeling, allowing individuals to report drinking behaviors from age 12–30.

Alcohol use frequency: Similar to the prior study (chapter 2), self-reported past 30-day frequency of drinking alcohol (range 0–30 days) was used as a marker of habitual use.

Binge drinking frequency: Similar to the prior study (Chapter 2), self-reported past 30-day binge drinking frequency (range 0–30 days) was used as a marker of excessive alcohol use.

3.2.3 Variables for exploring the association between alcohol policy and trajectory membership

Exposure, baseline Alcohol Policy Scale (APS) score: Similar to the prior study (chapter 2), this analysis used the APS as a measure of the state-level alcohol policy environment. For the current study, we focused on the APS score incorporating the youth binge drinking efficacy rating (Youth APS detailed in chapter 2). Each eligible NLSY97 individual was assigned an APS score from 1999 (the closest available APS year to baseline year) based on the individual's state of residence at 1997 (between ages 12–16 depending on baseline age). Focus on this time period for exposure to the alcohol policy environment reflects interest in mid-adolescence as a critical period in the life course for development of individual behavioral patterns and norms.[33] APS was used as a continuous exposure. While the theoretical range is 0–100, the range for the APS score for the sample based on 1997 state-of-residence was 23.96 to 59.84.

Outcome, trajectory membership: Trajectory membership (categorical) as determined during the trajectory modeling stage of the study was used as the outcome. Two separate outcomes were explored—drinking days trajectory membership and binge drinking days trajectory membership.

Covariates: Potential baseline individual-level confounders for inclusion based on the literature included: age (continuous), gender (binary, male/female), race (categorical: white; Black or African American; American Indian, Eskimo, or Aleut; Asian or Pacific Islander; other, don't know, or refused), Hispanic ethnicity (binary, yes/no), living in an urban area (binary, yes/no), Census region (categorical: Northeast; North Central; South;

West), household size, parent/guardian education (binary, whether at least one parent/guardian completed high school), parent/guardian religiosity (binary, whether parent/guardian was very religious), total family income (total annual cash receipts from all sources prior to taxes), and family poverty ratio (ratio comparing total income with the federal poverty threshold, accounting for number of household residents and number of residents under age 18). We also evaluated state-level factors as potential confounders. We included a minimally sufficient confounder set in models estimating associations between state-level policy exposure and trajectory membership.

3.2.4 Statistical analysis

We used latent class growth modeling (also known as group-based trajectory modeling) to identify drinking trajectories across time for each of the two drinking outcomes. This group-based, semi-parametric approach assumes heterogeneity of trajectories. More specifically, it assumes the sample and underlying population it represents are composed of a mixture of distinct, developmental drinking trajectories.[60,65] The SAS procedure PROC TRAJ was used.[65] Similar to latent curve models and hierarchical models, the procedure uses a polynomial function to model the relationship between age and the behavioral outcome.[60] Unlike growth mixture modeling, the group-based trajectory modeling approach assumes no within-group variance among members in the same group.[66,67]

Alcohol use frequency was modeled using a censored normal distribution, while binge drinking frequency was modeled using a zero-inflated Poisson distribution. Zero-inflated Poisson was preferred for the binge drinking days outcome given the excess number of zeros due to being a non-drinker that are likely generated via a separate process from zeros for drinkers who may not have binge drank during the time period. For each solution, posterior probability of group membership and parameters for trajectories were estimated using maximum likelihood. Standard errors and 95% confidence intervals for parameter estimates were generated by a first-order Taylor series expansion.[68] For each outcome, we examined trajectory solutions with up to 6 groups, after which models failed to converge or had multiple small group sizes.

Deciding on the number of trajectory groups that best fit the data is an iterative process based on model fit as well as researcher assessment of plausibility. A variety of approaches and frameworks have been proposed for model specification, fitting, and selection.[66,69] Following these recommendations, we first outlined group expectations and shapes based on the literature. Then we estimated a single-group cubic trajectory (one-group, simple average trajectory) before proceeding with more complex, multi-group models.[65,68] As groups were added and linear, quadratic, and cubic terms for the trajectory shapes were tested, we examined the Bayesian Information Criterion (BIC), selecting models with lower absolute BIC. However, BIC tends to as groups and complexity are added to the model which could lead to selection of a trajectory model that does not fit with theory or performs poorly on other metrics.[66] As such, we also assessed the following: group size, group average maximum posterior probabilities, odds of correct classification within each group, and model relative entropy.[69] These metrics as well as substantive knowledge based on the literature were used to guide selection of the most parsimonious trajectory model for each outcome. We then described the resulting trajectories in terms of prevalence within the sample and demographic characteristics, accounting for complex survey design and sampling weights. Trajectories were graphed to examine their overlap with each other, and spaghetti plots of a random sample of 25 participants from each trajectory group were output and plotted to assess how well the group classifications reflected their individual drinking trajectories.

The second aim for this study was to assess the relationship between state-level alcohol policy environment at adolescence and trajectory membership. Prior to building models of association, we examined demographics and APS score distributions within each of the trajectory groups. Next, we ran unadjusted multinomial logistic regression models, followed by models adjusting for individual-level confounders. We also explored adjustment for state-level confounders. Analyses accounted for complex survey design.

Sensitivity analyses exploring variations in the final trajectory models selected in aim 1 were undertaken including examining shortened trajectories from age 12–22 and restricting the analytic sample to individuals present for half of the assessments or more during follow-up. We also examined a dichotomized policy score (based on the sample median). Finally, we assessed the association between APS score and membership in trajectories with a larger proportion of individuals initiating alcohol use prior to age 13.

Acknowledgment: This research was conducted with restricted access to Bureau of Labor Statistics data. The views expressed here do not necessarily reflect the views of the Bureau of Labor and Statistics.

3.3 RESULTS

3.3.1 Sample summary

At baseline, respondents were 14.4 years of age, and roughly 49% of the sample were female (Table 3.1). The majority of the sample identified as white and 13% of the sample identified as Hispanic. Over a third of the sample lived in the Southern Census region at baseline (34.2%), with a little under a quarter from North Central (26.4%) and West regions (21.1%). The majority of the sample lived in an urban area (73.6%). Respondent households included 4.5 individuals on average with an average household income of $52,256. The average poverty ratio was 3.2 and roughly 80% of the sample had at least one parent/guardian who completed high school. At baseline, respondents reported 0.8 drinking days and 0.4 binge drinking days in the past 30 days, on average. Roughly a quarter of the sample reported drinking prior to age 13, and 4% of the sample never drank prior to age 30.

3.3.2 Drinking frequency trajectories

We evaluated group-based trajectory models from 1 group up to 6 groups at which time sample sizes of several groups became too small (avoiding group sizes representing less than 4–5% of the sample is recommended[66]). For each model, we recorded the BIC, group proportions, average posterior probability assignment, relative entropy, and odds of correct classification (Appendix Table A3.1). The 5-group solution with all cubic parameters provided the best fit. Model parameters can be seen in Appendix Table A3.2. The 5 groups of drinking days trajectories were graphed (Figure 3.1) and named based on trajectory shape and characteristics: late escalating (10.8%), normative—as it follows roughly the average developmental trajectory (19.0%), high frequency (5.6%), low frequency (47.0%), and no/infrequent drinking days (17.7%). The largest trajectory group, the low frequency group, was characterized by a relatively sustained low level of drinking across the time period (47.0%, Table 3.1 and Figure 3.1). The no/infrequent drinking group (17.7%) was characterized by no or very low number of drinking days, with a fifth reporting no drinking across the time period and only 15% reported drinking before age 13. The low frequency and no/infrequent drinking groups had higher proportions of females compared with the other groups. The no/infrequent drinking group had a higher proportion of racial minorities, and those living in the South at baseline (43.2%) compared with other trajectory groups. In addition, this trajectory group (compared to the 4 other groups) had the lowest average household income, a lower average poverty ratio, a lower proportion of parents/guardians who had completed high school, and were more likely to have a very religious parent/guardian. This group also had the lowest proportion of individuals drinking before age 13, and had the highest average age at initiation.

The normative drinking group (19.0%) followed roughly the expected, average drinking trajectory. Specifically, the trajectory showed slowly increasing drinking days peaking near 8.5 drinking days around age 21 before drinking days declined slightly into the late-twenties (Figure 3.1, Table 3.1). Compared to low frequency and no/infrequent drinkers, this group had a higher proportion of male (58.9%) and white (84.9%) participants. In addition, the trajectory had one of the lowest average ages at first drink (13.6 years) and 43.6% drank before age 13.

We identified two groups characterized by a high number of use days: a so-called high frequency group (5.6%) with a peak number of days at around 18 days, and a later escalating group who drank fewer days initially but increased drinking days after age 21 (10.8%). Compared to low-frequency drinkers, these groups included a higher proportion of individuals who were male. The average age at first drink in the high frequency group was 13.6, with 42.6% drinking before 13. While this group had similar baseline drinking characteristics to the normative drinking group, the high frequency group were slightly more likely to live in the Southern region at baseline and had a higher proportion of males. In addition, the two groups diverged in terms of drinking frequency at around age 18 when the high frequency group continued to increase drinking frequency, while the normative group increased at a lower rate before declining around age 21. The later escalating group was slightly more racially diverse than the high frequency group which was majority white (84.4%). Only 25% of the later escalating group reported a first drink before 13 (average age of first drink was 15.4). To assess the fit of the model solution, a random sample of 25 individual trajectories were plotted. Review of these spaghetti plots showed these individual trajectories roughly matched with their assigned group trajectory shape (Appendix Figure A3.1).

3.3.3 Binge drinking frequency trajectories

For binge drinking days, the best fit model was a 5-group solution with all cubic parameters (model fit assessment summary: Appendix Table A3.1; parameter estimates: Appendix Table A3.3). The model showed what we defined as a no/infrequent binge drinking group (39.1%) along with "once-a-month" (34.8%), later (10.5%), high frequency (4.4%), and earlier (11.3%) binge drinking groups (Table 3.2 and Figure 3.2). Similar to the no/infrequent drinking days group, the no/infrequent binge drinking group had a larger proportion of females, Black/African American participants, and persons who were more likely to be from the South. In this group, there was also a slightly larger proportion of Asian and Pacific Islanders. In terms of socioeconomic conditions, this group had the lowest average household income, poverty ratio, and proportion with a parent/guardian that completed high school. Drinking frequency and binge drinking frequency were low at baseline with the oldest age at first drink compared to the other groups (16.9 years). Roughly 11% of the group sample did not drink during follow-up and only 15.9% started drinking prior to age 13.

The next largest group was characterized by binge drinking roughly once-a-month across follow-up. This group had closer to an even gender split, were more likely to be white compared to the no/infrequent binge drinking group, and were the group with the highest proportion of individuals identifying as Hispanic. The group was characterized by reporting close to 1 drinking day in the past 30 days, but only 0.4 binge drinking days at baseline. One third of this group reported drinking prior to age 13 and all reported consuming alcohol at some point during follow-up.

Three groups with higher, fluctuating binge drinking patterns were identified: a later binge drinking group (10.5%), a high frequency binge drinking group (4.4%), and an earlier binge drinking group (11.3%). These three groups were fairly similar in terms of demographics with a few exceptions. The high frequency binge drinking group was predominately male (81.2% compared to ~66% in the other two groups). The later binge drinking group had a higher proportion of Black/African American participants. In addition, there were regional differences with the high frequency binge drinking group being more likely to be from the South, the later group having a higher proportion residing in the Northeast, and the earlier binge drinking group having a higher proportion from Northcentral compared to the other two groups. All three groups displayed frequent binge drinking at some point during follow-up. Baseline drinking was higher among the heavy binge drinking group at baseline (1.9 drinking days, 1.1 binge drinking days) and across follow-up (peaking at just over 9 days at age 23). The early binge drinking group also had higher baseline use (2.2 drinking days, 1.7 binge drinking days) rising quickly and reaching 4 days at age 19.

For each of the 5 binge drinking days groups, a random sample of 25 individuals were selected for spaghetti plots. Assessment of the plots demonstrates that individual trajectories of those assigned to a given group matched with the estimated group trajectory shape (Appendix Figure A3.2a–d).

3.3.4 Binge drinking trajectory membership within drinking day trajectory classes

We examined the cross-classification of individuals into trajectories of drinking days and trajectories of binge drinking days (Table 3.3). Looking within the 5 identified drinking days trajectories and the 5 identified binge drinking days trajectories, the late escalating drinking days group were most likely to belong to the once-a-month binge drinking group (42.3%) or the later binge drinking group (29.6%). A lower proportion appeared to be no/infrequent binge drinkers (10.6%) or high frequency binge drinkers (5.2%). Those in the drinking days group, characterized by a normative number of drinking days, were most likely members of the once-a-month binge drinking group (41.0%) or the earlier binge drinking group (32.2%). The high frequency drinking days group were more likely to be in groups characterized by a higher level of binge drinking, with 38.4% classified in the high frequency binge drinking group, 29.1% in the later binge drinking group, and 21.4% in the early binge drinking group. Low frequency drinking members were most likely to be classified under the no/infrequent binge drinking group (44.9%) or in the once-a-month binge drinking group (43.6%). Finally, persons in the no/infrequent drinking days group were mostly no/infrequent binge drinkers (90.6%).

3.3.5 Association between alcohol policy score and trajectory group membership

Within the analytic sample, individuals resided in 43 different states with baseline (~ age 14) APS score ranging from 23.96 to 55.00. This was only slightly more restricted than the range across all states for 1997 (23.96 to 59.8). The score was roughly normally distributed (Appendix Figure A3.3). Mean APS score and distributions of scores were similar across drinking day trajectories (Appendix Figure A3.4) and binge drinking day trajectories (Appendix Figure A3.5). Adjustment for potential confounders among state-level factors revealed little to no changes in the comparison of mean APS scores by drinking day trajectory. However, several individual-level factors were determined to be likely confounders of the association between APS score and trajectory membership. As such, we only adjusted for individual-level confounders in estimating the association of APS score with both the drinking days and binge drinking days trajectory membership.

In the unadjusted multinomial modeling (Table 3.4), a 10-unit higher APS score at baseline (a unit change used in prior APS publications, reflecting approximately 1.5 standard deviation units in this sample[12,37]) was associated with slightly higher odds of membership in the late escalating drinking days group than membership in the no/infrequent drinking days group (OR=1.14, 95% CI 0.95, 1.36). The OR was similar (1.13, 95% CI 0.98, 1.31) after adjusting for individual-level factors (gender, race, Hispanic ethnicity, living in an urban area, and having at least one parent that completed high school). Compared with the no/infrequent trajectory, a 10-unit higher APS score at baseline was associated with slightly lower proportional odds of normative drinking membership (aOR=0.94, 95% CI 0.81, 1.10), slight increased odds of high frequency membership (aOR=1.08, 95% CI 0.89, 1.32), and slight increased odds of low frequency membership (aOR=1.06, 95% CI 0.97, 1.17). Multinomial results were similar after excluding those who did not drink over the time period (Appendix Table A3.4). When the comparator outcome was updated to low frequency drinking (Appendix Table A3.5), the 10-unit higher APS score at baseline was associated with decreased odds of being in the normative versus low frequency group (aOR=0.89, 95% CI 0.80, 0.99), increased odds of late escalating membership (aOR=1.06, 95% CI 0.96, 1.18), increased odds of high frequency membership (aOR=1.02, 95% CI 0.86, 1.20), and decreased odds of no/infrequent membership (aOR=0.94, 95% CI 0.85, 1.04).

For the binge drinking trajectories, we set the comparator outcome to no/infrequent binge drinkers. A 10-unit higher APS score was associated with a small, increased odds of assignment to all other trajectories (Table 3.4). Multinomial results were similar after excluding those who never reported drinking over the follow-up period

(Appendix Table A3.4). When the comparator outcome was updated to the "once-a-month" binge drinking group (Appendix Table A3.5), the 10-unit higher APS score was associated with small, decreased odds of being in the earlier binge drinking group (aOR=0.97, 95% CI 0.86, 1.11) and the no/infrequent group (aOR=0.96, 95% CI 0.86, 1.06) compared to the low frequency binge drinking group.

3.3.7 Sensitivity analysis: role of missing assessments on trajectory model selection and individual trajectory shape, and size

Restricting the analyses with roughly half (8 or more, N=8,098) of the follow-up assessments did not substantially impact trajectory selection, size, or shape (Appendix Figures A3.6 and A3.7). Further restriction to those who were missing no more than 2 follow-up periods (n=6,211) yielded similar results for the drinking days trajectory model selection, size, and shape (Appendix Figure A3.8). The binge drinking trajectory results were similar for 4 of the 5 trajectories (Appendix Figure A3.9). Rather than a later trajectory, these analyses resulted in a low, chronic trajectory.

3.3.6 Sensitivity analysis: Shortened trajectory time period (age 12–22)

Given that the APS score version used in these analyses focused on the efficacy of the policies for youth binge drinking, we re-constructed the trajectories using a shortened time period from age 12 through 22. Using a similar process, we evaluated model fit for 1- up through 6-group solutions for both drinking days and binge drinking days. We again selected the best fitting model based on model fit statistics and substantive knowledge.

For the drinking days trajectories using ages 12–22, a 5-group solution was selected as the best fit model (Appendix Table A3.6). The size and shapes of the groups were roughly similar to the age 12–30 trajectories with the exception that the late escalating group did not emerge in the shortened time period (Appendix Figure A3.10). Instead, we saw a small "early experimenting" group (7.7%) who peaked use at 4 drinks a month around age 16. We continued to see a normative drinking group, although this comprised a slightly smaller proportion of the sample (12.2% compared to 16.5% in the age 12–30 model). The no/infrequent group was larger (29.4% versus 21.0%)—due to including individuals who initiated drinking at later ages. We then examined the association between APS score and group membership. The high frequency (4.2%) and low frequency (46.5%) groups were similar to the main model. While there was a small decreased odds of membership in the normative compared to the no/infrequent group with higher APS score, the confidence interval crossed the null (aOR=0.92, 95% CI 0.80, 1.06; Appendix Table A3.8). All other effect estimates were at or near the null of 1.0. Overall, the results were attenuated compared with the age 12–30 trajectory results.

For the binge drinking days trajectories using ages 12–22, a 5-group solution was found to have be the best model fit (Appendix Table A3.6). The size and shapes of the groups were roughly similar to the age 12–30 trajectory results with some shifts in the size of the groups (Appendix Figure A3.11). The main shift in trajectory shapes related to the later and earlier binge drinking. In the age 12–30 model, these two groups crossed near age 23, but in the age 12–22 model they cross closer to age 20. This may reflect that data used to fit these trajectories, according to procedure, lacked information from ages 23 onward from the later binge drinking group (the slope of this group is estimated as slightly larger than it might be with the additional years of drinking information). We then examined the association between APS score and binge drinking days group membership (Appendix Table A3.8). Overall, the results for the association between APS score and group membership showed APS score as slightly more protective for binge drinking when looking at the shortened trajectory period compared to the longer time period. For example, a 10-unit higher APS score was associated with decreased odds of membership in the earlier binge drinking trajectory (compared to no/infrequent; aOR=0.90, 95% CI 0.76, 1.07). In the main age 12–30 models, this effect estimate was 1.02 (95% CI 0.86, 1.21).

3.3.8 Sensitivity analysis: operationalizing APS score

There may be threshold effects for the APS score-trajectory association. As such, we explored a version of APS score dichotomized at the sample median (median score 38.2). The results for past 30-day drinking days trajectory multinomial models were in line with the continuous results (Appendix Table A3.9). Effect sizes were slightly larger for low frequency and high frequency trajectory groups compared with the continuous APS analyses.

For binge drinking trajectory analyses, we found that rather than mostly null effects seen in the continuous APS analyses, higher than median APS score (compared with below the median) was associated with decreased odds of membership in later (aOR=0.95, 95% CI 0.80, 1.11; Appendix Table A3.9), once-a-month (aOR=0.98, 95% CI 0.86, 1.12), and earlier (aOR=0.97, 95% CI 0.79, 1.20) binge drinking trajectories compared to the no/infrequent comparator outcome trajectory.

3.3.9 Sensitivity analysis: examining trajectories with early initiation of alcohol use

Two drinking days trajectories (normative and high frequency) had earlier average age at initiation of alcohol use (~40% before age 13) compared to other drinking days trajectories. We grouped these two trajectories together and evaluated whether APS score was associated with membership in these earlier trajectories versus the remaining comparator trajectories. Higher APS score was associated with reduced odds of membership in these earlier initiating groups compared to the other three trajectory groups (adjusted OR: 0.92, 95% CI 0.83, 1.01).

Similar to the drinking days, 2 binge drinking trajectories (high frequency and earlier) had earlier average age at initiation of alcohol use and a higher proportion drinking prior to age 13. Specifically, a 10-unit higher APS score was not associated with reduced membership in either of these earlier initiating groups compared to all other groups (aOR= 1.00, 95% CI 0.89, 1.12).

3.4 DISCUSSION

3.4.1 Overview of findings

In this study, we identified heterogeneous drinking frequency and binge drinking frequency trajectories in a nationally representative, longitudinal cohort of U.S. adolescents maturing into adulthood. The current work advances the field in several ways. First, the follow-up period from early adolescence to age 30 is longer than the majority of prior research focused on drinking trajectories. This allowed us to identify and characterize several trajectories less often noted in the literature and deviating from the often cited average drinking trajectory (a trajectory rising in late adolescence, peaking around age 21, and then decreasing). These findings were relatively consistent across the two outcomes examined. Across both the drinking days and binge drinking days trajectories, we found a variety of groups, including those who: (1) started drinking (or binge drinking) early in mid-adolescence and sustained relatively high drinking frequency into early adulthood, (2) initiated drinking (or binge drinking) earlier in adolescence, and (3) started drinking (or binge drinking) later into adulthood. Such groups may be missed by current initiatives centered around late adolescence. In addition, we found demographic distinctions across groups that may be relevant for development of interventions that are culturally competent.

The second advancement was the examination of the relationship between state-level policy environment and trajectory membership. Few studies have connected policy-level interventions to alcohol use trajectories.[52] We hypothesized that individuals exposed to less stringent state-level policy environments in mid-adolescence would be more likely to follow earlier, frequent use drinking trajectories compared to those in stricter environments. Overall, we found weak associations between state-level APS at around age 14 and drinking or binge drinking trajectory membership. In addition, we found inconsistent directionality of effects within sensitivity analyses and some counterintuitive results (i.e., higher APS score was associated with increased odds of high frequency drinking days membership). We discuss some possibilities for these findings below. We also found a consistent, slight decreased odds of membership in the normative drinking days group and increased odds of late escalating trajectory membership with higher APS score (compared to both the no/infrequent and low frequency drinking groups). Sensitivity analyses showed APS score may decrease odds of membership in drinking day trajectory groups typified by earlier age at initiation. The alcohol environment may therefore have a stronger impact on those following the "typical" developmental trajectory and may discourage use patterns typified by early initiation.

3.4.2 Trajectory findings

The current study examined roughly 18 years of drinking frequency data. Prior trajectory work (both drinking and binge drinking) has focused on smaller time ranges (often 10 years or less) with a variety of start and ending ages. In spite of this variety, the majority of these studies identify low frequency (which sometimes includes abstainers), "normative" (increasing and peaking at 21 prior to declining), and high frequency drinking groups. The size of these groups varies, but low frequency drinking trajectories are typically the most common, followed by normative drinking trajectories. We also identified these three groups in the current analyses. Due to the size of the sample, we were able to separate out no/infrequent drinkers from low frequency drinkers in both the drinking and binge drinking trajectory analyses.

Studies typically identify 1–3 additional drinking or binge/heavy drinking groups beyond low/abstainers, normative, and high frequency. In the current drinking day trajectory analyses, we identified a group typified by escalating use from age 18 onward and peaking near age 25 (late escalators) representing roughly 11% of the sample. Unlike some prior work, we did not identify a group that started drinking in earlier adolescence and de-escalated use prior to age 21.[52,70,71] When examining binge drinking patterns, we identified a group with earlier binge drinking onset (similar to the high frequency group) representing 11% of the sample as well as a later onset group (10% of the sample). Results highlight the need for continued programming into early adulthood even among those with low prior levels of alcohol consumption.

In addition to other factors which explain variations in trajectory results such as sample size (limiting the number of groups that can be identified) and the specific drinking outcome examined, the age range used for analyses also impacts the number and types of trajectory groups identified. Studies focusing on later adolescence (~16–18) into either the beginning of adulthood[52,70] (~21–24) or later early[67,71,72] adulthood (~25–30) often identify a group that decreases use into early adulthood and a group with later (after 21) onset. Others focusing on early adolescence (~10–12) into the beginning of adulthood (~21–24) often identify an earlier onset group (relative to the "normative" later adolescence onset group) and a relatively larger portion of abstainers or low frequency drinkers.[63] That our study spans the above age ranges may explain the differences in identified group shapes (i.e., the pattern of drinking, including onset and amounts) and their sizes. For example, in prior work which only went through age 21–25, those who reported drinking infrequently prior to age 21 but then increased alcohol use into their mid-to-late 20s may have been categorized as low frequency drinkers or non-drinkers, while in our study we had additional years of information to classify them as late escalators. When we shortened our follow-up time in sensitivity analyses, the proportion of individuals assigned to the no/infrequent and low frequency groups grew and a late escalating group was not identified (drinking frequency) or was less distinguishable (binge drinking frequency). Results emphasize that the start and cut-off points for trajectory modeling impact identified trajectories.

Examining overlap between general alcohol use frequency and binge drinking trajectories, we found links between overall trajectories of use and binge drinking trajectories. Over 90% of those in the no/infrequent drinking group were also assigned to the no/infrequent binge drinking group. Yet, low frequency drinking was roughly evenly distributed between no/infrequent binge drinking and once-a-month binge drinking groups, suggesting that some low frequency drinkers do not engage in binge drinking while others do so occasionally. For other groups, drinking trajectory membership aligned moderately with a binge drinking trajectory membership of similar shape (i.e., those in the high frequency drinking group tended to belong to the high frequency binge drinking group). Yet, individuals in any given drinking trajectory were typically highly prevalent (close to one-third) in at least one additional binge drinking group. For example, among those in the normative drinking days group, they were most likely to be assigned to the once-a-month binge drinking groups (~40%), but the next most common was early binge drinking (32%). This demonstrates that, even within drinking days groups, there is variation in binge drinking patterns, including a subset who may be engaging in riskier drinking earlier in adolescence. Furthermore, this uneven distribution highlights the benefit of examining multiple aspects of drinking simultaneously.

3.4.3 State-level alcohol policy and trajectory membership

Prior research examining the alcohol policy environment and youth drinking, found evidence that a more stringent policy environment reduces youth drinking and binge drinking.[12,13,35,38] Fewer studies have used longitudinal data to examine the association between policies and individual drinking trajectories.[52] Our findings build off this prior alcohol policy environment work by examining how policy environment impacts individual-level drinking patterns. We found weak evidence that exposure to state-level alcohol policy environments during mid-adolescence influences binge drinking trajectory membership from mid-adolescence through early adulthood. We found stronger evidence for the influence of exposure to state-level alcohol policy environments during mid-adolescence on drinking days trajectories. Specifically, higher APS score (stricter policy environment) was associated with decreased odds of membership in the normative drinking group—a group with earlier age at initiation. Furthermore, when we compared the trajectories with earlier age of initiation (normative and high frequency) with the three other trajectory groups (low frequency, no/infrequent, and late escalating), higher APS score decreased the odds of membership in these earlier initiation drinking day trajectories.

Prior work by Fairman et. al. found lower state-level policy strength (across 19 policies) was associated with increased risk of being in an escalating binge drinking trajectory (age 16–21).[52] While we found less evidence to support an association between APS and binge drinking trajectory in our main analyses (trajectories from age 12–30), in sensitivity analyses where we restricted trajectories to age 12–22, we found higher APS score decreased odds of membership in all binge drinking groups compared to the no/infrequent comparator outcome group. Furthermore, in the drinking days analyses, we found higher APS score reduced odds of membership in the normative drinking group—a group with some consistent initiation timing and shape to that of the escalating group identified by Fairman.

It is important to note that our APS score results were inconsistent across drinking and binge drinking outcomes and sensitive to exposure parameterization. These mixed results emphasize the challenges of state-level alcohol policy evaluations and suggest areas for future inquiry. In the current analyses, our exposure period of interest was limited to a single year in mid-adolescence, which may not be the etiologically relevant time period for the role of policy environment on drinking trajectories—particularly when individuals reach legal drinking age. In addition, the focus on a single exposure year means differences in policy score across individuals reflects static differences in state-level policy implementation at a specific period in time rather than differences arising from changes in policy scores overtime or due to migration across states. It is possible that a focus on change in policy score or a time varying score may have yielded different results. Furthermore, it may be that the policy environment influences certain parts of these trajectories. We saw some evidence of this in our sensitivity analyses. Examining the relationship between alcohol policy environment across time and trajectories is an area for future research. Additionally, it may be that APS score wields heterogeneous influence both across and within trajectories, with some individuals drinking more and others drinking less as a result of the policy environment. Due to the trajectory modeling approach used, we were unable to examine effects of APS within the trajectory groups themselves.

3.4.4 Conclusions and Future Directions

The current study used longitudinal data from a nationally representative sample of individuals followed from mid-adolescence into adulthood. The cohort has a high retention rate and asked about drinking frequency consistently across interviews. This data allowed us to examine trajectories across multiple critical developmental periods, to describe trajectories in terms of demographics and drinking frequency, and to evaluate the association between state-level alcohol policy environment and trajectory membership.

However, the results should be viewed in light of the following limitations. First, the trajectory model used (latent class growth modeling) assumed no variation within each trajectory group. This is helpful for simplifying the process of identifying and typifying trajectories and includes an imputation process to account for missing data, but it limits the flexibility of the model to examine within-trajectory variation or differences. Future directions for research include using the identified trajectories as a starting point for modeling techniques that allow for variation, such as general growth mixture modeling.

While the alcohol use frequency questions we used were continuous (an improvement over prior work that has involved categorization of drinking frequency), they are self-reported and are thus sensitive to recall bias and underreporting. Furthermore, the question only asked about drinking in the past 30 days, which may not fully represent an individual’s use since the prior interview. In addition, although we examined two different aspects of drinking—drinking overall and binge drinking specifically—both focused on frequency. While the binge drinking question attempts to assess quantity/heavy alcohol use, the question did not differ binge drinking thresholds by gender or age group. The use of this threshold-based definition of binge drinking also ignores amounts that fall below the threshold, which may still be high-risk drinking events. Furthermore, the gold standard for the assessment and the definition of binge drinking is still debated in the literature.[73]

The exposure used acknowledges the complexity of the policy environment, but the APS score does not capture the extent to which policies were enforced. The score also does not reflect potential variation in implementation and enforcement at the local level. Another limitation is that the first available year for the APS was 1999. We therefore had to apply scores from 1999 to each participant's state of residence in 1997. As policy scores tended to rise over time across states, it is likely the assigned score was higher than the true score in 1997. It is also possible that states with higher APS scores adopted policies due to high levels of youth drinking and drinking-related outcomes. Although we explored adjusting for state-level confounders, we were unable to fully assess and account for this potential bi-directionality.

We assessed a wide array of potential confounders (individual and state-level). However, we had no information on family and peer drinking patterns—factors known to heavily influence drinking during this time period and which may also relate to state of residence and thus APS score. We instead relied on proxies such as parental education, religiosity, and individual demographic characteristics. As such, we may have residual confounding that may have biased the results. This residual confounding may be even more complex when looking at trajectories across this life course period. Specifically, the confounders of interest may vary from earlier years (e.g., peer influences, familial factors) versus later years of the trajectory (e.g., marital status, employment, mental health, prior alcohol dependence). Future research should acknowledge this complexity in confounder mechanisms.

Finally, while many of the trajectory patterns identified are consistent with prior work using a variety of samples from various age cohorts, our findings may not be fully generalizable. Specifically, our sample includes individuals who "came of age" in the early 2000s. This includes unique lived experiences and social norms. Prior research across a wide variety of age-cohorts in both the U.S. and abroad has consistently identified certain trajectories (i.e., a portion of abstainers, high frequency, etc.). As such, we would expect some consistency in the trajectories identified in later age cohorts in the US. However, the size and demographics of these groups would likely change if examining a different age cohort. For example, recent research suggests the "gender gap" in drinking is reducing. While men have traditionally been more likely to use alcohol, evidence from birth cohorts of the late 1990s suggests women are closing the gender gap and now make up a larger portion of the drinking (and binge drinking) population.[74] In addition, substance use patterns in the U.S. have shifted in recent decades with general declines in alcohol use and heavy episodic use among more recent birth cohorts.[75,76]

In this study, we identified a variety of drinking and binge drinking trajectories in a nationally representative cohort aging from 12–30. Results from the drinking day trajectory analyses suggest the state-level alcohol policy environment may impact those following the “typical” developmental trajectory by discouraging use patterns characterized by earlier initiation. For the most part, these associations were not reflected when examining binge drinking trajectories. This study adds to the evidence-base on the alcohol policy environment and drinking trajectories. These findings highlight areas for future research, including incorporating trajectory modeling methods that allow for heterogeneity within trajectories, assessing the role of time-varying APS score, and identifying critical time periods where alcohol policy may influence drinking trajectories. Longitudinal cohorts offer opportunities to examine the impact of state-level policies on individuals over time to better inform policy implementation.

3.5 FIGURES AND TABLES

Figure 3.1: Drinking day trajectories from age 12–30 in the NLSY97 cohort (n=8,860)

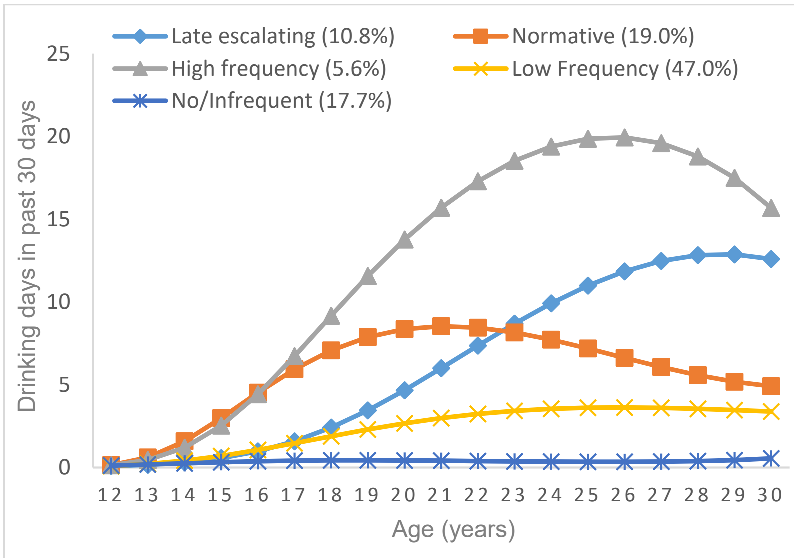


Figure 3.2: Binge drinking day trajectories from age 12–30 in the NLSY97 cohort (n=8,860)

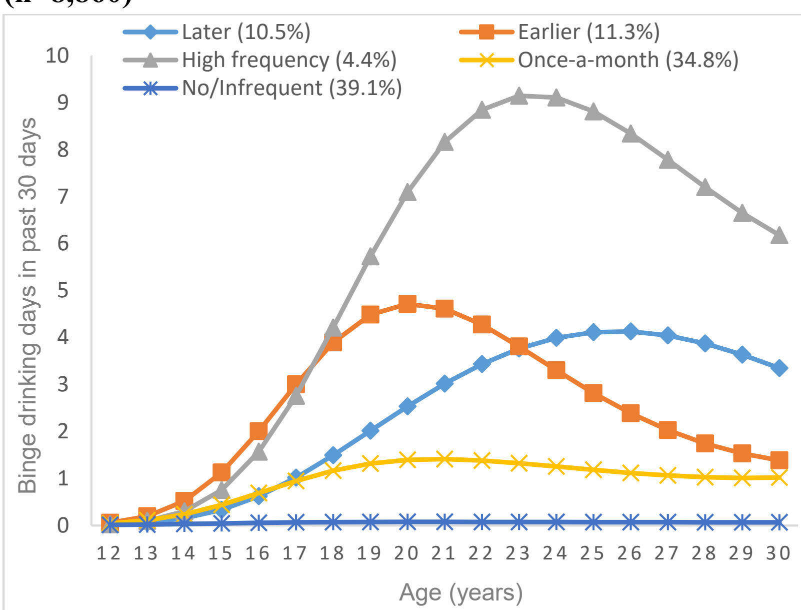
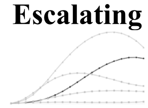
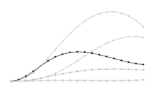
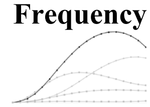
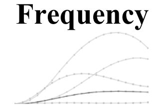
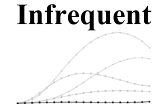


Table 3.1. Baseline demographics by drinking days trajectory group in the NLSY97 cohort (n=8,860)

	Total	Late Escalating 	Normative 	High Frequency 	Low Frequency 	No/ Infrequent 
Sample size	8,860	894	1,464	428	4,212	1,862
Sample %	-	10.8	19.0	5.6	47.0	17.7
Female, n(%)	4,322 (48.7)	329 (38.4)	582 (41.1)	113 (28.4)	2,267 (54.1)	1,031 (54.9)
Baseline age, mean (SE)	14.4 (0.02)	14.3 (0.05)	14.4 (0.03)	14.3 (0.08)	14.3 (0.02)	14.4 (0.04)
Race, n(%)						
White	5,147 (72.3)	569 (75.5)	1,107 (84.9)	321 (84.4)	2,419 (71.4)	731 (55.3)
Black or African American	2,361 (15.8)	208 (13.8)	168 (6.6)	57 (7.0)	1,115 (15.8)	813 (29.5)
American Indian, Eskimo, or Aleut	60 (0.8)	5 (0.5)	4 (0.3)	3 (0.7)	29 (0.9)	19 (1.4)
Asian or Pacific Islander	159 (2.4)	24 (3.4)	17 (1.4)	4 (1.1)	74 (2.4)	40 (3.5)
Other[a]	1,133 (8.7)	88 (6.8)	168 (6.9)	43 (6.8)	575 (9.5)	259 (10.4)
Hispanic ethnicity, n(%)	1,887 (13.0)	155 (10.9)	279 (10.9)	65 (8.5)	964 (13.9)	424 (15.3)
Census region, n(%)						
Northeast	1,556 (18.3)	161 (19.7)	282 (20.6)	77 (20.0)	742 (17.8)	294 (15.8)
North Central	2,024 (26.4)	210 (26.0)	382 (28.7)	99 (25.5)	1,002 (27.3)	331 (21.8)
South	3,308 (34.2)	317 (31.7)	437 (27.9)	149 (32.9)	1,532 (34.1)	873 (43.2)
West	1,972 (21.1)	206 (22.6)	363 (22.8)	103 (21.5)	936 (20.8)	364 (19.1)
Rural,[b] n (%)	2,001 (26.4)	219 (27.1)	329 (24.7)	98 (25.3)	931 (26.5)	424 (27.8)
Household size, mean (SE)	4.5 (0.02)	4.3 (0.05)	4.3 (0.04)	4.3 (0.06)	4.4 (0.03)	4.8 (0.06)
Household income ($), mean (SE)[c]	52,256 (1,023)	60,202 (2,154)	60,990 (2,075)	62,696 (2,444)	50,483 (1,088)	38,689 (1,656)

Poverty ratio, mean (SE)[d]	3.2 (0.07)	3.6 (0.13)	3.7 (0.13)	4.0 (0.17)	3.1 (0.07)	2.3 (0.09)
Parent/ guardian high school,[e] n(%)	6,717 (81.8)	743 (87.2)	1,251 (89.4)	372 (90.5)	3,148 (80.5)	1,203 (70.8)
Parent/ guardian very religious,[f] n(%)	2,118 (22.4)	199 (21.6)	272 (17.8)	77 (16.5)	1,002 (22.2)	56 (30.1)
Alcohol use						
Drinking days, mean (SE)	0.8 (0.04)	0.5 (0.07)	2.2 (0.12)	1.8 (0.23)	0.5 (0.03)	0.3 (0.5)
Binge days, mean (SE)	0.4 (0.03)	0.2 (0.06)	1.2 (0.09)	1.0 (0.15)	0.2 (0.02)	0.1 (0.02)
Started drinking before 13	2,241 (26.7)	217 (25.0)	643 (43.6)	179 (42.6)	929 (22.9)	273 (15.0)
Age at first drink, mean (SE)	15.4 (0.06)	15.4 (0.13)	13.6 (0.07)	13.6 (0.15)	15.7 (0.06)	17.7 (0.15)
Non-drinker, n (%)	422 (4.2)	0 (0.0)	0 (0.0)	0 (0.0)	53 (1.3)	369 (20.4)

Note: means and percentages account for complex survey design and incorporate sampling weights

[a] Includes don't know and refused

[b] Unknown are included under urban

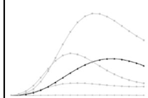
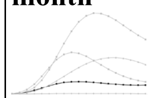
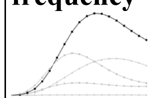
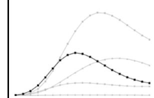
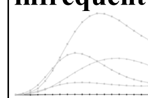
[c] n=6,528

[d] n=6,501

[e] At least one parent/guardian completed high school or GED equivalent

[f] religiosity index (0–600) based on response to battery of questions related to religion asked of parent/guardian at baseline. Scores of 500 or higher were considered very religious. Respondents with no responses to this question were coded as 0.

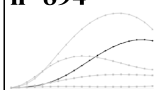
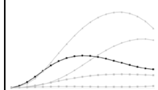
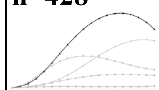
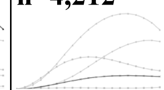
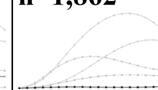
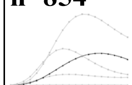
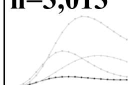
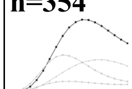
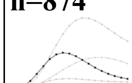
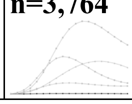
Table 3.2. Baseline demographics by binge drinking days trajectory group in the NLSY97 cohort (n=8,860)

	Total	Later 	Once-a-month 	High frequency 	Earlier 	No/ infrequent 
Sample size	8,860	854	3,013	354	874	3,765
Sample %	-	10.5	34.8	4.4	11.3	39.1
Female, n(%)	4,322 (48.7)	286 (34.6)	1,388 (47.2)	67 (18.8)	277 (33.6)	2,304 (61.4)
Baseline age, mean (SE)	14.4 (0.02)	14.4 (0.05)	14.4 (0.03)	14.3 (0.09)	14.4 (0.05)	14.3 (0.03)
Race, n(%)						
White	5,147 (72.3)	569 (78.6)	1,889 (75.4)	250 (81.0)	662 (84.9)	1,777 (64.2)
Black or African American	2,361 (15.8)	151 (10.6)	634 (12.3)	53 (8.7)	112 (6.7)	1,411 (23.6)
American Indian, Eskimo, or Aleut	60 (0.8)	7 (0.8)	15 (0.6)	3 (0.9)	5 (0.5)	30 (1.1)
Asian or Pacific Islander	159 (2.4)	12 (1.8)	55 (2.4)	3 (1.0)	11 (1.6)	78 (3.0)
Other[a]	1,133 (8.7)	115 (8.3)	420 (9.2)	45 (8.4)	84 (6.3)	469 (9.0)
Hispanic ethnicity, n(%)	1,887 (13.0)	174 (11.5)	706 (13.8)	73 (11.5)	156 (11.1)	778 (13.3)
Census region, n(%)						
Northeast	1,556 (18.3)	159 (20.1)	538 (18.4)	55 (16.9)	173 (21.7)	631 (17.0)
North Central	2,024 (26.4)	210 (27.8)	690 (26.4)	85 (27.5)	243 (30.2)	796 (24.8)
South	3,308 (34.2)	294 (31.7)	1,032 (32.0)	128 (35.1)	272 (28.7)	1,582 (38.3)
West	1,972 (21.1)	191 (20.4)	753 (23.2)	86 (20.5)	186 (19.4)	756 (19.9)
Rural,[b] n (%)	2,001 (26.4)	202 (26.4)	673 (25.9)	82 (26.2)	216 (27.0)	828 (26.6)
Household size, mean (SE)	4.5 (0.02)	4.5 (0.05)	4.4 (0.03)	4.3 (0.06)	4.3 (0.04)	4.6 (0.04)
Household income ($), mean (SE)[c]	52,256 (1,023)	56,595 (2,000)	54,367 (1,443)	53,607 (3,275)	57,707 (1,858)	47,339 (1,188)
Poverty ratio, mean (SE)[d]	3.2 (0.07)	3.5 (0.13)	3.3 (0.09)	3.3 (0.20)	3.6 (0.12)	2.9 (0.07)

Parent/ guardian high school,[e] n(%)	6,717 (81.8)	683 (85.2)	2,309 (82.5)	290 (86.3)	722 (86.9)	2,713 (78.2)
Parent/ guardian very religious,[f] n(%)	2,118 (22.4)	177 (19.6)	644 (20.2)	58 (15.4)	167 (18.1)	1,072 (27.1)
Alcohol use						
Drinking days, mean (SE)	0.8 (0.04)	0.9 (0.09)	0.9 (0.05)	1.9 (0.26)	2.2 (0.16)	0.2 (0.03)
Binge days, mean (SE)	0.4 (0.03)	0.4 (0.05)	0.4 (0.03)	1.1 (0.18)	1.7 (0.16)	0.04 (0.01)
Started drinking before 13	2,241 (26.7)	282 (34.3)	887 (30.5)	152 (44.2)	339 (39.2)	581 (15.9)
Age at first drink, mean (SE)	15.4 (0.06)	14.5 (0.1)	14.8 (0.06)	13.7 (0.2)	14.0 (0.1)	16.9 (0.1)
Non-drinker, n (%)	422 (4.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	422 (10.8)

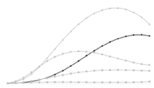
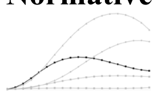
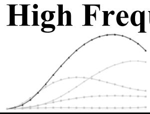
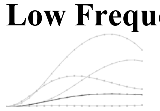
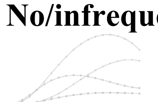
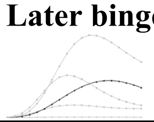
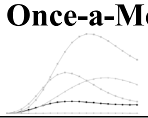
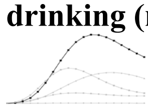
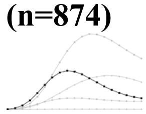
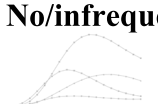
Note: means and percentages account for complex survey design and incorporate sampling weights
[a] Includes don't know and refused
[b] Unknown are included under urban
[c] n=6,528
[d] n=6,501
[e] At least one parent/guardian completed high school or GED equivalent
[f] religiosity index (0–600) based on response to battery of questions related to religion asked of parent/guardian at baseline. Scores of 500 or higher were considered very religious. Respondents with no responses to this question were coded as 0.

Table 3.3. Overlap of alcohol use frequency trajectories with binge drinking frequency trajectories (n=8,860)

		Drinking days trajectories					
		Total N=8,860	**Late Escalating n=894** 	**Normative n=1,464** 	**High Frequency n=428** 	**Low Frequency n=4,212** 	**No/ Infrequent n=1,862** 
		n (column%)	**n (column%)**	**n (column%)**	**n (column%)**	**n (column%)**	**n (column%)**
Binge Drinking Days Trajectories	**Later n=854** 	854 (10.5)	270 (29.6)	239 (16.5)	125 (29.1)	214 (5.3)	6 (0.3)
	Once-a-Month n=3,013 	3,013 (34.8)	385 (42.3)	611 (41.0)	47 (11.1)	1,838 (43.6)	132 (7.7)
	High frequency n=354 	354 (4.4)	47 (5.2)	95 (6.3)	169 (38.4)	38 (0.9)	5 (0.3)
	Earlier n=874 	874 (11.3)	100 (12.2)	459 (32.2)	87 (21.4)	205 (5.3)	23 (1.1)
	No/ Infrequent n=3,764 	3,765 (39.1)	92 (10.6)	60 (4.1)	0 (0.0)	1,917 (44.9)	1,696 (90.6)

Note: percentages account for complex survey design and sampling weights

Table 3.4. Association between a 10-unit higher baseline APS score and odds of trajectory membership (n=8,860)

	Unadjusted			Adjusted[a]		
	OR	95% CI		OR	95% CI	
Drinking days trajectory						
Late escalating (n=894) 	1.14	0.95	1.36	1.13	0.98	1.31
Normative (n=1,464) 	0.93	0.75	1.15	0.94	0.81	1.10
High Frequency (n=428) 	1.09	0.86	1.39	1.08	0.89	1.32
Low Frequency (n=4,212) 	1.04	0.91	1.17	1.06	0.97	1.17
No/infrequent[b] (n=1,862) 	-	-	-	-	-	-
Binge drinking days trajectory						
Later binge drinking (n=854) 	1.02	0.88	1.18	1.03	0.91	1.17
Once-a-Month (n=3,013) 	1.01	0.89	1.14	1.05	0.94	1.16
High frequency binge drinking (n=354) 	1.02	0.86	1.21	1.04	0.88	1.23
Earlier binge drinking (n=874) 	1.01	0.82	1.24	1.02	0.86	1.21
No/infrequent[b] (n=3,765) 	Ref	-	-	Ref	-	-

[a] Adjusted for gender, baseline age, race, Hispanic ethnicity, urban status, parent high school completion
[b] Comparator outcome trajectory

CHAPTER 4: NEIGHBORHOOD DISORDER AND SUBSTANCE USE-RELATED RISK- AND TREATMENT SEEKING BEHAVIORS: COMPARISON OF APPROACHES FOR DETERMINING NEIGHBORHOOD EXPOSURE

4.1 BACKGROUND

Substance use behaviors occur within a complex social-ecological framework,[3,4] wherein an individual's decision-making is highly influenced by daily exposure to social and physical environments. Neighborhood context is a critical sphere of influence on individual behavior and an important aspect of a neighborhood is neighborhood disorder. Neighborhood disorder is a lack of physical and social control within a neighborhood by neighborhood residents.[77] It often manifests and can therefore be measured via visible proxy measures within the neighborhood itself (e.g., litter, abandoned buildings).

Neighborhood disorder has been associated with a broad range of substance use-related behaviors and outcomes, across a variety of populations. Perceptions of neighborhood disorder have been linked to higher alcohol consumption.[15,16,18] Both the social and physical aspects of disorder have been associated with increased injection frequency as well as higher prevalence of equipment sharing among populations of persons who inject drugs.[22–25] Objective, observational measures of disorder have been associated with juvenile drug arrests,[78] marijuana use in adolescence,[79,80] and hazardous alcohol use.[15–21] Yet, the majority of studies assign levels of disorder to individuals based on their residential address (where one lives/sleeps). Individuals may spend time in a variety of locations beyond their residential neighborhood. An expanded consideration of opportunities for exposure to disorder is warranted to better understand the relationship between disorder in the lived environment and health behaviors, and may help to highlight new opportunities for location-based interventions.

Exposure to neighborhood disorder may influence behavior through a variety of mechanisms. One proposed pathway is that a more disordered neighborhood environment leads to chronic stress and anxiety, which can contribute to mental health symptoms and behaviors aimed at coping with stress.[15,16,81–84] Several studies have found positive associations between neighborhood disorder and depression symptoms over time,[85] poor mental health (e.g. psychological distress),[15,86] and biologic markers of stress such as telomere length[87] and allostatic load.[88] Some disorder research has tried to explore this pathway, including one study which found higher disorder led to increases in injection drug use frequency and equipment sharing via increased psychological distress.[22]

Neighborhood disorder may also influence behavior via more indirect pathways. Underinvestment in neighborhoods and the visual dilapidation of the space increases feelings of powerlessness[89,90] and erodes trust among residents in a process termed "structural amplification."[90] This loss of control and powerlessness may increase stress, anxiety, and resulting coping strategies. Another way neighborhood disorder may indirectly influence behavior is by creating more opportunities for risk taking and influencing location choices.[91,92] More specifically, the visual cues of disorder (i.e. abandoned buildings, trash, broken windows) may lower an individual's perceived risk of consequences.[77,91]

Finally, it is important to emphasize that neighborhood disorder may reflect wide-spread, historical disinvestment. This includes limited access to and the spatial distribution of resources to combat substance use such as community-building organizations and treatment services.[93] Given the long-standing history of discriminatory housing policies and racial residential segregation in the United States,[94] neighborhood disorder and its impacts may be experienced more frequently by Black individuals and communities.

While results consistently support that disorder plays a role in substance use and related behaviors across a variety of population subgroups, the magnitude of neighborhood disorder effects vary, and null effects have also been found.[19,95] Mixed results may be due to the myriad of disorder definitions (i.e., perceived versus objective disorder measures), the different areal units where disorder is assessed (i.e., community statistical area, Census block groups and tracts), and the variety of measurement instruments/scales used to quantify exposure to disorder. Indeed, validated instruments to assess the incidence and prevalence of environmental indicators of neighborhood disorder vary widely across the literature, including metrics ranging from self-report to those relying on independent, observational assessments. This, along with variations in how substance use outcomes were assessed, may explain the cross-study inconsistencies.

Another potential source of variation in the literature is the role of misclassification of disorder on observed results. Some behaviors such as sharing syringes or other injection equipment may occur within and be influenced by non-residential locations, while others such as treatment seeking may be most influenced by residential location. Failure to account for the most etiologically relevant disorder locations for a particular outcome could lead to over or under estimation of the effect. It is also possible that groups which have been stigmatized and marginalized—including those with HIV and/or a history of drug use—may be particularly sensitive to disorder outside of live/sleep location.

Disorder is typically assessed via self-report or observational metrics. These two methods of collecting information on disorder may represent different constructs.[19] Self-reported metrics (sometimes called subjective neighborhood disorder) reflect personal perceptions and personal lived experiences of disorder. They depend on not only exposure to disorder but how that disorder is interpreted and internalized by the resident. As such, different individuals may report different perceived disorder when experiencing the same neighborhood area[96] and self-report may vary by demographics such as age and gender identity.[19]

Use of disorder metrics not self-reported by residents (objective rather than subjective) may separate out the environmental indicators of disorder from how those indicators are perceived. Yet, some observational disorder assessment methods only rely on Census measures to characterize the neighborhood environment thus limiting exposure data to summary economic and structural factors (e.g. poverty rate, unemployment, single-family households).[97,98] Such observational metrics are unable to reflect the immediate physical and social environment.

Direct, rater-based observational metrics offer an opportunity to evaluate the neighborhood environment independently from respondent perceptions and with greater granularity than Census data can typically provide. One such scale, the Neighborhood Inventory for Environmental Typology (NIfETy), has been shown to be a reliable and valid measure of the prevalence of environmental indicators of neighborhood disorder.[77,91] NIfETy scores indicating high neighborhood disorder have been associated with a wide range of behaviors, including increased risk-taking among adolescents,[99] marijuana use[79,80], and crime.[78]

Beyond the challenge of quantifying neighborhood disorder, there is the question of where and when to measure exposure. The majority of research on neighborhood disorder and substance use has focused on where individuals live as the primary exposure point. Residence-based exposure determination is common because residential location data are often readily available.[100] In addition, environmental conditions close to place of residence may be the most etiologically relevant. Yet, individuals may spend time in a variety of locations that may be important for substance use and related behaviors. Focus solely on residential location could lead to exposure misclassification by assuming individuals are only influenced by their residential neighborhood.

Approaches that acknowledge and account for exposure variation introduced by individual movement patterns have risen in popularity in recent years.[101] One approach is to identify and measure exposure at locations a person comes into contact with during their daily activities beyond their residential location. These “activity spaces” have been used in a wide range of disciplines[102–109] and may be important sources of exposure variation missed when focusing solely on residential location. Accounting for activity-based location exposures may better summarize the full scope of environmental exposure.[100,110,111] Yet, most activity space evaluations do not consider the proportion of time spent at a given activity space location. Weighting by proportion of time spent at each location will further refine activity-space exposure methods, and acknowledge not only the spatial but also the temporal variation inherent in human movement.

Few studies have assessed neighborhood disorder exposure-levels taking these additional activity locations into account. Fewer studies have explored the relationship between neighborhood disorder and drug use and related behaviors within populations with higher prevalence of current and past drug use. To fill these research gaps, the aims of the current study are to: (1) evaluate the associations between exposure to neighborhood disorder and engaging in risk behaviors, using the traditional residential (live/sleep) address approach to measuring exposure to neighborhood disorder, (2) examine these associations accounting for proportion of time spent within the neighborhood where they live/sleep, and (3) create a measure of neighborhood disorder exposure that incorporates neighborhood exposures beyond just residential neighborhood (i.e. weighted by time spent in different activity-based locations) and estimate its association with behavioral outcomes. We hypothesized that, among a population with a high prevalence of persons living with HIV and/or a history of substance use, living in a neighborhood with more physical and social disorder would be associated with increased participation in risk behaviors and decreased participation in treatment-seeking behaviors, compared with living in areas with less disorder. We expected time spent at residential address would be an effect modifier of the observed disorder-outcome associations, suggesting time as a determinant of exposure "dose". We also hypothesized that a time- and activity-weighted exposure measure would be more strongly correlated with the outcomes and further improve model fit compared to residential address alone.

4.2 METHODS

Below, we first describe the two data sources used for this secondary data analysis: (1) the Baltimore-based HIV care and prevention study data that form the base of our individual-level location, covariate, and outcome data and (2) the observational data on disorder at sampled locations throughout Baltimore which determine disorder scores. We then describe how these two data sets were combined to construct measures of neighborhood disorder at an individual study participant's residential (live/sleep) address and an activity-weighted neighborhood disorder score. Finally, we detail the statistical analyses performed in order to assess the association between the disorder scores and our outcomes of interest.

4.2.1 Data sources: Baltimore-based HIV care and prevention study

Individual-level data for determining exposure location, personal covariates, and outcomes were from the previously collected baseline survey of an HIV care and prevention study in Baltimore, Maryland. Baseline data were collected from May 2014 through March 2017. Recruitment strategies included targeted street outreach and participant referral. Inclusion/exclusion criteria varied slightly depending on recruitment strategy. For those recruited directly via street outreach, individuals had to be: ≥18 years of age; current Baltimore residents (with no plans to move in the next year); not currently participating in intervention studies at the research site; HIV-positive (validated via documentation or OraQuick®, OraSure Technologies, Inc.); and to have used heroin, cocaine and/or crack (or marijuana added 5/14/15).[110] In addition, individuals had to be identified as being at increased risk for transmitting HIV to others due to specific health behaviors including (1) infrequent or inconsistent medical care (defined as either no HIV medical care in the past 6 months or treatment gap of 6 months or more any time in the past 2 years) or (2) any of these other behaviors in the past 90 days: not taking prescribed HIV medications, sharing injection equipment, or unprotected anal or vaginal sex. In addition, individuals had to be willing to participate in group sessions and to talk to others about HIV. Those recruited via participant referral (network-based recruitment), had to be 18 years of age or older and have a peer referral coupon from a verified street outreach-recruited participant. Those recruited via networks did not have an HIV test for eligibility nor were there any substance use requirements.

Baseline surveys were administered to qualifying individuals. Data collected included personal history and demographics, medication adherence, health services utilization, general substance use behaviors and history, and injection drug use behaviors (among those reporting injection drugs in past 6 months). Some sections of the survey were interviewer-administered using computer-assisted personal interviewing (CAPI) and a selection of potentially sensitive questions that may be misreported if an interview was present were self-administered using audio computer-assisted self-interview (ACASI). Topics that were reported via ACASI included: injection drug use, sexual history, and condom use behaviors. During these sections, the tablet was handed over to the interviewee and they were able to complete the questions without the interviewer knowing their answers.

In addition to the above topics, each individual reported information on the locations (i.e., address or cross streets) where they may have participated in various activities over the past 6 months. Details on data collection procedures for location data have been reported previously.[110] Briefly, the locations recorded (as applicable) were places where they: (1) were recruited to participate in the study, (2) most often lived or slept, (3) most often injected, (4) most often worked or earned money, (5) most often spent time with friends (hereon called socialized), and (6) spent the most time. In addition to reporting these locations (if applicable), individuals were asked to report the number of hours spent in each reported location on an average week in the past 6 months. Location information was recorded via an interviewer administered web-based survey, where participants were asked to confirm the locations they provided using map and street-view imagery.[110] If the respondent was unable to recall an address, participants could use landmark proxies and refine their searches to pinpoint locations via Google Mapping tools. Given confidentiality and misreporting concerns, if they preferred, participants could provide locations within the vicinity (a few blocks) of the exact location. After reviewing the location on google maps the interviewee confirmed and the agreed upon location was geocoded automatically using a web-based mapping software and stored in the database. At that point, two follow-up questions were asked: (1) “How many days per week do you typically spend in this location or in this area?” and (2) “On a typical day that you are at this location or in this area, how many hours do you typically spend there?”. These responses were used to calculate percent of time spent at each location in a typical week.

4.2.2 Data Sources: NIfETy data collection

The Neighborhood Inventory for Environmental Typology (NIfETy) is a validated tool for assessing neighborhood disorder.[77] This objective evaluation of disorder was previously collected for Baltimore metro-area neighborhoods in 2012 and forms the neighborhood-level exposure for the current secondary data analyses. Details on the NIfETy scale, data collection methods and validation have been published previously.[77,91] In brief, Baltimore neighborhood statistical areas (NSAs; defined by census data, city planning data, and community meetings regarding neighborhood boundaries) were assessed by pairs of trained field raters who visited randomly sampled blocks within each neighborhood during both day- and night-time periods for 30 minutes and assigned scores for 172 neighborhood characteristics (or items).[77] Certain items were marked as present or not present (dichotomous) while the frequency of other items were counted. Data were entered into a pre-programmed digital assistant and uploaded to a secure server.[77] The NIfETy instrument items fall into one of seven domains: (1) physical layout, (2) structure types, (3) adult activity, (4) youth activity, (5) physical disorder and order, (6) social disorder and order, and (7) violence, alcohol and other drugs.[77] Both the full scale and domains have been validated with high reliability.[91] Similar to prior neighborhood disorder investigations, current analyses used day-time ratings for the physical, social and violence, alcohol, and other drugs domains (domains 5, 6 and 7 respectively), which collectively include 91 different items (Appendix Table A4.1). In prior studies, NIfETy social and physical domains were correlated with young adult substance use and local crime data.[77,78,112]

4.2.3 Constructing neighborhood disorder scores

In order to construct and assign neighborhood disorder scores to individuals participating in the HIV prevention study, we first had to prepare the NIfETy data set for merging with the participant data set. This included (1) geocoding the NIfETy locations, (2) calculating the NIfETy scores and summarizing across neighborhood, and (3) then merging this neighborhood-level score data with the matching participant locations for live/sleep and other activity spaces. These steps are outlined below.

<u>1. Geocoding of NIfETy block-level data to assign a NSA:</u>

A total of 811 sampled blocks had a completed NIfETy evaluation for 2012. NIfETy block addresses were geocoded using the geocode address feature in ArcMAP.[113] Of the 811 addresses, 800 had a geocode match of 90% or higher. Eleven addresses were tied (more than one potential location was identified). The 11 tied matches were reviewed and found to be unmatchable due to incomplete address information. A random sample of 50 matched addresses were reviewed for data quality assurance. Locations were then mapped to confirm no addresses fell outside of the Baltimore city border (Appendix, Figure A4.1).

Each of the 800 geocoded NIfETy block data points were assigned to the NSA they were located within via the spatial join feature in ArcMAP.[113] Of the 277 Baltimore NSAs a block data point could be located within, 22 areas are considered non-residential (population = 0) and were not eligible for NIfETy sampling. Of the remaining 255 NSAs, 23 neighborhoods had no NIfETy data point contained along or within the borders of the neighborhood (see Appendix, Figure A4.2). The remaining 232 neighborhoods that had at least one NIfETy block data point.[114]

2. Creation of NIfETy disorder scores and summary by NSA

For each block data point, items were dichotomized to either present or not present. We then summed across the 91 items to create a score representing all items present in the NIfETy block at the time of data collection. Some of the items collected could potentially represent order rather than disorder (e.g., murals, parks and playgrounds) and some items were only asked if other items were present (i.e. police walking the beat was not collected if police were not present). For sensitivity analyses, an alternative score was constructed removing these two types of items. Descriptive statistics for overall disorder (hereon called Total Score) as well as the Physical, Social and VAOD domains can be found in Appendix Table, A4.2.

After sums for each of the 800 block data points were created, the scores were then averaged across all data points within an NSA to create an average total neighborhood disorder score for each NSA with at least one sampled block. Average scores were also created for each of the subdomains. Appendix Figure A4.3 shows the average total disorder score within each NSA prior to assigning scores to participant reported locations.

3. Merging NIfETy neighborhood scores with individual-level location data

Baseline survey participant's self-reported location information was used to assign an NSA for each reported location type (where they lived/slept, injected, worked/earned money, socialized, and spent the most time) using ArcGIS 10.2.[113] Once assigned, the previously created NIfETy disorder scores were matched to each participant for each reported location.

4.2.4 Residential address-based neighborhood disorder and time spent within Baltimore

For each participant's residential address-based exposure, we assigned NIfETy disorder scores (Total, Physical, Social and VAOD scores) to the mapped NSA where they reported living/sleeping for the past 6-months. Since individuals could identify locations outside of Baltimore city limits, individuals whose live/sleep location was outside of Baltimore or could not be assigned a NIfETy score were excluded.

Even if participants reported living/sleeping at a Baltimore location, some reported spending time outside of Baltimore on other activities (e.g. socializing outside of city limits) or time where no NIfETy value could be assigned (visiting an area where no block sample was nearby). As such, an individual's percentage of total time accounted for within Baltimore city-limits could be less than 100%. The median percent time in Baltimore was 98.9% with 38% of the sample reporting 100% of time in the city and 82% reporting 75% or more (overall range 5.6% to 100%). A histogram of the percent of time in Baltimore city-limits can be found in Appendix Figure A4.4.

Final disorder scores for where individuals lived/slept were evaluated as continuous variables. This residential exposure definition is commonly used within social/neighborhood-exposure literature and serves as the "standard" of comparison against the time-weighted exposure score described below.

4.2.5 Time-weighted activity space-based neighborhood disorder

We next constructed time-weighted activity space exposure measures. As previously mentioned, in addition to reporting where they lived/slept, participants were asked to report where they: worked/earned money, socialized, and injected drugs (if applicable) in the last 6 months and the average hours per week spent in each reported location.[110] Similar to live/sleep address exposure, locations reported for each activity were matched to all corresponding NSA NIfETy scores (e.g., for a participant reporting 4 different locations for each activity, each location was assigned the corresponding disorder score).

Using a previously published weighting method, we then created an activity space-weighted measure of exposure for each individual based on self-reported hours in each unique NIfETy area.[110] First, we identified all unique locations identified by the individual and the corresponding proportion of time spent at that location. As such, in cases where the same location was identified for different activities (i.e., residential location was the same as socializing location) the location was only used once in the calculation. The proportion of time spent in each unique location was multiplied by the disorder score for that given location and then the products for each unique location were summed to construct the weighted score. This value was then divided by total time spent within Baltimore to further account for individuals having less than 100% of time accounted for:

$$Activity\ Weighted\ Disorder = \frac{\sum_{Location}(\%activity\ time_i\ \times\ location\ disorder\ score_i)}{\sum_{Location}\%activity\ time_i}$$

Similar to the live/sleep exposure measure, the score was analyzed as a continuous exposure.

4.2.6 Outcomes

Associations between each of the exposure definitions (residential and activity-weighted) and substance use related outcomes were explored via separate models. Each outcome is outlined below:

- Alcohol misuse: The Alcohol Use Disorders Identification (AUDIT-10) scale developed by the World Health Organization was used to assess alcohol misuse.[115] Each AUDIT item is scored from 0–4 (total AUDIT-10 score range: 0–40).[115] Hazardous/harmful use in the past year was defined as a score of 8 or higher. This cut-point has high sensitivity and specificity across a broad range of populations, including individuals who use drugs.[115–117] In sensitivity analyses, we also explored AUDIT-10 score as a continuous outcome.
- Injected drugs in the past 6 months: Individuals were asked how recently, if ever, they had injected drugs. Those who reported injecting drugs at least once in the past 6 months were defined as having recent injection drug use.
- Needle lending, cotton/rinse water sharing, and cooker sharing (among those who injected drugs in the past 6 months): Those who reported injecting drugs in the past 6 months, were then asked questions about injection-related behaviors. Specifically, they were asked separately whether they had lent a needle after use, shared cotton or rinse water after use, or shared a cooker after use. For example, the needle sharing question was, “When was the last time you gave or lent a needle to another person after you used it?” Anyone answering they had given or lent a needle after use in the past 6 months was defined as having engaged in

needle sharing. Questions for sharing cotton/rinse water ("When was the last time you shared cotton or rinse water with another person after you used it?") and cookers ("When was the last time you shared a cooker with another person after you used it?") had similar response options and were defined in a similar fashion.

- Recent substance use treatment (non-alcohol) among those with a history of drug use: Among those who reported a history of any drug use, we explored non-alcohol treatment engagement. History of drug use was determined by assessing a collection of questions, which asked if they had used any of the following in the past 6 months: crack, cocaine, heroin, injection drugs, methamphetamines, ecstasy (E, X, MDMA), club drugs (i.e., Special K, GBH, Rohypnol), Oxycontin, Percocet, Vicodin, Buprenorphine/Bupes, Valium, Xanax, or other drugs. Any drug treatment in the past 6 months (yes/no) was based on responses to "In the past 6 months have you gone for any kind of drug treatment, meetings, or groups to help you stop using drugs (not including alcohol treatment)?" Among those who had received treatment in the past 6 months, we examined whether individuals took part in any outpatient or residential treatment types. This was assessed based off whether respondents answered yes to questions for each respective treatment type: "(In the past 6 months) were you admitted to an outpatient drug treatment program" and "(In the past 6 months) were you admitted to residential drug treatment?"

4.2.7 Covariates and confounders

A directed acyclic graph informed by the literature was used to identify critical confounders for adjustment. Final inclusion was contingent upon association between exposure and potential confounder and the confounder-outcome association. Based on the literature, potential confounders and descriptive covariates available via the Baltimore baseline data set were as follows:

- <u>Demographic variables</u> included: age at baseline interview (continuous: in years), sex at birth (dichotomous: male, female), race (categorical: Black or African, white, other or multiracial), gender identity (categorical: male, female, transgender, other), sexual orientation identity (categorical: Heterosexual/Straight, Bisexual, Queer, Homosexual/Gay/Same gender loving, Not sure or Questioning, Other). We also evaluated several variables related to income and socioeconomic status, including: past-year income from all sources (categorical: <5000, 5000–10,000, 10,000–19,999, 20,000–29,999, >30,000); how often in the past 6 months they worried about not having enough money for rent, food, or utilities (categorical: never, once in a while, fairly often, very often); and completion of high school or GED equivalent (yes, no). Given this is a population with varying levels of housing stability, we also evaluated variables related to housing, including: whether an individual had been homeless in the past 6 months (yes, no), whether they had squatted for a week or more in the past 6 months (yes, no), details of current living situation (categorical: own place, parent/family, someone else's, rooming/boarding/hallway house/shelter/welfare hotel, on the streets, other), and length of current living situation (categorical: 3 months or less, 4–6 months, 7 months – 1 year, over a year).

- Health-related variables included: health insurance status (yes, no), self-rated health (ordinal: poor, fair, good, very good, excellent), test-confirmed HIV status (positive, negative), self-reported Hepatitis C status (positive, negative). Mental health variables were also explored, including how much mental health interferes with quality of life (ordinal: not at all, a bit, a lot) and depressive symptoms (defined as having a Center for Epidemiologic Studies Depression (CES-D) Score of 23 or higher).

4.2.8 Analytic sample and statistical analyses

As NIfETy scores for areas outside of Baltimore city limits are unknown (but could be assumed to be non-zero), requirements were placed on the percent of time that had to be spent within Baltimore in an average week in order to be included in the analytic sample. This decision also reflects the aims of focusing on persons who reside, and thus spend the majority of their time, within Baltimore. Specifically, we required individuals to have spent 75% or more of their time within Baltimore city limits. Sensitivity analyses were conducted with a higher cut-point (90% or more) and without any exclusions based on percentage of time within Baltimore. Overall analytic sample inclusion criteria were: completing the baseline survey and mapping survey, reporting a live/sleep location within Baltimore city-limits that could be matched to a disorder score, available outcome and demographic information, and spending 75% or more of time in Baltimore.

Prior to building models, descriptive analyses were conducted for relevant variables. To assess the magnitude of the association, we estimated prevalence ratios for a standard-deviation higher neighborhood disorder and each of the dichotomous outcomes. The outcomes assessed in the study were not rare (<10%) for the sample (e.g., 24% reported harmful alcohol use, and over 50% reported drug treatment in the past 6 months). As such, odds ratios resulting from logistic regression would likely not approximate the risk ratio. Instead, a series of log-binomial models were constructed and risk ratios were calculated. Given the cross-sectional and temporal nature of our outcomes (i.e., use in the past 6 months), these risk ratios are conceptually considered to be prevalence ratios. We also assessed the association between a standard deviation higher neighborhood disorder score and log AUDIT score using a negative binomial model. Both unadjusted and adjusted effect estimates with corresponding 95% confidence intervals accounting for clustering within NSA are reported for all models. We then explored whether proportion of time spent in the live/sleep location modified associations via stratified analyses accounting for hours at live/sleeping location on an average week.

Regression analyses for each outcome were then repeated using the time-weighted activity space-based exposure. The exposure definitions were then compared to examine which had a stronger association with the outcomes of interest and which improved model fit.

4.3 RESULTS

4.3.1 Analytic sample

A total of 565 individuals were recruited and completed the baseline survey. Due to interviewer error, 18 participants did not complete the mapping portion of the survey. Of the 547 who completed all portions of the survey, 277 were recruited via targeted street outreach (all HIV positive) and 270 were recruited via peer referral. Of these, 540 participants reported a location where they most often lived/slept. The current study required reporting a live/sleep location that was within Baltimore that could be geocoded (n=494). Of these 494, 88 were excluded due to spending less than 75% of their time within Baltimore. This led to a final sample of 406 for the alcohol use outcomes (harmful alcohol use and continuous AUDIT score) and any injection drug use in the past 6 months. A total of 392 of the 406 individuals reported any history of drug use, with 280 reporting use in the past 6 months. This formed the base sample for the treatment seeking outcomes. Eighty-four had injected drugs in the past 6 months and 70 of these individuals answered the paraphernalia use-related questions. Figure 4.1 displays a flow diagram with the exclusions and restrictions leading to the final analytic samples for each of the given outcomes.

4.3.2 Sample characteristics

The average age of the analytic sample was 49.3 (range 18 to 56), and roughly 57% were assigned male sex at birth (Table 4.1). Ninety percent of the sample identified as Black or African American. Two thirds of the sample had completed high school, GED equivalent, or higher. Half of the sample identified their primary living/sleeping location as their own place, while roughly one third reported living with family (23%) or at someone else's place (10%). The majority of the sample (over 60%) reported their living situation had been in place for over a year. Some individuals reported instability of housing situations, with roughly 21% of the sample experiencing homelessness in the past 6 months and 19% reporting squatting for a week or more in the past 6 months. The majority of the sample identified as being unemployed (83.7%) and earning under $10,000 a year. Over 40% of the sample reported worrying about having enough money for basics fairly or very often in the past 6 months.

Persons living in NSAs with higher levels of neighborhood disorder (top 25% total scores), were slightly younger, more likely to be Black or African American, and less likely to have completed high school or GED equivalent compared with those in neighborhoods with less disorder (Appendix, Table A4.3). There was little variation in prevalence of homelessness or squatting in the past 6 months by disorder score level, but those living in locations in the top 25th percentile of total disorder tended to report having spent less time in their current living situation and were more likely than participants in lower disorder neighborhoods to report worrying about money fairly/very often.

Approximately 59% of the sample were HIV positive, and over one-third tested positive for Hepatitis-C (Table 4.2). The majority of the sample reported their health as fair (37%) or good (33%). A quarter of individuals reported symptoms consistent with depression (CES-D of 23 or higher). Only 14% said their mental health interfered "a lot" in their social lives. When looking at health demographics by disorder score, those with live/sleep locations in the top 25th percentile of disorder had a slightly higher prevalence of being uninsured, HIV positive, and selecting poor/fair for self-reported health (Appendix Table A4.4).

In addition to reporting a live/sleep location, 324 reported a location where they socialized (79.8%, Appendix Table A4.5), 104 reported a location where they worked or earned money (25.6%), and 94 reported an injection location (23.2%). Proportions were similar in the treatment seeking sample. Among the injection behavior sample (those who injected in the past 6 months), 67 out of 70 reported an injection location. In the overall sample (n=406), 340 individuals (roughly 84%) reported 2 or more activity locations. However, only 44% of these 340 individuals identified an additional location for socializing, working, and/or injecting that was unique from their live/sleep NSA (Appendix Table A4.6). Overlap with live/sleep location was most common for the socializing location (45%, Appendix Table A4.7).

Neighborhood disorder scores were fairly consistent across the residential and activity-weighted definitions explored and never reached maximum possible values (Table 4.3). For overall disorder, the neighborhood average was roughly 20 out of a possible 91, with values ranging from 5 to 32. Across domains, activity-weighted score averages were slightly lower than live/sleep averages. Live/sleep disorder score and activity-weighted scores were highly correlated overall (Pearson correlation coefficient = 0.97) and across each subdomain (Appendix Figure A4.5).

4.3.3 Neighborhood disorder and alcohol use

Average AUDIT score was 5.5, with roughly a quarter of persons having scores consistent with harmful alcohol use (AUDIT score of 8 or more) in the past month (Table

4.4). A standard deviation higher live/sleep location neighborhood disorder, was associated with a prevalence ratio (PR) of harmful alcohol use (AUDIT 8+) of 1.14 (95% CI 0.94, 1.40) (Table 4.5). Results were similar after adjustment for age, sex at birth, high school completion status, homeless status, and economic worry (adjusted PR 1.14, 95% CI 0.94, 1.37). This estimated effect was largest for the physical neighborhood disorder domain (adjusted PR 1.14, 95% CI 0.93, 1.40). In sensitivity analyses, a larger portion of time spent in live/sleep location was associated with decreased risk of harmful alcohol use independent of disorder score. However, results were imprecise and accounting for time at live/sleep location did not alter the neighborhood disorder-alcohol use association (Appendix Table A4.8).

We next examined potential effect measure modification by time. When stratified by percent of time (spending 75% or more of their time at live/sleep) we found evidence for effect measure modification (Appendix Table A4.9). Specifically, the relationship between live/sleep location neighborhood disorder and harmful alcohol use was stronger for those who reported spending 75% of their time or more in their live/sleep location.

Activity-weighted neighborhood disorder score results were similar to the live/sleep exposure results (Table 4.5; adjusted PR 1.13, 95% CI 0.93, 1.37). QICs between the live/sleep and activity-weighted exposure were similar with the live/sleep modeling providing a slightly lower QIC (Appendix Table A4.10).

Results for continuous AUDIT score were consistent with the harmful alcohol use models, with a 1 standard deviation higher total disorder being associated with an increase in the log AUDIT score of 0.08—a little over 1 point (Table 4.5). Live/sleep and activity-weighted scores yielded similar model results. QICs were again similar (Appendix Table A4.10).

4.3.4 Neighborhood disorder and substance-use related treatment seeking

Among individuals reporting a history of drug use (n=280), over 60% reported attending drug treatment in the past 6 months, with outpatient service being the most common (Table 4.4). Higher total neighborhood disorder at live/sleep location was associated with slight, decreased prevalence of non-alcohol drug treatment in the past 6 months adjusted results (adjusted PR = 0.97, 95% CI 0.89, 1.07, Table 4.6).

A percentage point increase in time spent at live/sleep location slightly reduced treatment seeking independent of disorder score (Appendix Table A4.8). However, results were imprecise and accounting for time at live/sleep location did not alter the disorder-treatment effect estimate. Effect measure modification assessment where we stratified results by percent of time (75% or more at live/sleep) showed little variation by amount of time spent at live/sleep location (Appendix Table A4.9)

Model results did not vary greatly by disorder domain nor when using the activity-weighted exposure definition (Table 4.6). Model fit statistics suggested similar performance by the two exposure definitions (Appendix Table A4.10).

When considering type of treatment obtained among those who had attended drug treatment in the past 6 months (n=173), higher neighborhood disorder at live/sleep location was associated with an increased likelihood of outpatient treatment versus no outpatient treatment (adjusted PR=1.12, 95% CI 0.96, 1.31; Table 4.6). Results were consistent across domains. Conversely, higher neighborhood disorder was associated with lower prevalence of residential drug treatment versus no residential treatment (adjusted PR=0.88, 95% CI 0.67, 1.16). Results were similar for activity-weighted exposure.

4.3.5 Neighborhood disorder, injection drug use, and risk behaviors

While over 50% of the sample had ever injected drugs, only 20% of all those interviewed had injected drugs in the past 6 months (Table 4.4). Needle lending in the past 6 months among this subsample was low, while sharing cookers or cotton was more common (Table 4.4). This sample was slightly distinctive from those not reporting recent injection drug use. Their AUDIT score was higher (7.01 +/- 8.09 vs. 5.11 +/- 7.33 in other participants) as was the proportion with harmful alcohol scores (30% versus 22%, respectively). They were also less likely than those not reporting recent injection drug use to report living in their own place (36% versus 57%), and more likely to report: homelessness (35% versus 17%) and squatting (33% versus 15%) in the past 6 months. Worry about money (very often) was more common (44% versus 26%) as was the prevalence of depressive symptoms (39% CESD of 23 or higher versus 23%). Prevalence of HIV was slightly lower (50% versus 63%).

Higher total neighborhood disorder at live/sleep location was associated with small increased prevalence of injecting drugs in the 6 months prior in both unadjusted and adjusted models (adjusted PR per standard deviation higher disorder score=1.03, 95% CI 0.88, 1.22, Table 4.7). The activity-weighted total disorder exposure yielded slightly larger effect estimates overall (adjusted PR=1.07, 95% CI 0.91, 1.25) and across subdomains. However, results were imprecise. Model fit statistics suggested similar performance by the two exposure definitions (Appendix Table A4.10).

When assessing the role of time spent at live/sleep location on live/sleep exposure model results, time at live/sleep was associated with a decrease in prevalence of injection drug use independent of disorder score (Appendix Table A4.8). However, the estimates were imprecise with wide confidence intervals and accounting for time had little impact on the disorder-injection association. We next assessed whether there could be effect measure modification by time on the live/sleep-injection drug use association. In stratification analysis higher disorder at live/sleep location was associated with higher injection drug use prevalence among those spending less time at live/sleep location compared to those spending 75% of their time or more at live/sleep location (Table A4.9).

Results for injection related risk behaviors (among those who injected in the past 6 months) were imprecise, likely due to small sample size (Table 4.7). For lending needles in the past 6 months, higher disorder was associated with a slight, decreased prevalence of lending needles. Conversely, higher total neighborhood disorder score was associated with increased prevalence of sharing a cooker and sharing cotton in the past 6 months. Across injection-related outcomes, there was little variation between the live/sleep exposure definition and the activity-weighted exposure definition results. Prior work has shown syringe exchange programs may influence injection-related behaviors.[24] In the current study, 48.6% those who had injected in the past 6 months reported visiting a needle exchange a few times a month or more often with roughly 35.7% visiting once a week or more. Those who did not lend needles were more likely to visit a few times a week or more compared with those who reported lending needles (56.8% versus 34.6%).

4.3.6 Sensitivity analyses

We conducted several sensitivity analyses. Overall, our results were robust to a variety of different exposure aggregation methods and sample inclusion criteria. Each assessment is outlined below.

First, for the activity-weighted exposure measure we divided by total proportion of time in Baltimore (range of proportion of time 75% to 100%) to account for the differences in the proportion of time reported across individuals. For those that spent less time in the city (i.e., 75%) this strategy assumed the person's remaining time was spent in a similar level of neighborhood disorder to their reported time. To test this assumption, we assigned the missing proportion of time to the minimum and then the maximum disorder levels for the study. Accounting for missing time in the activity-weighted measure using the population maximum, average, and minimum disorder scores did not substantially alter exposure scores or model results for the main study outcomes (Appendix, Table A4.11).

The main analyses restricted the sample to individuals who spent 75% or more of their time in Baltimore. In sensitivity analyses we removed this restriction. The removal of this restriction did not alter the results for alcohol use or treatment seeking, but attenuated the injection drug use results (Appendix, Table A4.12).

The NIfETy instrument included a broad range of items—some of which could be associated with order rather than disorder, depending on the circumstances. For example, parks/green spaces may offer opportunities for drug use, but can also be stress reducing and health protective. In a sensitivity analysis, we removed 33 items from the score that could potentially be sources of order rather than disorder, as well as those that were contingent upon presence of another item (see Appendix Table A4.1 for list of items). Effect estimates increased in magnitude for alcohol use and injection drug use, while the treatment seeking effect estimates were null (Appendix Table A4.12).

Given the potential specificity of the injection risk behaviors to the injection activity location, we assessed the association between disorder at injection location and injection risk behaviors (lending needles, sharing cookers, and sharing cotton) among those who reported injecting drugs in the past 6 months and reporting an injection location. The sample size dropped to n=68 from the main analyses as 2 reported no injection location. The protective association between disorder and needle lending was strengthened when looking specifically at injection location. Cooker and cotton sharing results were attenuated (Appendix, Table A4.13).

Finally, our analyses used disorder scores that had been aggregated to the NSA-level. As such, the exposure did not vary within an NSA based on where someone spent time within the neighborhood. An alternative approach would have been to match each individual's reported location to the nearest street location with a NIfETy assessment. As a sensitivity analysis, we assigned disorder score based on NIfETy sampling location nearest to the participant's activity location with a maximum reach of 1 mile (note: 4 addresses couldn't be matched as there was no sampling point within the 1-mile buffer). This alternative exposure assignment approach attenuated the results for alcohol use while strengthening effect size magnitude for treatment seeking and injection drug use (Appendix, Table A4.12).

4.4 DISCUSSION

Neighborhood disorder has been associated with a variety of substance use behaviors including hazardous alcohol use,[15–17,19–21] injection drug use[22,23] and injection equipment sharing.[22] The current study used an objective, independently collected assessment of disorder and compared results using live/sleep location exposure disorder score with an activity-space weighted exposure score. While spending time in a neighborhood with higher disorder was associated with higher prevalence of self-reported harmful alcohol use and was associated with higher AUDIT-10 score, results were imprecise. We found a similar directional relationship between disorder and injection drug use in the past 6 months. Conversely, the relationship of disorder to injection-related risk behaviors (among those who injected drugs in the past 6 months) was inconsistent. We found no association between higher neighborhood disorder and non-alcohol related treatment (among those with a history of drug use). Contrary to our hypothesis, there was little variation in results or model fit between the live/sleep exposure and activity-weighted exposure. However, time spent in live/sleep location may have modified the observed relationships for harmful alcohol use and injection drug use.

Our findings related to harmful alcohol use, though imprecise, are similar to several prior studies.[16,17,20] Yet, some prior studies found no association between neighborhood disorder and alcohol use.[19,84] Furthermore, the majority of studies which found significant associations had samples that only included women,[15,20,86] or found variations in magnitude of effect by gender,[16] race/ethnicity,[18] and individual socioeconomic status.[21,118] The wide variation in findings may reflect the range of exposure definitions (i.e., overall, social, physical, and/or socioeconomic disorder), data collection methods (self-report versus observational), alcohol use definitions, and modeling approaches. In addition, there may be differences in effects seen based on geographic extent examined and overall context of disorder. In our own analyses, results were sensitive to the disorder assignment level (average NSA disorder versus nearest disorder location match), illustrating the impact of geographic extent on findings.

We found a weak, inverse association between higher neighborhood disorder and receipt of any non-alcohol drug treatment. Again, our results were imprecise. Among those receiving treatment in the past 6 months, disorder was associated with increased outpatient treatment. Conversely, higher disorder was associated with decreased residential treatment. While these findings might suggest residential programs are less accessible to those living in higher disorder neighborhoods, it is more likely this finding reflects selection into neighborhoods based on treatment facility location (i.e. entering into residential treatment changes your address to a lower disorder neighborhood rather than directly impacting treatment choice). In addition, the overall null finding related to any non-alcohol drug treatment may reflect heterogeneity of effects—a violation of the consistency assumption. More specifically, in some instances disorder may decrease accessibility (as seen in the case of residential treatment) while disorder may be associated with increased accessibility in other instances.

Our findings related to injection drug use, though imprecise, were in line with prior work that has shown associations between neighborhood disorder and injection drug use.[22,25] These results were also fairly robust across the various sensitivity analyses performed.

Among those who injected drugs in the past six months, greater disorder was associated with small increases in prevalence of both cooker and cotton sharing, but not needle lending (distributive). Prior work has found increased high risk injection behaviors in inner-city settings, but not in surrounding suburban areas.[23] Yet others have found minimal associations between neighborhood-level characteristics and needle sharing (both receptive and distributive)[95] as well as unsterile syringe use.[24] In the current study, the reduced sample size for examining risk behaviors may explain inconsistencies in our study results. In addition, as a large proportion of the sample were HIV+ and aware of their status, it is possible they had received and were familiar with risk reduction practices (i.e., not sharing needles with others) from doctors and other health practitioners—reducing the prevalence of distributive sharing in this sample. Another possibility is that our results reflect success of location-based interventions and education surrounding needle sharing (i.e., clean needle exchange locations). This may have reduced prevalence within higher disorder neighborhoods, similar to prior studies that found access to syringe exchange programs attenuated the relationship between neighborhood socioeconomic disadvantage and unsterile syringe use.[24] In sensitivity analyses, we found this may be occurring in the current sample. Specifically, those who visited exchanges more frequently were less likely to report lending needles.

In the current study, the live/sleep and activity-weighted disorder scores were similar and yielded similar model results across a variety of substance use-related outcomes. This similarity between scores reflects that the greatest proportion of time reported by individuals was often their live/sleep activity space location. As such, the activity-weighted score tended to mirror the live/sleep score. Another contributor to the similarity between the two scores was that activity-locations such as socializing tended to be the same location as the live/sleep location. In addition, only a quarter of the sample identified a location where they worked/earned money or injected drugs. In addition, participants in this study were concentrated in areas of the city with similar disorder levels. This may be a reflection of the recruitment locations used for the study. It could also reflect unspoken boundaries individuals adhere to within the city limits. The study results emphasize the importance of using activity-based measures of exposure in instances where there is sufficient variation in reported locations within the data set.

While we found little variation across the two exposure definitions, time spent at live/sleep location modified results for the live/sleep disorder exposure and harmful alcohol use, as well as injection drug use. Exposure time in addition to location may thus be an important dimension in determining the level of exposure to neighborhood disorder and the magnitude of the disorder-alcohol use association.

This study adds to a growing body of evidence connecting the lived environment to substance use and related behaviors. The current work compared two approaches (residential versus activity-weighting) for determining neighborhood disorder across several different substance use related outcomes. In the activity-weighted exposure, we incorporated other activity-based locations and accounted for the proportion of time spent in each given location. This approach acknowledged there are other opportunities for exposure beyond immediate residential neighborhood that may be etiologically relevant and that time spent at a location may impact disorder exposure. An additional strength of the research was the use of an independent, observational measure of neighborhood disorder. This reduces concerns surrounding dependent error that arise with self-reported exposure, while adding additional granularity on disorder beyond Census-level data (i.e., Census tract-level income) common in the literature. Finally, while a growing body of research has examined exposure misclassification related to neighborhood definitions and boundaries,[119] fewer substance-use studies have compared residential to activity-space exposure measures.[108,109]

This study has important limitations. First, the sample size was reduced for the treatment and injection equipment use outcomes. As such, our results were often imprecise. In addition, the analyses only used baseline survey data. Given the cross-sectional nature of the analyses, associations cannot be interpreted as causal and reverse-causation cannot be ruled out. In addition, recruitment efforts may have led to selection of individuals who spent time only in certain areas of the city and thus may not be representative of this population overall. Furthermore, self-selection into neighborhood may have biased our observed associations.[120] While we tried to account for characteristics that could impact location choices we cannot rule out residual confounding from past substance use or other confounders. Future studies should incorporate activity-space location with longitudinal follow-up or consider methods such as instrumental variable analyses to address neighborhood self-selection concerns.

While the weighted disorder score used in this study is an attempt to acknowledge the diversity of locations an individual may be exposed to, the activity-based score is limited to key activity locations (e.g., live/sleep, work, etc.). It does not cover all locations and subsequent exposures. The current sample also reported experiencing a lot of housing instability and squatting in the past 6 months. It is therefore possible that locations reported were temporary or relevant for a shorter period of time than the requested 6-month time frame. Furthermore, live/sleep locations reported by individuals may have reflected locations such as homeless shelters, residential treatment centers, and jails. In these cases, the live/sleep location may not have the same association with substance use as a longer term, residential neighborhood location.

There may are also limitations related to self-report of substance use. While risk and health behavior self-reports among persons who use drugs have been shown to be valid and reliable,[121,122] participants may have been particularly reticent to report illegal drug use. Prior studies suggest underreporting of risk-behaviors and over reporting of health behaviors.[122,123] Researchers took steps to mitigate underreporting by allowing individuals to complete the substance use behavior questions without the interviewer being able to see and review responses, but the risk of self-reporting error remains. If individuals in higher disorder areas under-reported their substance use, this may have led to underestimation of the true relationship. Conversely, non-differential outcome misclassification or underreporting among those in lower disorder areas may have led the observed to be an overestimation of the true effect. Additional validation research on measurement error by neighborhood characteristics could inform our understanding of self-reporting error and the estimation of resulting impacts on effect estimates.

There are important limitations to the disorder assessment used in the study. First, the neighborhood disorder scores were from 2012 assessments, while the respondent data was collected between 2015 and 2017. While neighborhoods often remain stable over time, there is a chance that the measurements may no longer have reflected the disorder level during respondent reporting. Second, we have summarized point-level disorder data into an area summary score, introducing the modifiable area unit problem—our disorder scores may have varied based on the unit selected (e.g., census tract versus neighborhood statistical area). It is possible we have not selected the proper geographic scale to assess the relationship between disorder and substance use.[124] Finally, the disorder scoring only reflected the disorder of the area, ignoring the mechanisms by which such disorder evolved. Specifically, it ignores the historical and current injustices that may have contributed to observed disorder within neighborhoods and that may continue to influence where individuals spend time within the city. Historical practices targeting communities of color such as redlining and systematic underinvestment in institutions and local infrastructure may have led to the current disorder distribution within the City of Baltimore. The mechanisms by which disorder arises may have important ramifications for interpretation of associations between disorder and substance use. Efforts to apply historical context to the current lived environment continue to be critical for the next phases of neighborhood-level research.

The current study adds to our understanding of the role of the lived environment on substance use and related behaviors. While results were imprecise and causal conclusions are limited due to the cross-sectional nature of the data, persons who live/sleep in neighborhoods with higher disorder reported higher prevalence of harmful alcohol use and injection drug use. In this sample, there was little variation in disorder by live/sleep versus the activity-weighted approach. Yet, this work demonstrates the feasibility and utility of having participants identify activity spaces with the support of mapping technology, while respecting privacy and confidentiality. Particularly when working with populations who have concerns about confidentiality and privacy, as well as low prevalence of smartphone ownership (as was the case with the current population), this approach may be preferred over other data collection methods such as geographic momentary assessments.[125]

As activity-spaces and other methods to capture spatial variation rise in popularity and become more accessible with mobile technologies, the question of which spaces are etiologically relevant will be important considerations for researchers. In addition, researchers should consider the mobility of their sample when deciding whether to explore activity-based exposure definitions. Additional longitudinal assessments[98,126,127] and evaluation of the impact of interventions aimed at neighborhood improvement[128] are needed to better understand the bi-directional relationship between behavior and place, particularly among marginalized groups. Better conceptualizing space and considering the role of non-residential locations in exposure variation could advance neighborhood exposure research and inform area-improvement initiatives.

4.5 FIGURES AND TABLES

Figure 4.1. Sample flow diagram

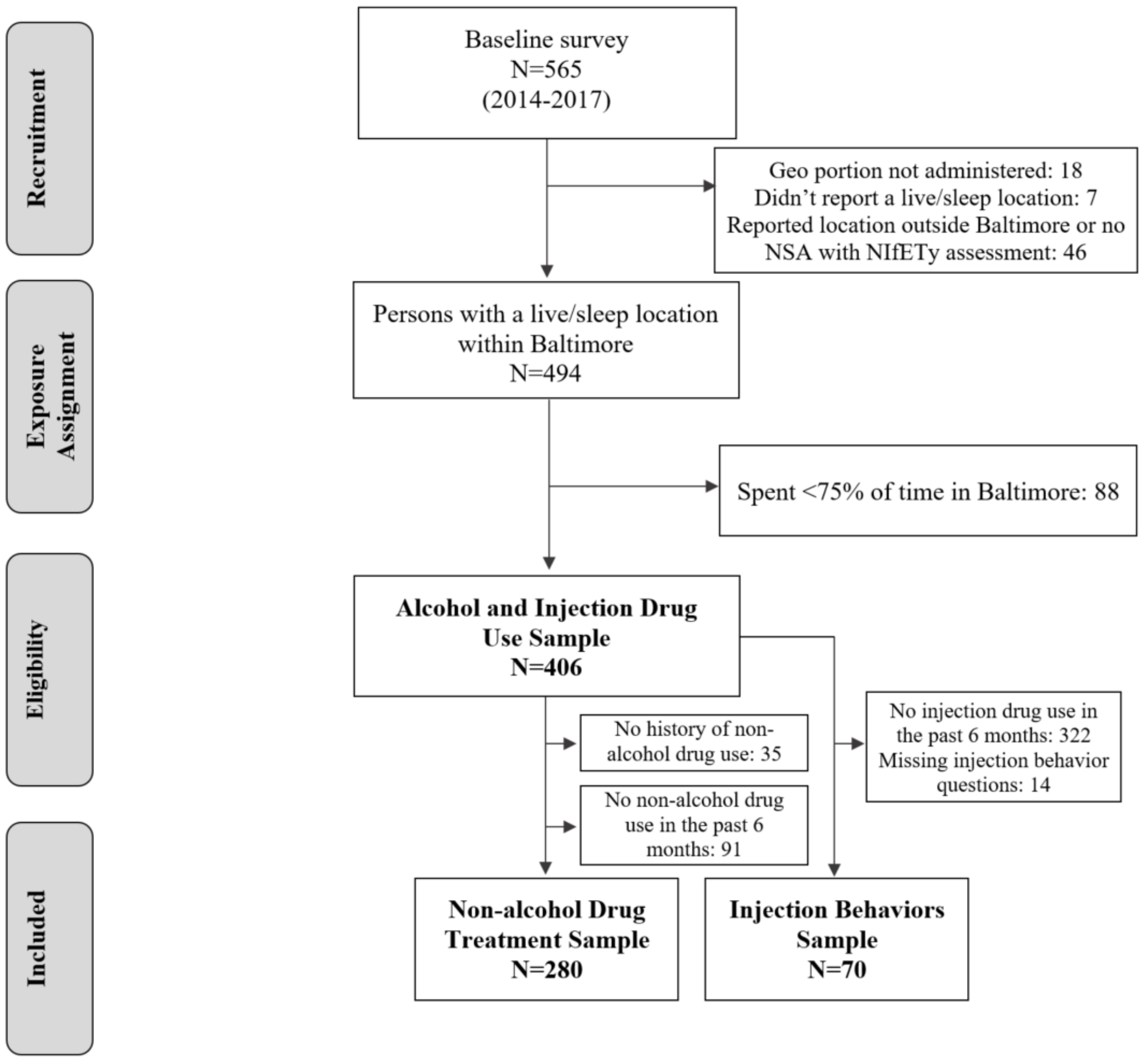


Table 4.1. Demographic characteristics of the overall analytic sample (n=406)		
Variable	**n**	**% or Mean (SD)**
Age (yrs.)		49.3 (9.6)
Assigned male sex at birth	230	56.7
Gender Identity		
Male	224	55.2
Female	176	43.4
Transgender	6	1.5
Other	0	0.0
Sexual Orientation		
Heterosexual	321	79.1
Bisexual	44	10.8
Homosexual, Gay, Same Gender loving, Queer, Questioning, Other	41	10.1
Race		
Black or African American	369	90.9
White	31	7.6
Other, Mixed, or Multiracial	6	1.5
Completed Grade 12, GED, or higher	249	61.3
Living Situation		
Own place	212	52.2
Parent/Family	94	23.2
Someone else's	42	10.3
Rooming, boarding, hallway house, or a shelter/welfare hotel	50	12.3
On the street(s) (vacant lot, abandoned building, etc.)	2	0.5
Other	6	1.5
Length in living situation		
3 months or less	53	13.1
4–6 months	43	10.6
7 months – 1 year	59	14.5
Over a year	251	61.8
Homeless in past 6 months	85	20.9
Squatted for 1 week or more in past 6 months	75	18.5
Unemployed	340	83.7
Income past year (total personal)[a]		
Less than $5,000	165	41.0
$5,000 – $10,000	128	31.8
$10,000 – $19,999	73	18.2
$20,000 – $29,999	26	6.5
Greater than $30,000	10	2.5

Worry about enough money for basics (past 6 months)		
Never	96	23.7
Once in a while	126	31.0
Fairly Often	64	15.8
Very Often	120	29.6

[a]n=402, due to 4 individuals missing data on income

Table 4.2. Health demographics among the overall analytic sample (n=406)

Variable	**n**	**% or Mean (SD)**
Currently has insurance / medical coverage	349	86.0
Self-rated health, General		
Poor	19	4.7
Fair	151	37.2
Good	134	33.0
Very Good	68	16.8
Excellent	34	8.4
Mental health interference in social life		
Not at all	197	48.5
A bit	153	37.7
A lot	56	13.8
CES-D Score		15.9 (10.7)
CES-D Score (23+)	108	26.6
HIV positive	241	59.4
Last HIV medical care[a]		
Never	5	2.1
Over 1 year ago	8	3.3
Past year	11	4.6
Past 6 months	20	8.3
Past 3 months	197	81.7
Hepatitis C positive	138	34.0
Last Care for Hepatitis C[b]		
Never	65	47.8
More than a year ago	28	20.6
In the past year	9	6.6
In the past 6 months	10	7.4
In the past 3 months	24	17.7

[a]Among HIV positive, n=241
[b]Among Hepatitis C positive missing 2, n=136

Table 4.3. Disorder score among the overall analytic sample (n=406)

Disorder score	Minimum	Maximum[a]	Mean	SD	Median
Total Neighborhood Disorder					
Live/Sleep	5.0	32.0	20.0	5.5	20.3
Activity-space weighted[b]	5.0	32.0	19.8	5.2	20.3
Physical Neighborhood Disorder					
Live/Sleep	4.0	21.0	13.2	3.4	13.3
Activity-space weighted[b]	4.0	21.0	13.1	3.2	13.3
Social Neighborhood Disorder					
Live/Sleep	0.0	8.0	2.7	1.1	2.5
Activity-space weighted[b]	0.0	8.0	2.7	1.0	2.5
Violence, Alcohol, Other Drugs Domain					
Live/Sleep	0.0	8.0	4.1	1.9	4.2
Activity-space weighted[b]	0.0	8.0	4.0	1.7	4.2

[a] Theoretical maximums: Overall (91), Physical (50), Social (17), VAOD (24)

[b]Activity-weighted includes where they slept/lived, earned money, injected drugs (if applicable), and socialized; only those locations reported and unique from residential location were used in the calculation.

Table 4.4. Use of substances and substance-related behaviors among the overall analytic sample (n=406)		
Variable	**n**	**% or Mean (SD)**
Alcohol frequency		
Never	169	41.6
Monthly or less	79	19.5
2-4 times a month	50	12.3
2-3 times a week	60	14.8
4 or more times a week	48	11.8
AUDIT Score		5.5 (7.5)
Hazardous/Harmful Alcohol use in past year (AUDIT 8+)	96	23.7
History of drug use (any non-alcohol in past 6 months)	280	69.0
Any Drug treatment in the past 6 months (non-alcohol)[a]	173	61.8
Outpatient drug treatment in past 6 months[b]	82	47.4
Residential drug treatment in past 6 months[b]	42	24.4
Last time injected drugs to get high		
Never in your life	200	49.3
More than 5 years ago	73	18.0
1–5 years ago	30	7.4
6–12 months ago	19	4.7
4–6 months ago	3	0.7
In the past 3 months	81	20.0
How often injected drugs to get high in past 6 months[c]		
< 1 per week	13	15.5
1–2 times per week	13	15.5
3–4 times per week	9	10.7
Almost every day	9	10.7
Every day	32	38.1
2–5 times per day	5	6.0
Greater than 5 times a day	3	3.6
Last time lent a needle after using it[d, e]		
Never	40	57.1
More than 6 months ago	4	5.7
Within the past 6 months	2	2.9
Within the past 3 months (90 days ago)	6	8.6
Within the past month	8	11.4
Within the past week	10	14.3
Last time shared a cooker after using it[d, e]		
Never	19	27.1
More than 6 months ago	4	5.7
Within the past 6 months	6	8.6

Within the past 3 months (90 days ago)	4	5.7
Within the past month	10	14.3
Within the past week	27	38.6
Last time shared cotton after using it[d, e]		
Never	22	31.4
More than 6 months ago	3	4.3
Within the past 6 months	6	8.6
Within the past 3 months (90 days ago)	4	5.7
Within the past month	10	14.3
Within the past week	25	35.7

[a] Among those with a history of past 6-month drug use [excluding marijuana and alcohol] (n=280), including crack, cocaine, heroin, injection drugs, methamphetamine, ecstasy (E, X, MDMA), club drugs (i.e., Special K, GBH, Rohypnol), Oxycontin, Percocet, Vicodin, Buprenorphine/Bupes, Valium, Xanax, or other drugs
[b] Among those reporting any drug treatment in the past 6 months, n=173
[c] Among those who injected drugs in the past 6 months, n=84
[d] Among those who injected drugs in the past 6 months and answered usage questions, n=70
[e] Categories are non-overlapping, mutually exclusive. For example, *within the past 6 months* is 3–6 months ago

Table 4.5. Association between a standard deviation higher neighborhood disorder score and alcohol use outcomes, comparing residential and activity-weighted disorder (n=406)

	Total Disorder		Physical Disorder		Social Disorder		VAOD Disorder	
Harmful Alcohol Use[a] (AUDIT 8+)	**PR**	**95% CI**	**PR**	**95% CI**	**PR**	**95% CI**	**PR**	**95% CI**
Live/Sleep, Unadjusted	1.14	0.94, 1.40	1.15	0.93, 1.42	1.08	0.92, 1.27	1.11	0.92, 1.35
Live/Sleep, Adjusted[b]	1.14	0.94, 1.37	1.14	0.93, 1.40	1.05	0.92, 1.20	1.12	0.94, 1.34
Activity-weighted,[c] Unadjusted	1.12	0.92, 1.38	1.13	0.91, 1.39	1.07	0.91, 1.27	1.10	0.90, 1.34
Activity-weighted,[c] Adjusted[b]	1.13	0.93, 1.37	1.12	0.92, 1.38	1.05	0.92, 1.21	1.12	0.93, 1.34
AUDIT Score[d]	**Beta**	**95% CI**	**Beta**	**95% CI**	**Beta**	**95% CI**	**Beta**	**95% CI**
Live/Sleep, Unadjusted	0.07	-0.07, 0.21	0.07	-0.08, 0.22	0.01	-0.12, 0.15	0.06	-0.08, 0.21
Live/Sleep, Adjusted[b]	0.08	-0.05, 0.20	0.08	-0.05, 0.21	0.01	-0.10, 0.13	0.07	-0.07, 0.22
Activity-weighted,[c] Unadjusted	0.06	-0.09, 0.20	0.06	-0.09, 0.21	0.00	-0.14, 0.14	0.06	-0.10, 0.21
Activity-weighted,[c] Adjusted[b]	0.07	-0.06, 0.20	0.08	-0.06, 0.21	0.00	-0.12, 0.12	0.07	-0.08, 0.22

PR = prevalence ratio, CI = confidence interval

[a]Log binomial model estimating relative risk of harmful alcohol use with a 1 standard deviation higher disorder score (conceptually considered prevalence ratios); accounting for neighborhood-level clustering

[b]Adjusted for age, sex at birth, high school completion status, homelessness status, and degree of worry about money

[c]Activity-weighted includes where they slept/lived, earned money, injected drugs (if applicable), and socialized; only those locations reported and unique from residential location were used in the calculation

[d]Negative binomial regression estimating increase in log AUDIT score with a 1 standard deviation higher disorder score; accounting for neighborhood-level clustering

Table 4.6. Association between a standard deviation higher neighborhood disorder score and treatment seeking outcomes, comparing residential and activity-weighted disorder (among those with a history of drug use, n=280)

	Total Disorder		Physical Disorder		Social Disorder		VAOD Disorder	
	PR[a]	95% CI	PR[a]	95% CI	PR[a]	95% CI	PR[a]	95% CI
Any drug treatment (non-alcohol) in past 6 months								
Live/Sleep, Unadjusted	0.99	0.91, 1.09	0.98	0.89, 1.08	1.00	0.91, 1.10	1.02	0.92, 1.13
Live/Sleep, Adjusted[b]	0.97	0.89, 1.07	0.96	0.88, 1.05	0.99	0.90, 1.09	1.00	0.92, 1.10
Activity-weighted,[c] Unadjusted	1.00	0.91, 1.11	0.99	0.90, 1.09	1.02	0.94, 1.12	1.02	0.92, 1.13
Activity-weighted,[c] Adjusted[b]	0.99	0.90, 1.08	0.98	0.89, 1.07	1.01	0.93, 1.10	1.00	0.92, 1.10
Outpatient treatment, among those seeking treatment (n=173)[d]								
Live/Sleep, Unadjusted	1.16	0.99, 1.36	1.13	0.95, 1.34	1.11	1.01, 1.22	1.12	0.96, 1.32
Live/Sleep, Adjusted[b]	1.12	0.96, 1.31	1.07	0.92, 1.25	1.14	1.04, 1.24	1.13	0.97, 1.32
Activity-weighted,[c] Unadjusted	1.16	0.98, 1.37	1.13	0.95, 1.34	1.14	1.04, 1.24	1.13	0.96, 1.34
Activity-weighted,[c] Adjusted[b]	1.12	0.95, 1.31	1.07	0.92, 1.25	1.16	1.07, 1.26	1.13	0.97, 1.32
Residential treatment, among those seeking treatment (n=173)[d]								
Live/Sleep, Unadjusted	0.90	0.69, 1.17	0.89	0.69, 1.17	0.96	0.76, 1.22	0.91	0.72, 1.14
Live/Sleep, Adjusted[b]	0.88	0.67, 1.16	0.89	0.71, 1.13	0.97	0.76, 1.23	0.86	0.68, 1.09
Activity-weighted,[c] Unadjusted	0.91	0.69, 1.21	0.89	0.68, 1.18	1.00	0.80, 1.25	0.93	0.72, 1.20
Activity-weighted,[c] Adjusted[b]	0.88	0.67, 1.17	0.89	0.71, 1.13	0.98	0.77, 1.24	0.87	0.68, 1.10

PR = prevalence ratio, CI = confidence interval

[a]Log binomial model estimating relative risk of treatment with a 1 standard deviation higher disorder score (conceptually considered prevalence ratios); accounting for neighborhood-level clustering

[b]Adjusted for age, sex at birth, high school completion status, homelessness status, and degree of worry about money

[c]Activity-weighted includes where they slept/lived, earned money, injected drugs (if applicable), and socialized; only those locations reported and unique from residential location were used in the calculation

[d]Among those with any non-alcohol drug treatment in the past 6 months

Table 4.7. Association between a standard deviation higher neighborhood disorder score and injection drug-related outcomes, comparing residential and activity-weighted disorder (n=406)

	Total Disorder		Physical Disorder		Social Disorder		VAOD Disorder	
	PR[a]	95% CI	PR[a]	95% CI	PR[a]	95% CI	PR[a]	95% CI
Injected drugs in the past 6 months (n=406)[b]								
Live/Sleep, Unadjusted	1.04	0.88, 1.24	1.03	0.87, 1.23	1.09	0.92, 1.29	1.01	0.85, 1.20
Live/Sleep, Adjusted[c]	1.03	0.88, 1.22	1.02	0.86, 1.21	1.07	0.93, 1.24	1.00	0.86, 1.16
Activity-weighted,[d] Unadjusted	1.07	0.90, 1.26	1.05	0.90, 1.24	1.12	0.95, 1.31	1.04	0.88, 1.23
Activity-weighted,[d] Adjusted[c]	1.07	0.91, 1.25	1.05	0.89, 1.24	1.09	0.95, 1.25	1.04	0.90, 1.19
Lent a needle in the past 6 months (among persons who inject, n=70)								
Live/Sleep, Unadjusted	0.96	0.72, 1.27	1.00	0.75, 1.34	0.69	0.47, 1.02	1.04	0.75, 1.45
Live/Sleep, Adjusted[c]	0.87	0.61, 1.25	0.94	0.65, 1.34	0.78	0.53, 1.15	0.93	0.64, 1.37
Activity-weighted,[d] Unadjusted	0.90	0.66, 1.21	0.93	0.69, 1.26	0.66	0.41, 1.06	0.95	0.68, 1.33
Activity-weighted,[d] Adjusted[c]	0.80	0.55, 1.18	0.86	0.59, 1.25	0.80	0.52, 1.21	0.86	0.59, 1.26
Shared a cooker in the past 6 months (among persons who inject, n=70)[e]								
Live/Sleep, Unadjusted	1.09	0.88, 1.35	1.09	0.94, 1.26	1.08	0.90, 1.30	1.09	0.93, 1.28
Live/Sleep, Adjusted[c]	1.07	0.89, 1.28	1.07	0.90, 1.27	1.07	0.88, 1.31	1.08	0.91, 1.28
Activity-weighted,[d] Unadjusted	1.07	0.92, 1.26	1.08	0.92, 1.27	1.09	0.89, 1.33	1.05	0.90, 1.22
Activity-weighted,[d] Adjusted[c]	1.08	0.89, 1.32	1.08	0.89, 1.32	1.10	0.86, 1.41	1.05	0.87, 1.26
Shared cotton in the past 6 months (among persons who inject, n=70)[e]								
Live/Sleep, Unadjusted	1.03	0.84, 1.26	1.03	0.87, 1.23	1.09	0.89, 1.33	1.00	0.85, 1.18
Live/Sleep, Adjusted[c]	1.04	0.84, 1.30	1.04	0.84, 1.27	1.06	0.83, 1.35	1.03	0.83, 1.27
Activity-weighted,[d] Unadjusted	1.01	0.84, 1.21	1.02	0.84, 1.23	1.10	0.89, 1.37	0.97	0.82, 1.14
Activity-weighted,[d] Adjusted[c]	1.03	0.81, 1.31	1.03	0.81, 1.31	1.07	0.86, 1.33	0.99	0.80, 1.23

PR = prevalence ratio, CI = confidence interval

[a] Log binomial model estimating relative risk with a 1 standard deviation higher disorder score (conceptually considered prevalence ratios)

[b] Robust standard errors and corresponding 95% confidence intervals accounting for neighborhood-level clustering

[c] Adjusted for age, sex at birth, high school completion status, homelessness status, and degree of worry about money

[d] Activity-weighted includes where they slept/lived, earned money, injected drugs (if applicable), and socialized; only those locations reported and unique from residential location were used in the calculation

[e] Did not account for neighborhood clustering due to small sample size

CHAPTER 5: CONCLUSIONS

Through the three studies of this dissertation, we explored two important spheres of influence on individual substance use—state-level policy environment and neighborhood. In the first study, we estimated the short-term association between the stringency of the state-level alcohol policy environment and two measures of alcohol frequency. In the second study, we took a longer view of the influence of state policy environment on drinking patterns across adolescence and young adulthood. In the final study, we zoomed in to a more local measure of place and assessed the role of neighborhood environment on substance use and treatment seeking.

In the first study, we assessed the association between the stringency of the state-level alcohol policy environment as measured by a policy environment index score (the APS) and two drinking frequency outcomes. We used a nationally representative cohort assessed annually. This allowed us to evaluate the short-term role of policy on drinking frequency across critical years of maturation. We first examined the relationship between current policy environment and current drinking. Higher policy environment at interview was associated with small reductions in past 30-day drinking. No association was found between current policy environment and past 30-day binge drinking. We next looked at how changes in the policy environment across a short time period (approximately one year) impacted current drinking. We found that an increase in the stringency of the policy environment across roughly one year was associated with a slight reduction in drinking days. Results for binge drinking days were weaker than those seen for drinking days. In addition, we evaluated the policy-drinking frequency association when individuals were under legal drinking age versus over legal drinking age. Our stratification results showed the policy effects were strongest for those under legal drinking age. While effect sizes are small, these small reductions in drinking over the time period examined (roughly age 12-30) could have benefits for population health. In addition, this is one of the first studies to look at APS and drinking outcomes in a cohort followed longitudinally. These findings add the literature examining the role of policy environment on drinking and drinking-related outcomes.

In the second study, we identified distinct drinking and binge drinking trajectories in the same cohort as study 1 as they aged from roughly age 12 up to age 30. Overall, these trajectories were consistent with prior research, but the current analyses were able to cover a wider age period than many prior studies. We then examined the association between state-level policy environment in adolescence and trajectory membership. Overall, our findings were mixed. However, we found a consistent increased odds of late escalating drinking days trajectory membership and decreased odds of normative drinking days trajectory membership with higher APS in adolescence. Taken together, it is possible a stricter policy environment in adolescence may discourage individuals from following the "typical" drinking trajectory and reduce odds of membership in trajectories typified by early initiation of drinking. While our results were imprecise, this study adds to the evidence-base on the alcohol policy environment and drinking trajectories. It also highlights several areas for future research including potentially incorporating time-varying policy environment and trying to identify critical time periods for intervention. This analysis also demonstrates how longitudinal cohorts offer opportunities to examine the impact of state-level policies on individual behavioral trajectories over time to better inform policy implementation.

In the final study, we explored two strategies to quantify exposure to a neighborhood stressor—neighborhood disorder. Specifically, we compared a more traditional measure of exposure (based on residential location) to one that incorporated multiple activity-based locations. The two exposure measures yielded relatively equivalent disorder scores and associations with substance use outcomes in a sample of individuals living in Baltimore who were enrolled in a HIV care and prevention study. While there was less variation than expected between the two disorder scores, time spent at a location may still be an important determinant of exposure to disorder. We found that time spent at residential (live/sleep) location modified associations between residential neighborhood disorder and alcohol use as well as injection drug use. Particularly in this sample, where many had a history of drug use and some individuals were insecurely housed, incorporating time spent at a location and examining other locations that may facilitate certain behaviors (such as injection and socializing locations) could lead to a deeper understanding of how disorder influences substance use, substance-use related risk behaviors, and treatment seeking.

This dissertation explored just a few of the many influences on individual substance use. These analyses add to the literature examining the often complex interplay between people and their environment. This work also highlights the many challenges that arise when examining these relationships. Although additional investigations are needed, the current results may help inform policy makers and community planners.

APPENDIX: CHAPTER 2

Figure A2.1. Correlation between current interview APS and prior interview APS in the analytic sample

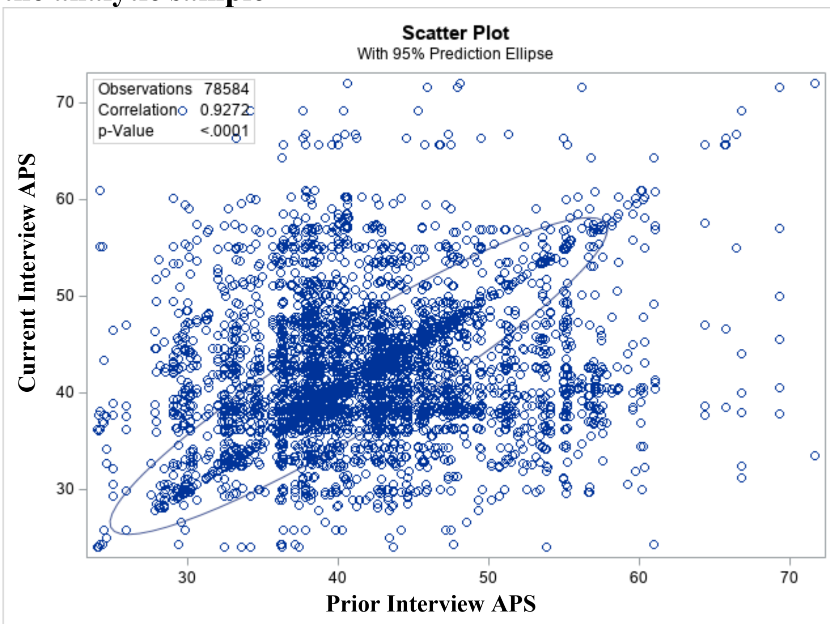


Figure A2.2. Correlation between prior interview APS and change in APS in the analytic sample

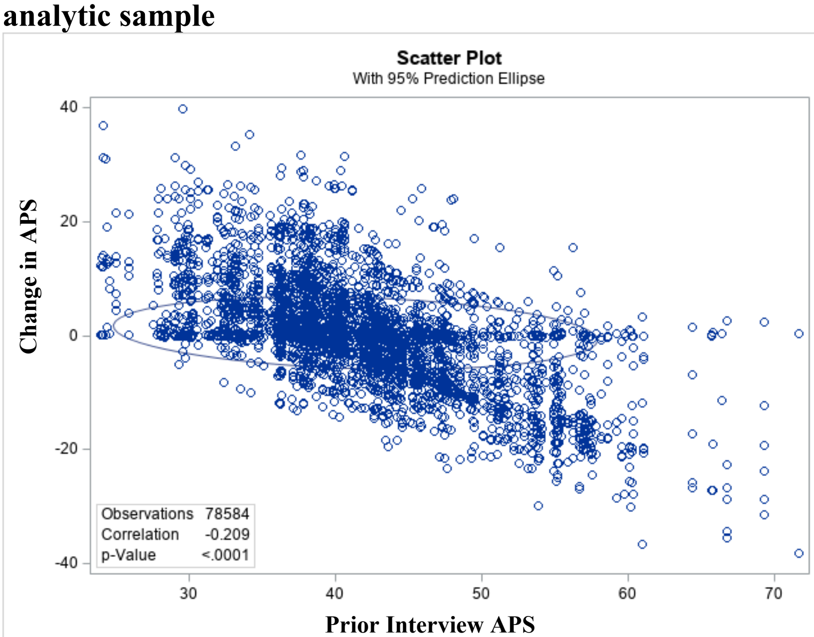


Figure A2.3. Correlation between current interview APS and change in APS in the analytic sample

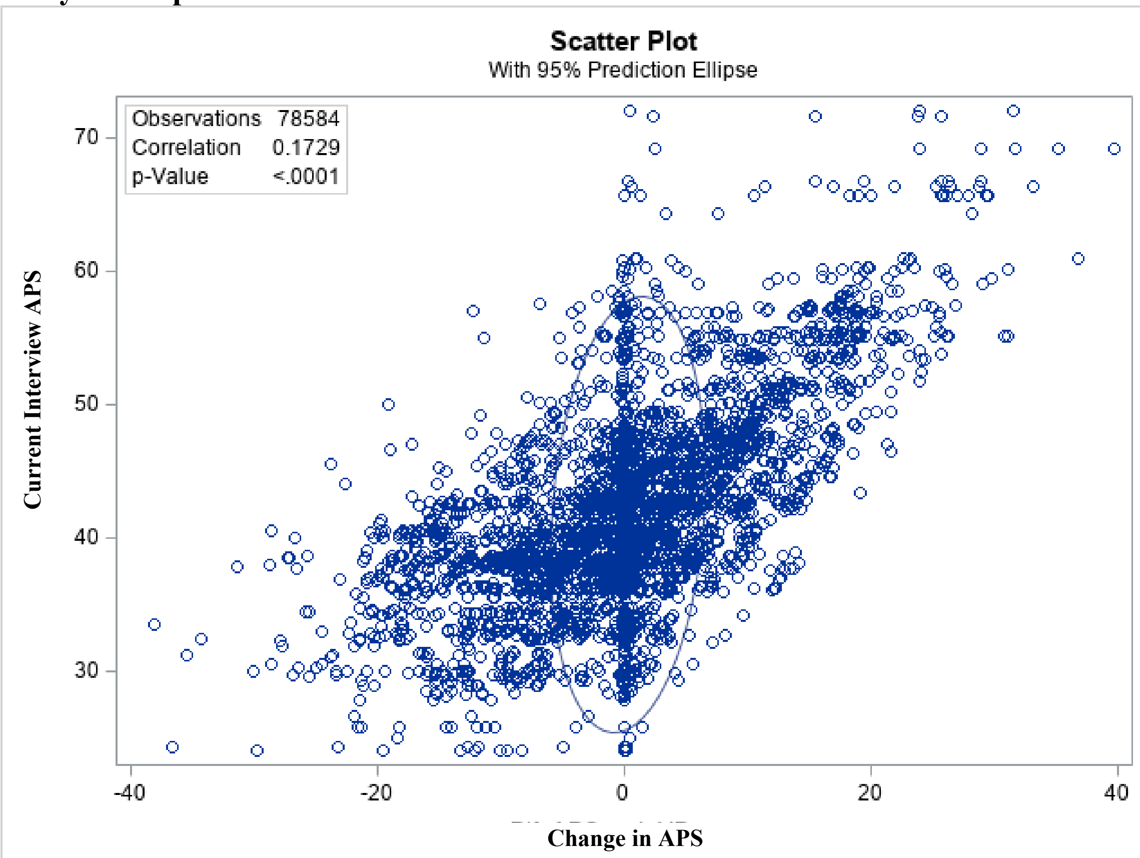


Table A2.1. List of policies included in the APS
1. Alcohol Beverage Control agency present, functional, adequately staffed
2. Administrative license revocation
3. Blood alcohol concentration 0.08/per se laws
4. Days of sale restriction (Sunday sales)
5. Dram shop/commercial liability laws
6. False ID laws
7. Fetal alcohol syndrome warning signs
8. Furnishing alcohol to minors prohibited
9. Graduated driver license laws
10. Home delivery and direct shipment of alcohol to consumers restricted
11. Hours of sale restrictions
12. House party laws, criminal liability
13. Ignition interlock laws for driving-under-the-influence offenders
14. Keg registration laws
15. Local option permissible
16. Minimum age of server/seller
17. Minimum legal drinking-age laws
18. Open-container laws, automobiles
19. Outlet density
20. Responsible beverage service training
21. Retail price restrictions
22. Sales or service to intoxicated patrons prohibited
23. Sobriety checkpoints
24. Social host laws (civil liability)
25. State alcohol control systems (monopoly)
26. Taxes
27. Use/lose license laws for youth
28. Wholesale price restrictions
29. Zero-tolerance laws

Table A2.2. Associations between prior APS (lagged) and past 30-day drinking and binge drinking (n=78,584 intervals)

	Youth binge drinking APS			General population binge drinking APS		
	Beta[a]	95% CI		Beta[a]	95% CI	
Drinking days in the past 30 days						
Age adjusted	0.01	-0.09	0.10	0.03	-0.06	0.11
Fully adjusted[b]	0.01	-0.12	0.14	0.04	-0.05	0.14
Binge drinking days in the past 30 days						
Age adjusted	-0.02	-0.08	0.03	-0.001	-0.06	0.05
Fully adjusted[b]	0.02	-0.02	0.05	0.02	-0.03	0.07

[a] Mean difference in past 30-day drinking outcome at current interview with a 10-unit higher APS score at prior interview (APS_{t-1})
[b] Adjusted for age at start of interval, Hispanic ethnicity, gender, race (dichotomous: white, other race), parent completed high school, highest grade completed at start of interval interview (3-level: less than high school, high school, associates/ bachelors or higher) and census region (4-level: Northeast, North Central, South, and West)

Table A2.3. Associations between current general population APS and drinking outcomes by prior interview APS (n=78,584 intervals)

	Current APS range	Past 30-day drinking	Past 30-day binge drinking
		Beta[a, b] (95% CI)	Beta[a, b] (95% CI)
Overall	23.2 – 68.4	0.01 (-0.09, 0.12)	0.01 (-0.04, 0.06)
By prior interview APS quartile			
75th percentile and above (prior APS 44.5 or higher)	23.2 – 68.4	-0.10 (-0.35, 0.15)	0.01 (-0.13, 0.14)[c]
50th - 75th percentile (prior APS 40.1 up to 44.5)	24.1 – 67.3	-0.24 (-0.64, 0.15)	0.19 (-0.02, 0.40)[c]
25th - 50th percentile (prior APS 36.9 up to 40.1)	23.2 – 68.4	-0.22 (-0.53, 0.09)	-0.02 (-0.18, 0.13)
25th Percentile and lower (prior APS <36.9)	23.2 – 66.8	0.02 (-0.26, 0.30)	-0.11 (-0.20, -0.01)[c]

[a] Mean difference in past 30-day drinking outcome at current interview with a 10-unit higher APS score at interview (APS_t)
[b] Adjusted for age at start of interval, Hispanic ethnicity, gender, race (dichotomous: white, other race), parent completed high school, highest grade completed at start of interval interview (3-level: less than high school, high school, associates/ bachelors or higher) and census region (4-level: Northeast, North Central, South, and West)
[c] Model failed to converge; removed highest grade completed, census region, and parental education

Table A2.4. Associations between cross-interview change in general population APS and drinking outcomes by prior interview APS score (n=78,584 intervals)

	Current APS range	**Past 30-day drinking**	**Past 30-day binge drinking**
		Beta[a, b] (95% CI)	Beta[a, b] (95% CI)
Overall	-36.0, 38.4	-0.15 (-0.28, -0.01)	-0.05 (-0.13, 0.02)
By prior interview APS quartile			
75th percentile and above (prior APS 44.5 or higher)	-36.0, 23.2	-0.25 (-0.55, 0.05)	-0.04 (-0.18, 0.09)
50th - 75th percentile (prior APS 40.1 up to 44.5)	-19.4, 24.6	-0.27 (-0.69, 0.15)	0.02 (-0.11, 0.15)[c]
25th - 50th percentile (prior APS 36.9 up to 40.1)	-15.7, 32.2	-0.11 (-0.44, 0.22)	0.06 (-0.09, 0.22)
25th Percentile and lower (prior APS <36.9)	-10.1, 38.4	0.09 (-0.20, 0.39)	-0.11 (-0.15, -0.08)

[a] Mean difference in past 30-day drinking outcome at current interview with a 10-unit higher change in APS score at interview (ΔAPS_t)
[b] Adjusted for age at start of interval, Hispanic ethnicity, gender, race (dichotomous: white, other race), parent completed high school, highest grade completed at start of interval interview (3-level: less than high school, high school, associates/ bachelors or higher) and census region at start of interval (Northeast, North Central, South, and West)
[c] Main model failed to converge, so census region and highest grade were removed

Table A2.5. Association between legal drinking age and past 30-day drinking and binge drinking (n=78,584 intervals)

	Legal drinking age status at interview (compared to underage)		
	Beta[a]	95% CI	
Drinking days in the past 30 days			
Unadjusted	1.64	1.53	1.74
Adjusted[b]	0.97	0.82	1.11
Binge drinking days in the past 30 days			
Age adjusted	0.32	0.26	0.38
Adjusted[b]	0.25	0.18	0.33

[a] Mean difference in past 30-day drinking outcome at current interview from being of legal drinking age at interview (compared with under legal drinking age)
[b] Adjusted for age at start of interval, Hispanic ethnicity, gender, race (dichotomous: white, other race), parent completed high school, highest grade completed at start of interval interview (3-level: less than high school, high school, associates/ bachelors or higher) and census region (4-level: Northeast, North Central, South, and West), and current youth domain APS

Table A2.6. Associations between general population APS and drinking outcomes stratified by legal drinking age (n=78,584 intervals)

	<age 21 N=22,338			>= age 21 N=56,246		
	Beta	95% CI		Beta	95% CI	
Drinking days in the past 30 days						
Current year APS score[a, b]	0.01	-0.10	0.11	0.02	-0.13	0.16
Change in APS score[a, d]	-0.12	-0.34	0.11	-0.08	-0.26	0.10
Binge drinking days in the past 30 days						
Current year APS score[a, b]	-0.002	-0.06	0.05	0.01	-0.06	0.07
Change in APS score[c, d]	-0.12	-0.15	-0.10	0.01	-0.08	0.09

[a] Adjusted for Hispanic ethnicity, gender, race (dichotomous: white, other race), parent completed high school, grade completed at start-of-interval (3-level: less than high school, high school, associates/ bachelors or higher), start-of-interval census region (4-level: Northeast, North Central, South, and West)
[b] Mean difference in past 30-day drinking outcome at interview with 10-unit higher APS at interview
[c] Adjusted for Hispanic ethnicity, gender, race (dichotomous: white, other race), parent completed high school
[d] Mean difference in past 30-day drinking outcome at interview with a 10-unit greater APS change across an interval

Table A2.7. Associations between APS and dichotomized outcomes at interview (n=78,584 intervals)

	Youth binge drinking APS			**General population binge drinking APS**		
	aRR[a, b]	95% CI		aRR[a, b]	95% CI	
Any drinking						
Current APS	0.99	0.94	1.03	0.99	0.95	1.03
Change in APS	1.00	0.95	1.05	1.00	0.95	1.04
Any binge drinking						
Current APS	0.98	0.94	1.02	0.98	0.94	1.02
Change in APS	0.97	0.92	1.02	0.97	0.93	1.02

[a] Risk of any past 30-day drinking (or binge drinking) at follow-up interview with a 10-unit higher APS score at interview (or greater APS change score at interview)
[b] Adjusted for start-of-interval age, Hispanic ethnicity, gender, race (dichotomous: white, other race), parent completed high school, highest grade completed at start-of-interval (3-level: less than high school, high school, associates/ bachelors or higher), and start-of-interval census region (4-level: Northeast, North Central, South, and West)

Table A2.8. Categorical APS change variable and past 30-day drinking and binge drinking (n=78,584 intervals)

	Youth binge drinking APS			**General population binge drinking APS**		
	Beta[a, b]	95% CI		Beta[a, b]	95% CI	
Drinking days in the past 30 days						
Decreasing (standard deviation or greater decrease across interval)	0.27	-0.03	0.57	0.21	-0.08	0.50
Stable (less than standard deviation increase or decrease across interval)	Ref	-	-	Ref	-	-
Increasing (standard deviation or greater increase across interval)	0.06	-0.08	0.19	0.04	-0.10	0.18
Binge drinking days in the past 30 days						
Decreasing (standard deviation or greater decrease across interval)	-0.01	-0.16	0.15	-0.05	-0.15	0.05
Stable (less than standard deviation increase or decrease across interval)	Ref	-	-	Ref	-	-
Increasing (standard deviation or greater increase across interval)	0.03	-0.05	0.12	0.02	-0.07	0.12

[a] Mean difference in past 30-day drinking outcome at interview compared to the reference exposure level
[b] Adjusted for age at start of interval, Hispanic ethnicity, gender, race (dichotomous: white, other race), parent completed high school, highest grade completed at start of interval interview (3-level: less than high school, high school, associates/ bachelors or higher), start-of-interval census region (4-level: Northeast, North Central, South, and West)

Table A2.9. Associations between APS and drinking outcomes, removing those who never drank across follow-up (n=75,398 intervals)

	Youth binge drinking APS			General population binge drinking APS		
	Beta[a]	95% CI		Beta[a]	95% CI	
Drinking days in the past 30 days						
Current year APS score[b]	-0.01	-0.15	0.13	0.03	-0.08	0.13
Change in APS score[c]	-0.14	-0.30	0.02	-0.14	-0.28	0.004
Binge drinking days in the past 30 days						
Current year APS score[b]	0.01	-0.05	0.08	0.01	-0.04	0.07
Change in APS score[c]	-0.04	-0.14	0.06	-0.05	-0.13	0.03

[a] Adjusted for age, Hispanic ethnicity, gender, race (dichotomous: white, other race), parent completed high school, grade completed at start-of-interval (3-level: less than high school, high school, associates/ bachelors or higher), start-of-interval census region (4-level: Northeast, North Central, South, and West)
[b] Mean difference in past 30-day drinking outcome at interview with 10-unit higher APS at interview
[c] Mean difference in past 30-day drinking outcome at interview with a 10-unit greater APS change across an interval

Table A2.10. Associations between change in APS and drinking outcomes, stratified by whether an individual moved across the interval (n=78,584 intervals)

	Stayed within the same state between interviews N=74,627			Switched states between interviews N=3,957		
	Beta[a,b]	95% CI		Beta[a,b]	95% CI	
Drinking days in the past 30 days						
Youth APS change	-0.08	-0.44	0.28	-0.15	-0.32	0.02
General population APS change	-0.03	-0.37	0.31	-0.18	-0.33	-0.03
Binge drinking days in the past 30 days						
Youth APS change	0.06	-0.23	0.36	-0.03	-0.12	0.07
General population APS change	-0.01	-0.23	0.20	-0.03	-0.12	0.06

[a] Adjusted for age, Hispanic ethnicity, gender, and race (dichotomous: white, other race)
[b] Mean difference in past 30-day drinking outcome at interview with a 10-unit greater APS change across an interval

APPENDIX: CHAPTER 3

Table A3.1. Group-based trajectory model adequacy assessment and selection for each alcohol use outcome (n=8,860)						
Number of Groups	Parameters Description	BIC	Group %	Average posterior probability assignment	Relative Entropy	Odds of correct classification
Past 30 day Drinking Frequency						
1 Group	cubic	-249442.9	100	-	-	-
2 Group	all cubic	-237575.2	59.4: 40.6	94.7: 93.6	0.81	12.2: 21.4
3 Group	all cubic	-233362.1	54.9: 13.4: 31.7	92.0: 92.4: 91.2	0.83	9.4: 78.6: 22.3
4 Group	cubic, cubic, cubic, quadratic	-231997.2	46.2: 26.5: 21.0: 6.4	86.7: 86.0: 90.0: 92.3	0.79	7.6: 17.0: 33.9: 175.3
5 Group	**all cubic**	**-230995.9**	**11.0: 17.2: 5.0: 45.6: 21.3**	**82.4: 82.9: 92.1: 86.6: 89.9**	**0.80**	**37.9: 23.3: 221.5: 7.7: 32.9**
5 group	cubic, cubic, quadratic, cubic, cubic	-230995.9	45.4: 10.9: 5.0: 21.2: 17.5	86.5: 82.4: 92.7: 90: 83.1	0.80	7.7: 38.3: 241.3: 33.5: 23.2
5 group	all quadratic	-231857.4	45.3: 5.1: 19.0: 25.0: 5.7	85.5: 93.0: 85.2: 85.4: 83.9	0.79	21.8: 15.8: 26.8: 49.3: 103.4
6 group	cubic, cubic, quadratic, cubic, quadratic	-230403.3	30.9: 25.3: 4.0: 7.5: 12.9: 19.4	78.2: 78.6: 91.0: 82.7: 82.6: 88.9	0.75	8.0: 10.8: 242.7: 59.0: 50.2: 3.7
Past 30 day Binge Drinking Frequency[a]						
1 Group	cubic	-176186.3	100	-	-	-
2 Group	all cubic	-156552.4	78.6: 21.4	94.4: 96.5	0.79	4.6: 104.4
3 Group	all cubic	-146456.5	46.2: 40.1: 13.7	94.9: 95.1: 96.3	0.89	21.7: 29.0: 164.0
4 Group	all cubic	-142783.7	41.6: 34.7: 18.3: 5.4	94.2: 91.7: 92.7: 94.9	0.87	22.8: 20.8: 56.7: 326.0
5 Group	**all cubic**	**-140854.3**	**41.1: 33.4: 10.7: 4.3: 10.6**	**94.1: 89.9: 87.9: 95.1: 87.8**	**0.86**	**22.9: 17.7: 60.6: 431.9: 60.7**
5 Group	quadratic, cubic, cubic, cubic, cubic	-140959.4	10.7: 41.2: 33.6: 4.4: 10.2	87.0: 94.1: 90.2: 94.7: 87.8	0.86	55.9: 22.7: 18.2: 388.2: 63.4
5 Group	quadratic, quadratic, cubic, cubic, cubic	-140956.0	10.0 10.8: 41.2: 33.6: 4.4	88.1: 87.0: 94.1: 90.2: 94.5	0.86	66.6: 55.3: 22.8: 18.2: 373.3

5 Group	quadratic, quadratic, quadratic, cubic, cubic	-141018.2	9.9: 4.2: 11.0: 33.6: 41.2	87.7: 95.0: 87.3: 90.1: 99.9	0.86	64.9: 433.4: 55.6: 18.0: 141.3
6 Group	all cubic	-139532.6	35.7: 23.8: 21.3: 8.7: 3.4: 7.1	92.1: 83.6: 84.3: 88.3: 94.2: 88.7	0.88	21.0: 16.3: 19.8: 79.2: 236.8: 11.6

[a] Zero-inflation parameter included across models was modeled as cubic

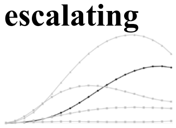
Table A3.2. Parameter estimates for the all-cubic 5-group drinking days trajectory solution (n=8,860)

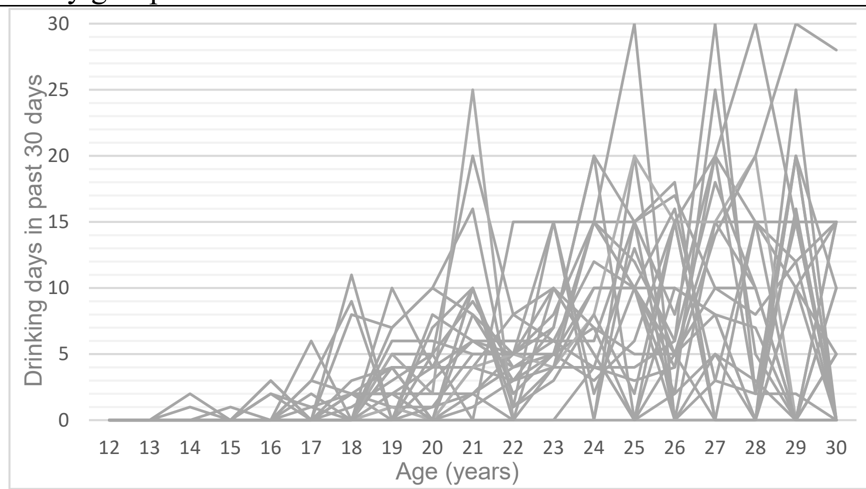
Group	Parameter	Estimate
Late escalating	Intercept	-16.756
	Linear	-1.63237
	Quadratic	0.22203
	Cubic	-0.0045
Normative	Intercept	-144.348
	Linear	18.66362
	Quadratic	-0.74181
	Cubic	0.00947
High frequency	Intercept	-57.677
	Linear	3.39853
	Quadratic	0.08938
	Cubic	-0.00404
Low Frequency	Intercept	-68.2022
	Linear	7.22292
	Quadratic	-0.24458
	Cubic	0.0027
No/infrequent	Intercept	-59.8319
	Linear	7.42066
	Quadratic	-0.34382
	Cubic	0.00519
	Sigma	6.60344

Table A3.3. Parameter estimates for the all-cubic 5-group binge drinking days trajectory solution (n=8,860)		
Group	Parameter Estimate	Estimate
No/Infrequent	Intercept	3.49077
	Linear	-0.51158
	Quadratic	0.01371
	Cubic	-0.00009
Once-a-month	Intercept	-8.01717
	Linear	1.30494
	Quadratic	-0.06132
	Cubic	0.00092
Later binge drinking	Intercept	-7.33299
	Linear	0.8688
	Quadratic	-0.02676
	Cubic	0.00027
High frequency	Intercept	-16.0062
	Linear	2.18266
	Quadratic	-0.08412
	Cubic	0.00107
Earlier binge drinking	Intercept	-15.7113
	Linear	2.43555
	Quadratic	-0.10649
	Cubic	0.00146
	Alpha0	22.05277
	Alpha1	-2.39403
	Alpha2	0.08095
	Alpha3	-0.00085

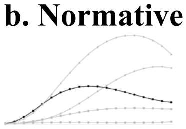
Figure A3.1. Spaghetti plots for a random sample of 25 individuals within each drinking day trajectory group

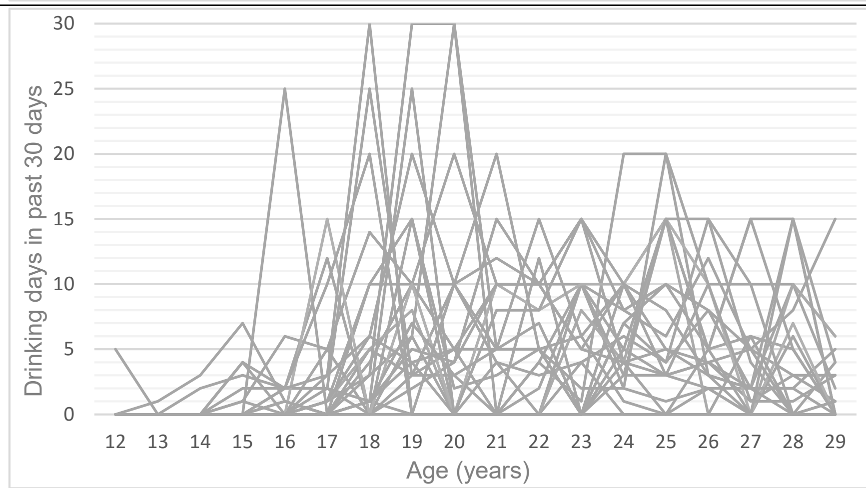
a. Late escalating



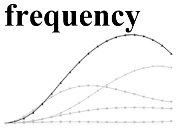


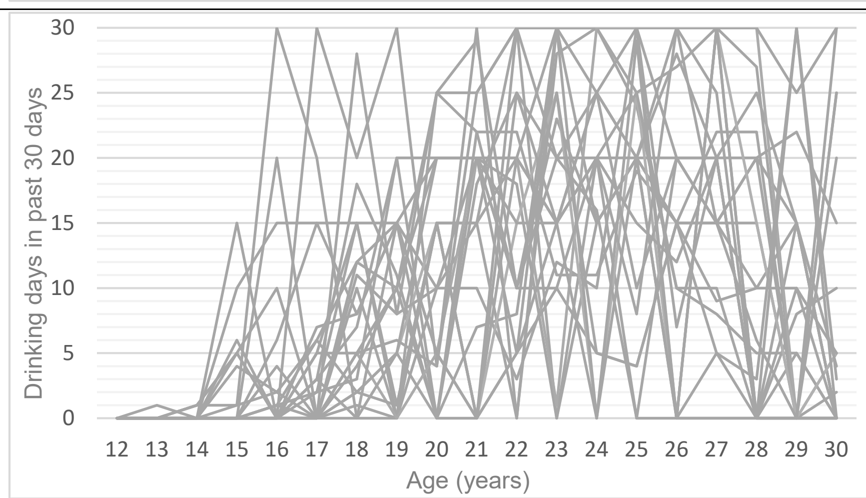
b. Normative





c. High frequency





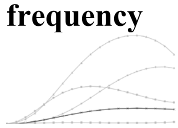
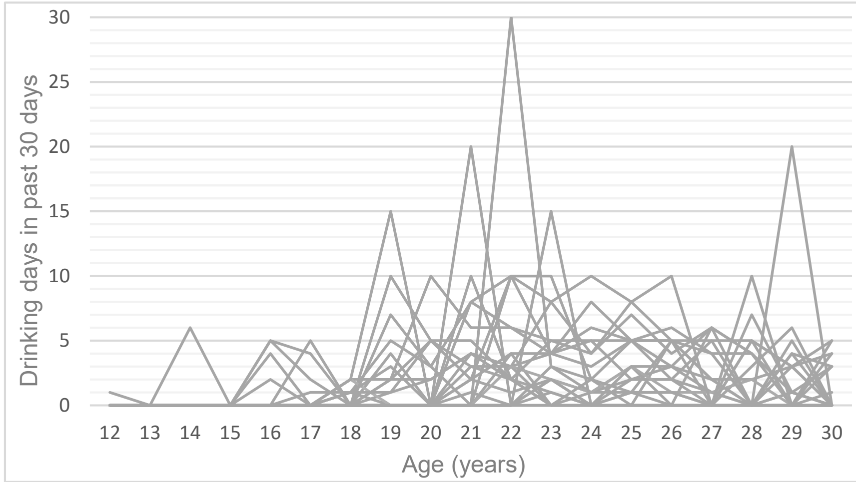
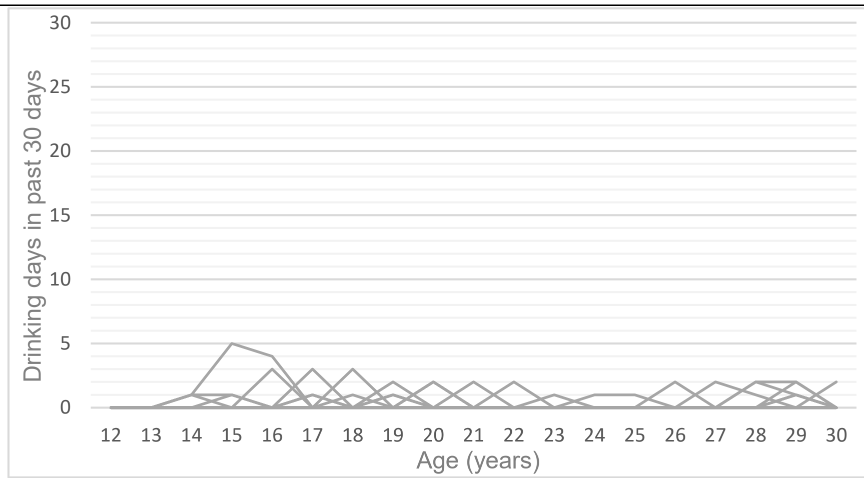
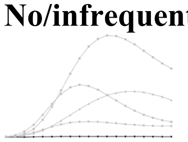
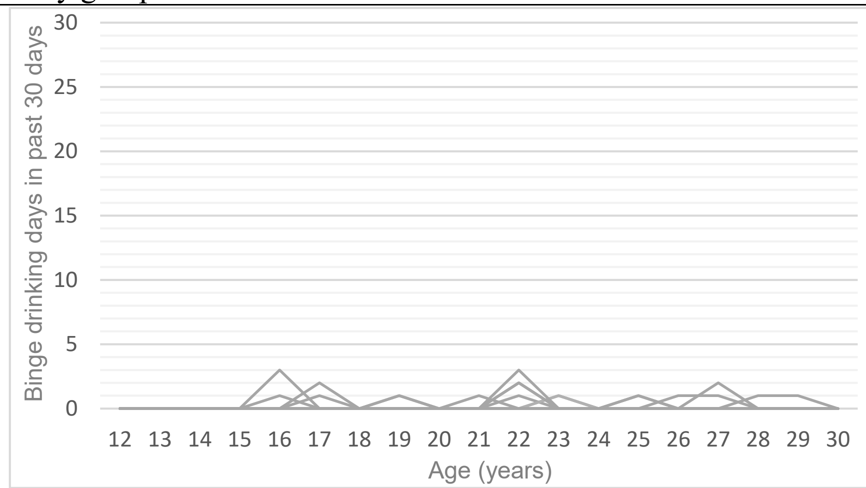
d. Low frequency 	
e. No/ infrequent 	

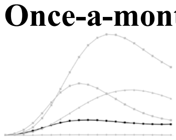
Figure A3.2. Spaghetti plots for a random sample of 25 individuals within each binge drinking day trajectory group

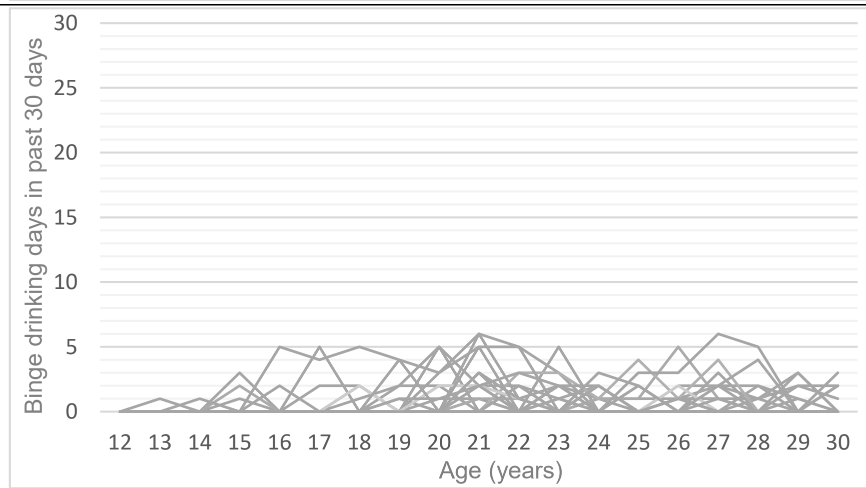
No/infrequent



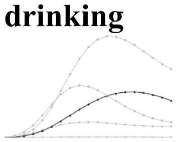


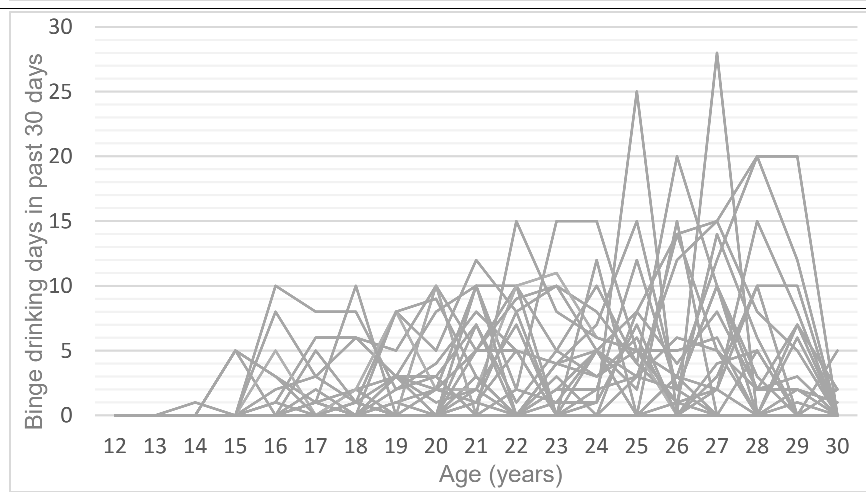
Once-a-month





Later binge drinking





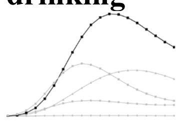
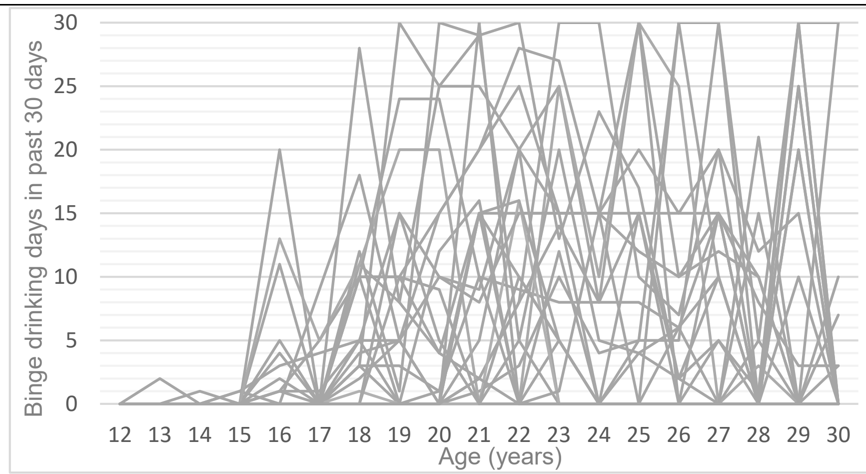
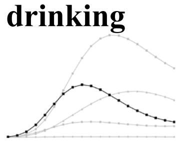
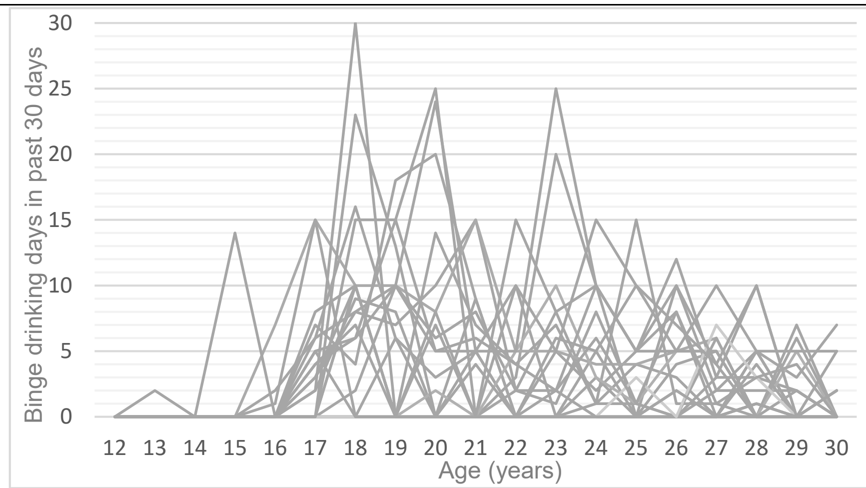
High frequency binge drinking 	
Earlier binge drinking 	

Figure A3.3. Distribution of baseline APS (n=8,860)

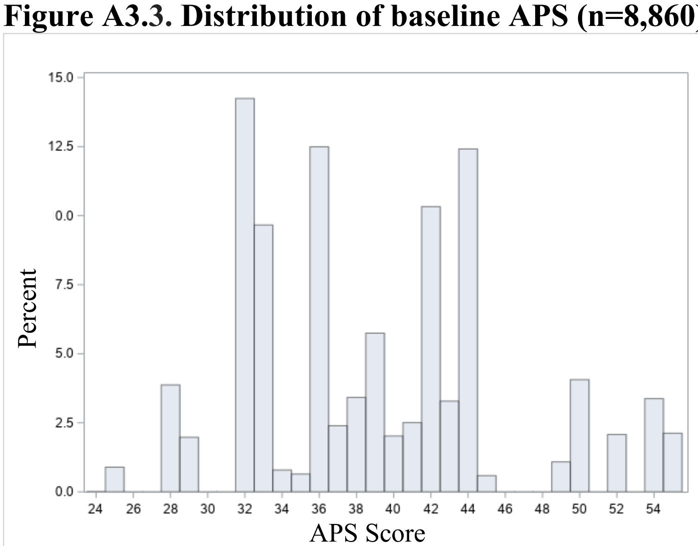
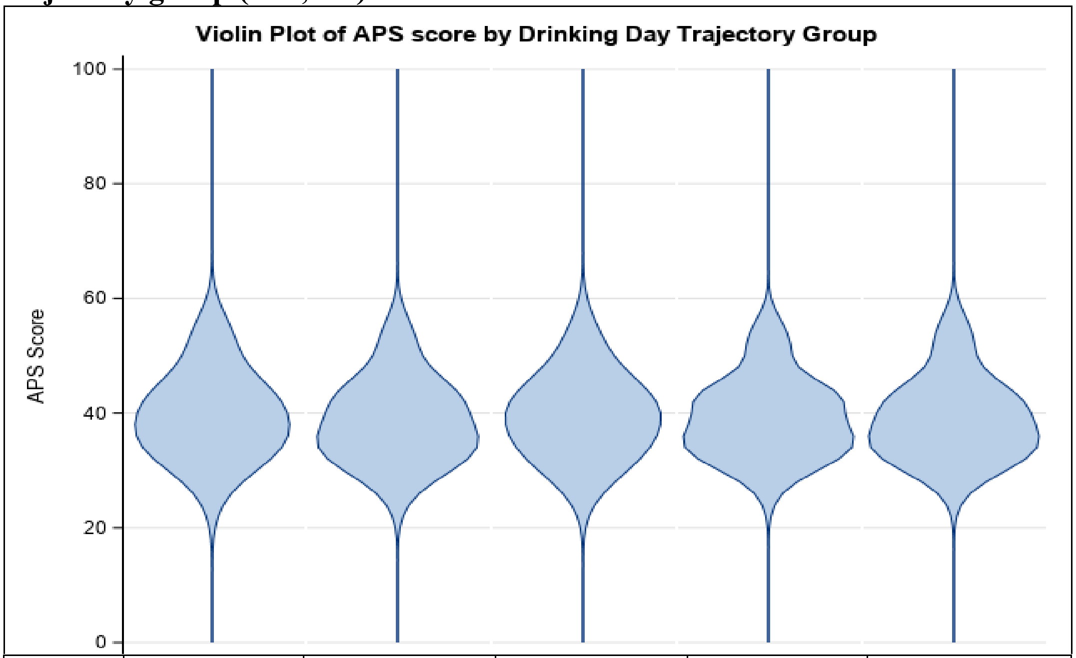
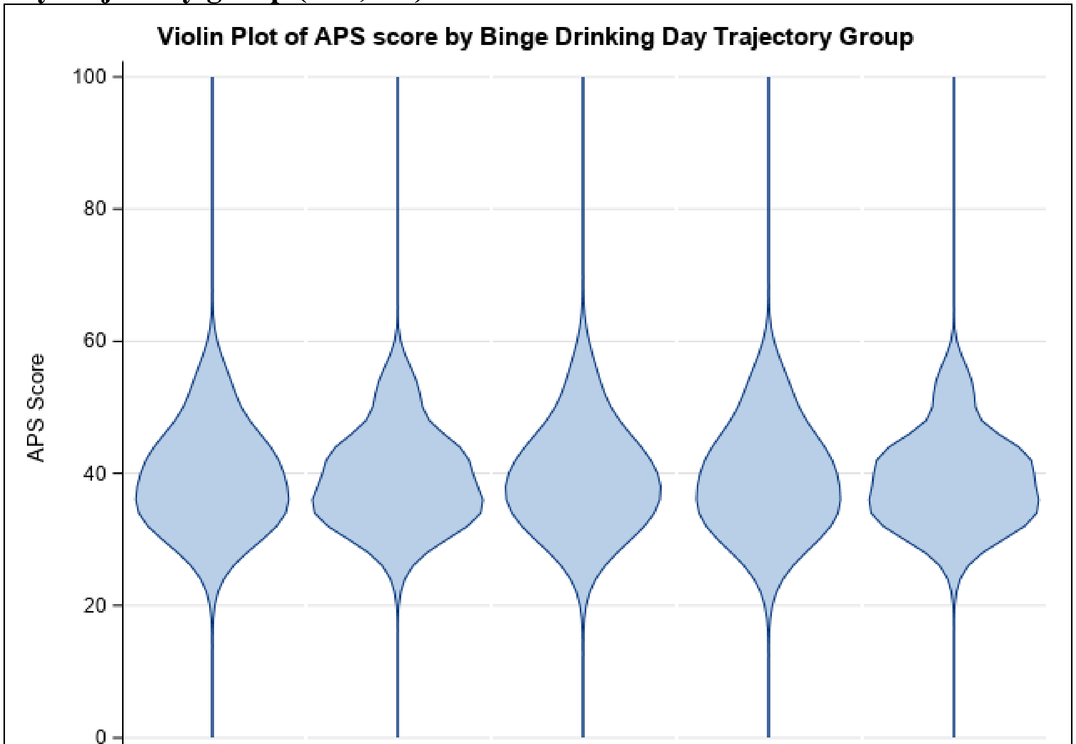


Figure A3.4. Distribution of baseline APS and summary statistics by drinking day trajectory group (n=8,860)



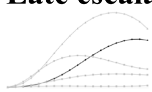
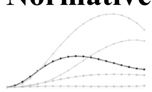
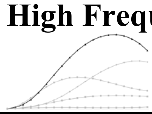
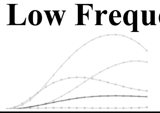
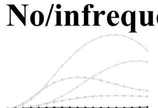
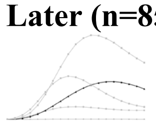
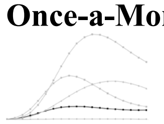
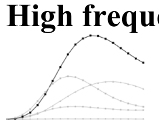
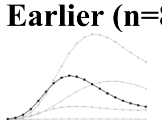
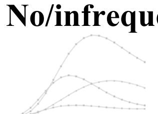
	Late Escalating n=854	**Normative n=3,013**	**High Frequency n=354**	**Low Frequency n=874**	**No/ Infrequent n=3,765**
Mean	39.6	38.6	39.4	39.1	39.0
Min	24.6	24.0	24.6	24.6	24.6
Max	55.0	55.0	55.0	55.0	55.0
SD	7.2	6.9	6.7	6.8	6.8

Figure A3.5. Distribution of baseline APS and summary statistics by binge drinking day trajectory group (n=8,860)



	Later N=854	Once-a-Month N=3,013	High frequency N=354	Earlier N=874	No/infreque nt N=3,765
Mean	39.1	39.1	39.1	39.1	39.0
Min	24.6	24.0	24.6	24.6	24.6
Max	55.0	55.0	55.0	55.0	55.0
SD	7.0	6.9	6.8	7.4	6.7

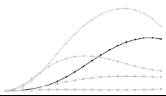
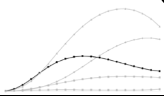
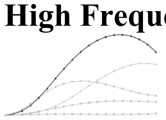
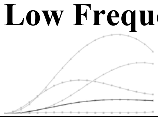
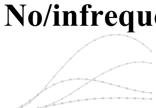
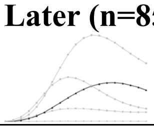
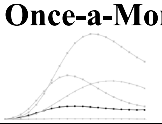
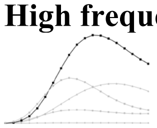
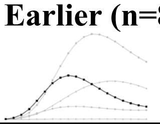
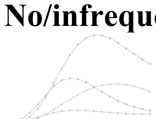
Table A3.4. Association between a 10-unit higher baseline APS score and odds of trajectory membership, excluding those who reported not drinking over follow-up (n=8,860)

	Unadjusted			Adjusted[a]		
	OR	95% CI		OR	95% CI	
Drinking days						
Late escalating (n=894) 	1.16	0.97	1.39	1.14	0.98	1.33
Normative (n=1,464) 	0.94	0.76	1.17	0.95	0.81	1.12
High Frequency (n=428) 	1.12	0.88	1.42	1.09	0.89	1.34
Low Frequency (n=4,212) 	1.06	0.93	1.20	1.08	0.98	1.19
No/infrequent[b] (n=1,862) 	Ref	-	-	Ref	-	-
Binge drinking days						
Later (n=854) 	1.02	0.88	1.18	1.03	0.91	1.17
Once-a-Month (n=3,013) 	1.01	0.90	1.14	1.05	0.94	1.17
High frequency (n=354) 	1.03	0.87	1.22	1.03	0.87	1.22
Earlier (n=874) 	1.02	0.83	1.25	1.02	0.86	1.20
No/infrequent[b] (n=3,765) 	Ref	-	-	Ref	-	-

[a] Adjusted for gender, baseline age, race, Hispanic ethnicity, urban status, parent high school completion status

[b] Comparator outcome trajectory

Table A3.5. Association between a 10-unit higher baseline APS score and odds of trajectory membership, with updated comparator outcomes (n=8,860)

	Unadjusted			Adjusted[a]		
	OR	95% CI		OR	95% CI	
Drinking days						
Late escalating (n=894) 	1.10	0.99	1.23	1.06	0.96	1.18
Normative (n=1,464) 	0.89	0.79	1.02	0.89	0.80	0.99
High Frequency (n=428) 	1.06	0.89	1.26	1.02	0.86	1.20
Low Frequency[b] (n=4,212) 	Ref	-	-	Ref	-	-
No/infrequent (n=1,862) 	0.97	0.85	1.09	0.94	0.85	1.04
Binge drinking days						
Later (n=854) 	1.01	0.91	1.12	0.99	0.89	1.10
Once-a-Month[b] (n=3,013) 	Ref	-	-	Ref	-	-
High frequency (n=354) 	1.01	0.86	1.19	0.99	0.83	1.18
Earlier (n=874) 	1.00	0.86	1.16	0.97	0.86	1.11
No/infrequent[a] (n=3,765) 	0.99	0.88	1.12	0.96	0.86	1.06

[a] Adjusted for gender, Baseline age, race, Hispanic ethnicity, urban status, parent high school completion status

[b] Comparator outcome trajectory

Figure A3.6. Drinking frequency trajectories from age 12–30 restricted to individuals with at least 8 follow-up periods (n=8,098)

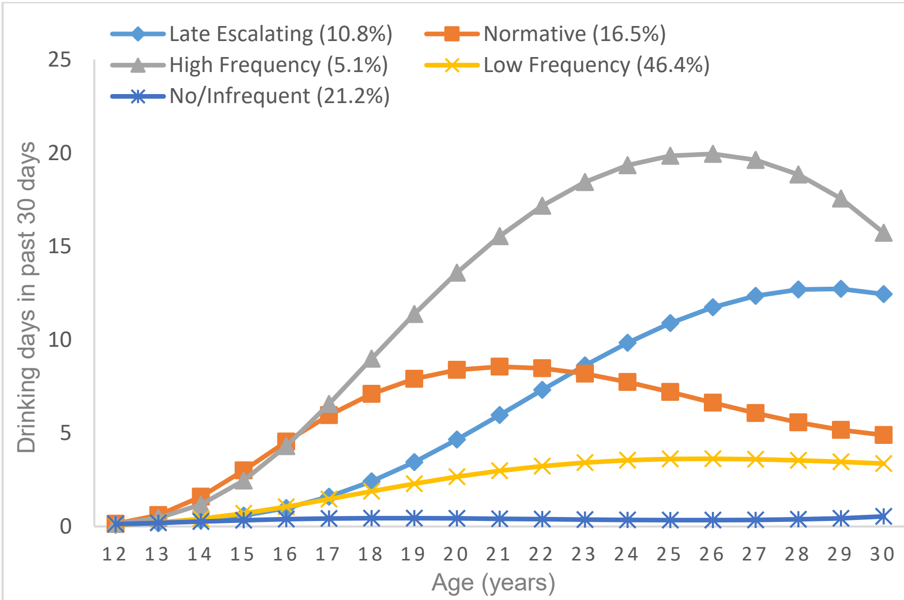


Figure A3.7. Binge drinking frequency trajectories from age 12–30 restricted to individuals with at least 8 follow-up periods (n=8,098)

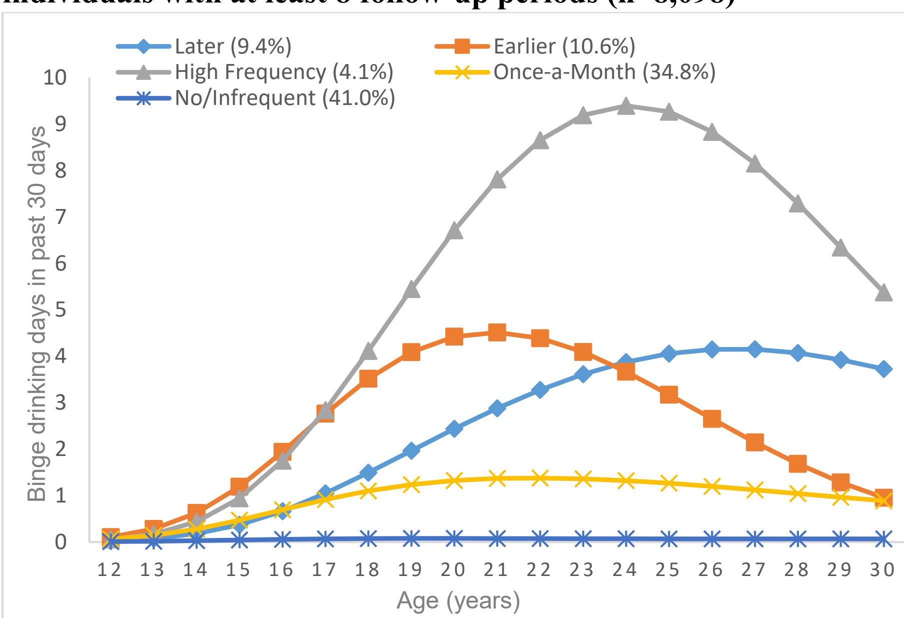


Figure A3.8. Drinking frequency trajectories from age 12–30 restricted to individuals with all but 2 follow-up periods (n=6,211)

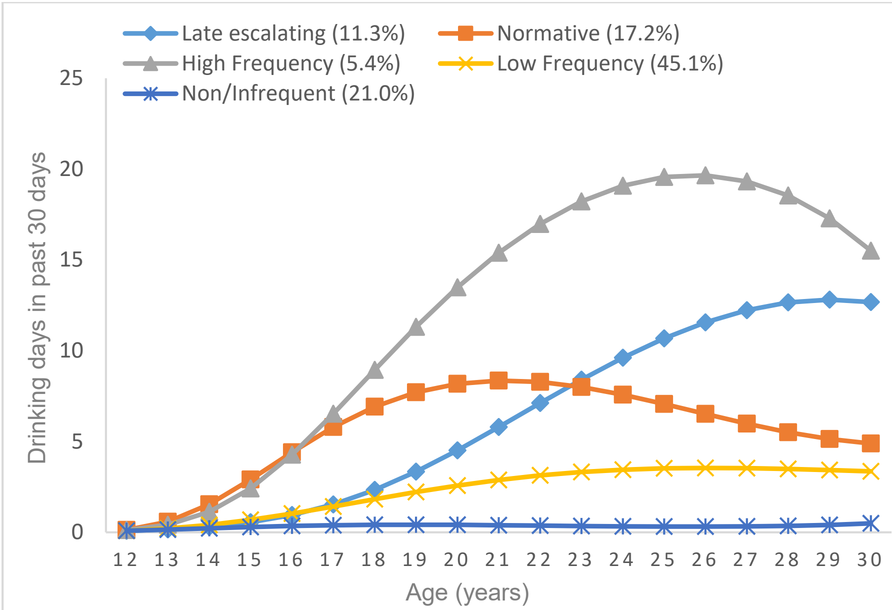


Figure A3.9. Binge drinking frequency trajectories from age 12-30 restricted to individuals with all but 2 follow-up periods (n=6,211)

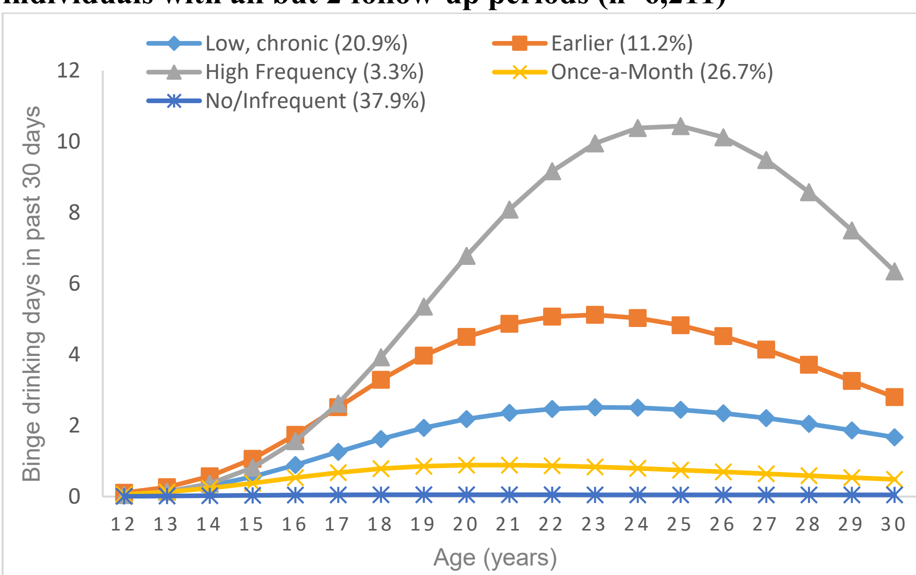


Table A3.6. Parameter estimates for the age 12–22 all-cubic 5-group drinking days trajectory solution (n=8,860)		
Group	Parameter	Estimate
No/Infrequent	Intercept	-87.1553
	Linear	13.53385
	Quadratic	-0.80477
	Cubic	0.01647
Early experimenters	Intercept	-344.319
	Linear	58.43556
	Quadratic	-3.24094
	Cubic	0.05903
Low frequency	Intercept	-29.6485
	Linear	-0.1966
	Quadratic	0.19423
	Cubic	-0.00515
High frequency	Intercept	156.3264
	Linear	-32.0083
	Quadratic	1.9678
	Cubic	-0.03578
Normative	Intercept	122.6875
	Linear	-29.2854
	Quadratic	2.08872
	Cubic	-0.0452
	Sigma	6.39876

Figure A3.10. Drinking frequency trajectories from age 12–22 (n=8,860)

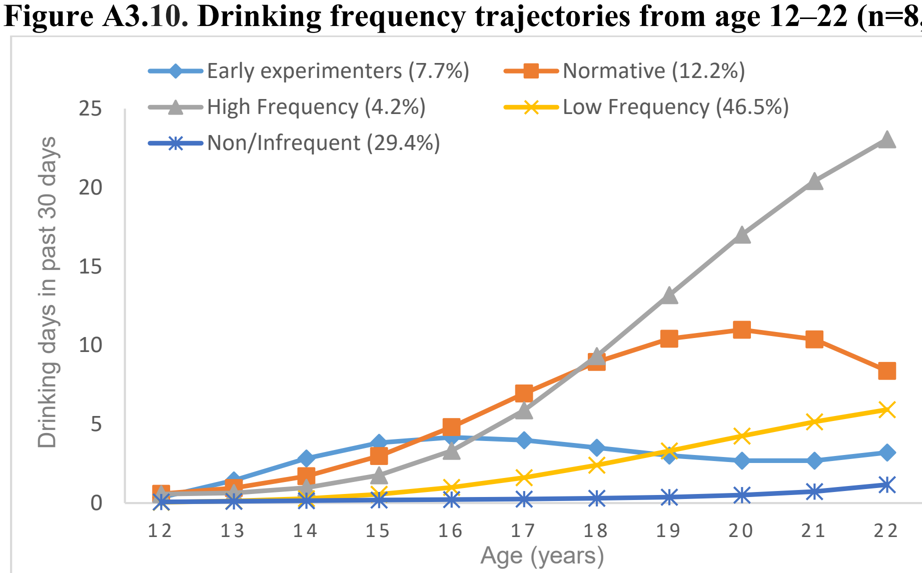


Table A3.7. Parameter estimates for the age 12–22 all-quadratic 5-group binge drinking days trajectory solution (n=8,860)

Group	Parameter	Estimate
Once-a-month	Intercept	2.61324
	Linear	-0.22905
	Quadratic	0.00687
No/infrequent	Intercept	6.70779
	Linear	-1.05476
	Quadratic	0.03035
Later	Intercept	-6.32444
	Linear	0.64973
	Quadratic	-0.01203
Earlier	Intercept	-4.21668
	Linear	0.85095
	Quadratic	-0.02771
High Frequency	Intercept	-18.8554
	Linear	2.10957
	Quadratic	-0.05154
	Alpha0	14.7358
	Alpha1	-1.13613
	Alpha2	0.00746
	Alpha3	0.00055

Figure A3.11. Binge drinking frequency trajectories from age 12–22 (n=8,860)

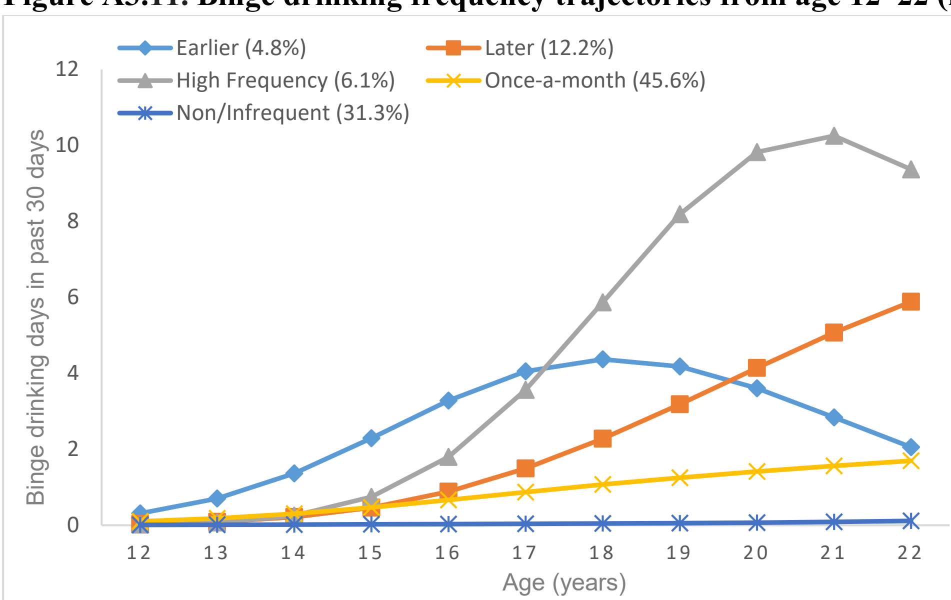


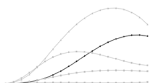
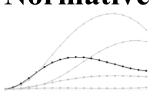
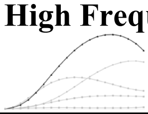
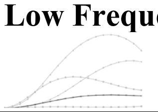
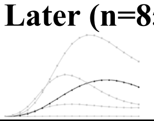
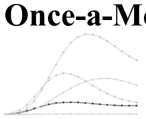
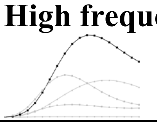
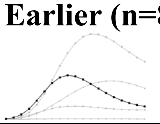
Table A3.8. Age 12–22 trajectories, association between a 10-unit higher baseline APS score and odds of trajectory membership (n=8,860)

	Unadjusted			Adjusted[a]		
	OR	95% CI		OR	95% CI	
Drinking days						
Early experimenters (n=655)	0.96	0.82	1.13	1.00	0.87	1.16
Normative (n=925)	0.91	0.76	1.10	0.92	0.80	1.06
High Frequency (n=329)	1.00	0.81	1.25	1.00	0.82	1.20
Low Frequency (n=3,931)	0.99	0.87	1.11	1.00	0.92	1.09
No/infrequent[b] (n=3,020)	-	-	-	-	-	-
Binge drinking days						
Once-a-Month (n=3,013)	1.01	0.89	1.16	0.98	0.88	1.11
Later (n=854)	0.98	0.87	1.12	0.95	0.86	1.06
High frequency (n=354)	1.00	0.87	1.16	0.96	0.84	1.11
Earlier (n=874)	0.92	0.78	1.09	0.90	0.76	1.07
No/infrequent[b] (n=3,765)	-	-	-	-	-	-

[a] Adjusted for gender, Baseline age, race, Hispanic ethnicity, urban status, parent high school completion status

[b] Comparator outcome trajectory

Table A3.9. Association between a high APS (above the sample median) and odds of trajectory membership (n=8,860)

	Unadjusted			Adjusted[a]		
	OR	95% CI		OR	95% CI	
Drinking days						
Late escalating (n=894) 	1.16	0.92	1.45	1.13	0.92	1.38
Normative (n=1,464) 	0.92	0.72	1.18	0.93	0.76	1.14
High Frequency (n=428) 	1.25	0.92	1.71	1.22	0.93	1.59
Low Frequency (n=4,212) 	1.08	0.92	1.26	1.14	0.98	1.31
No/infrequent[b] (n=1,862) 	-	-	-	-	-	-
Binge drinking days						
Later (n=854) 	0.93	0.78	1.11	0.95	0.80	1.11
Once-a-Month (n=3,013) 	0.92	0.80	1.06	0.98	0.86	1.12
High frequency (n=354) 	1.00	0.77	1.30	1.02	0.78	1.33
Earlier (n=874) 	0.98	0.77	1.24	0.97	0.79	1.20
No/infrequent[b] (n=3,765) 	Ref	-	-	Ref	-	-

[a] Adjusted for gender, Baseline age, race, Hispanic ethnicity, urban status, parent high school completion status

[b] Comparator outcome trajectory

APPENDIX: CHAPTER 4

Table A4.1. Prevalence of NIfETy items among the sampled NIfETy blocks (n=800)

Item	Count	Percent	N	Category
Total Broken Windows	191	24.2	791	Physical
Eviction Signs	12	1.5	791	Physical
Boarded Abandoned Buildings	226	28.6	791	Physical
Unboarded Abandoned Buildings	35	4.4	791	Physical
Vacant Houses	213	26.9	791	Physical
Vacant Commercial Buildings	104	13.2	791	Physical
New Construction or Renovations [a]	77	9.6	800	Physical
Unmaintained Property	433	54.1	800	Physical
Trash in Street	410	51.3	800	Physical
Trash in Alley	185	23.1	800	Physical
Trash in Other Open Spaces	479	59.9	800	Physical
Rats/ Mice	13	1.6	800	Physical
Dead Animals Visible	21	2.6	800	Physical
Live Animals Visible [a]	128	16.0	800	Physical
Vacant Lots	122	15.3	800	Physical
Broken Bottles	297	37.1	800	Physical
Potholes	169	21.1	800	Physical
Graffiti	523	65.4	800	Physical
Fire Escapes [a]	67	8.4	800	Physical
Damaged Sidewalks	734	91.9	799	Physical
Warning Signs	693	86.6	800	Physical
Bus Stops [a]	314	39.3	800	Physical
Train Stations [a]	1	0.1	790	Physical
Trolleys/Light Rail [a]	3	0.4	790	Physical
Taxis [a]	4	0.5	790	Physical
"Hacks" (illegal or unlicensed taxis)	1	0.1	790	Physical
Other Public Transportation [a]	7	0.9	790	Physical
Murals [a]	30	3.8	800	Physical
Speed Devices [a]	652	81.5	800	Physical
Government Camera(s) [a]	43	5.4	790	Physical
Other Surveillance Camera(s) [a]	58	7.3	790	Physical
Flood Light(s) [a]	3	0.4	800	Physical
Police Present [a]	35	4.4	800	Physical
Police Cruising in Car [b]	28	80.0	35	Physical
Parked Marked Police Cars [b]	12	34.3	35	Physical
Police Engaging with Civilians [b]	4	11.4	35	Physical
Police Walking the Beat [b]	1	2.9	35	Physical
Other Police Activity [b]	5	14.7	34	Physical
Days of the Week Posted for Street Cleaning [a]	196	24.5	800	Physical
Signs with Positive/Neutral Messages [a]	86	10.9	790	Physical
Signs with Negative Messages	5	0.6	790	Physical
Signs/Print Ads Related to Alcohol	38	4.8	800	Physical

Signs/Print Ads Related to Tobacco	16	2.0	800	Physical
Signs in Foreign Language [a]	11	1.4	789	Physical
Security Alarm Signs on Houses [a]	625	78.1	800	Physical
Evidence of Vandalism	412	51.5	800	Physical
Evidence of Landscaping [a]	723	90.4	800	Physical
Operable Vehicles [a]	744	93.0	800	Physical
Inoperable Vehicles	41	5.1	800	Physical
Used Condoms	42	5.3	790	Physical
Outdoor Community Recreation Outlets [a]	49	6.1	800	Social
Parks and Playgrounds [b]	37	72.6	51	Social
Court Yards [b]	23	45.1	51	Social
Organized Game Courts [b]	19	37.3	51	Social
Benches [b]	30	50.9	59	Social
Noisy	710	88.8	800	Social
Special Event Visible from Block [a]	4	0.5	790	Social
Traffic (Cars Passing in 3 Minutes)	670	83.8	800	Social
Homeless People	17	2.1	800	Social
People Yelling	121	15.1	800	Social
People Swearing	73	9.1	800	Social
People in Physical Fights	3	0.4	800	Social
People Loitering	42	5.3	800	Social
Male Adults Loitering [b]	38	73.1	52	Social
Male Youth Loitering [b]	13	25.0	52	Social
Intoxicated People	20	2.5	800	Social
Evidence of Prostitution	0	0.0	790	Social
Drug Paraphernalia	373	46.6	800	VAOD
Syringes	17	2.1	800	VAOD
Baggies	217	27.1	800	VAOD
Cotton Swabs	84	10.5	800	VAOD
Rubber Gloves	64	8.0	800	VAOD
Vials	87	10.9	800	VAOD
Blunt Guts/Wrappers	315	39.4	800	VAOD
Marijuana (Pot) Roaches	4	0.5	800	VAOD
Crack Pipes	3	0.4	800	VAOD
Batteries	10	1.3	800	VAOD
Other Drug Paraphernalia	10	1.3	800	VAOD
People Smoking Tobacco	109	13.6	800	VAOD
Cigarette Butts	607	75.9	800	VAOD
Black and Milds/Mini-Cigars	203	25.4	800	VAOD
Loose Cigarette Transactions	11	1.4	800	VAOD
Black & Mild/Mini-Cigar Transactions	3	0.4	800	VAOD
People Consuming Alcohol	21	2.6	800	VAOD
Alcohol Bottles	407	50.9	800	VAOD
People Using Drugs	4	0.5	800	VAOD
Obvious Signs of Drug Selling	7	0.9	790	VAOD
Blood in Street or Sidewalks	0	0.0	790	VAOD

Shell Casings in Street	0	0.0	790	VAOD
Police Tape/Outlines in Street	3	0.4	790	VAOD
Memorials	9	1.1	790	VAOD

[a] Potentially positive, could indicate neighborhood order rather than disorder
[b] Contingent upon presence of another item

Table A4.2. Disorder score descriptions by score summary version, among the n=800 NIfETy blocks

Disorder Score	**Possible Max**	**Min**	**Max**	**Mean**	**SD**	**Median**
Overall Neighborhood Disorder (All Domains)						
Version 1: Sum of all factors	91	0	46	17.1	7.7	17
Version 2: Minus positive spin and sub-items[a]	58	0	34	12.1	6.6	12
Physical Disorder Domain						
Version 1: Sum of all factors	50	0	27	11.6	4.6	11
Version 2: Minus positive spin and sub-items[a]	25	0	17	6.8	3.7	6
Social Disorder Domain						
Version 1: Sum of all factors	17	0	13	2.3	1.5	2
Version 2: Minus positive spin and sub-items[a]	9	0	6	2.1	1.0	2
Violence, Alcohol, and Other Drugs Domain						
Version 1: Sum of all factors	24	0	13	3.2	2.7	3
Version 2: Minus positive spin and sub-items[a]	24	0	13	3.2	2.7	3

[a] See A4.1 footnotes a and b indicating removed items.

Figure A4.1. Geocoded NIfETy blocks (n=800) within Baltimore neighborhood statistical areas

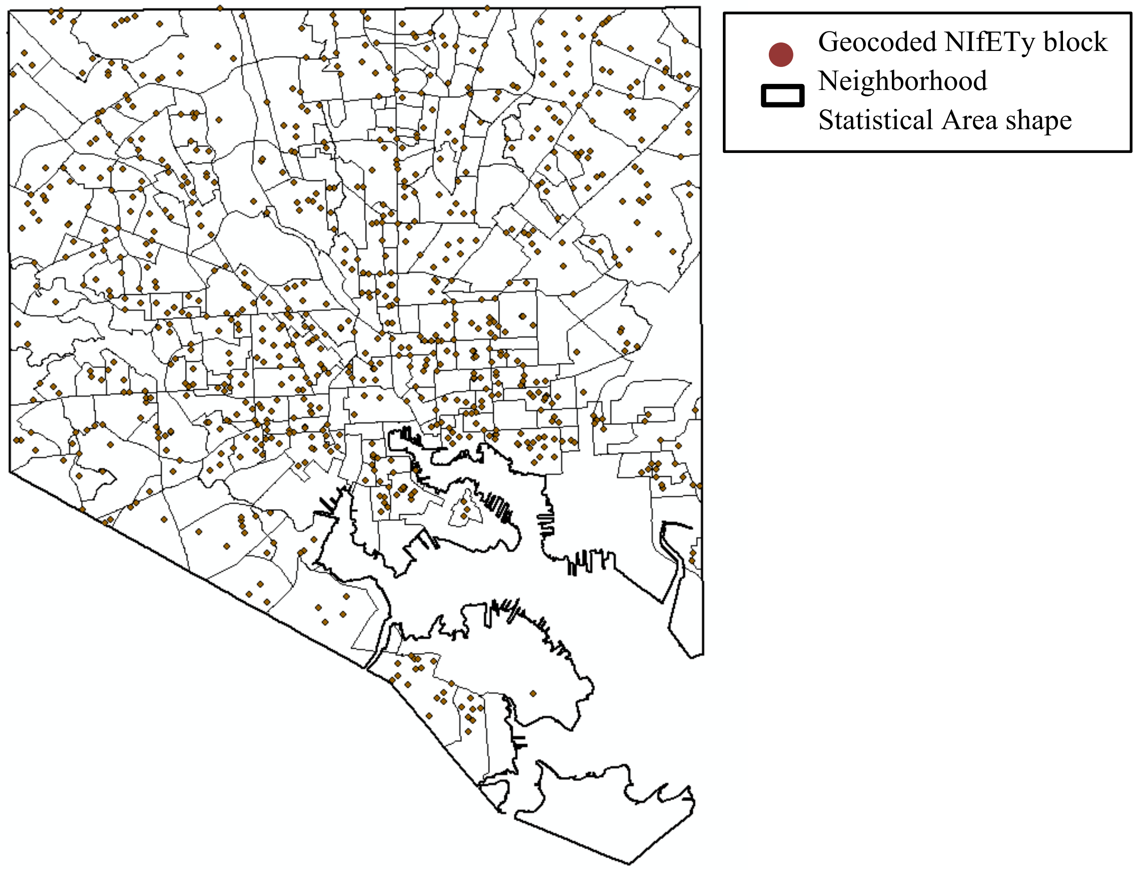


Figure A4.2. NIfETy block counts within each Baltimore neighborhood statistical area (n=800)

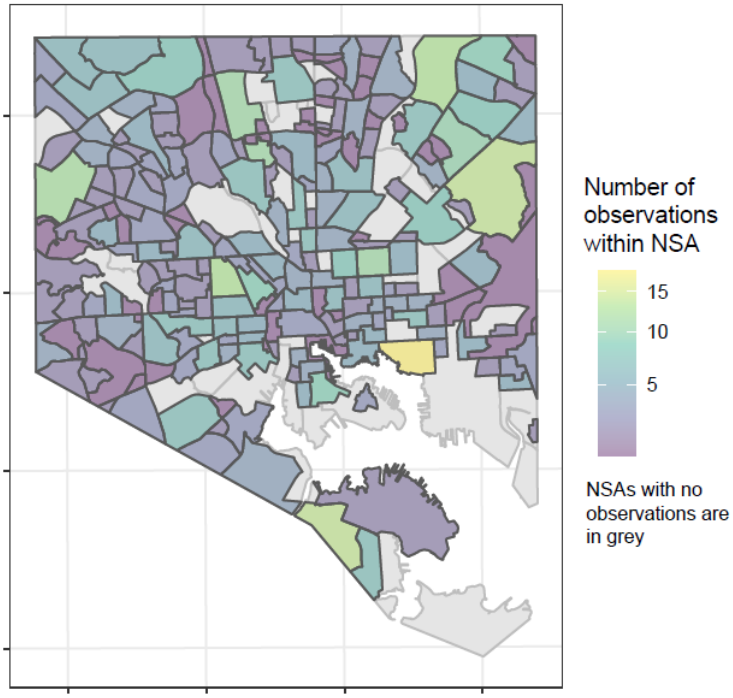


Figure A4.3. Average NIfETy total disorder scores within each Baltimore neighborhood statistical area (n=277)

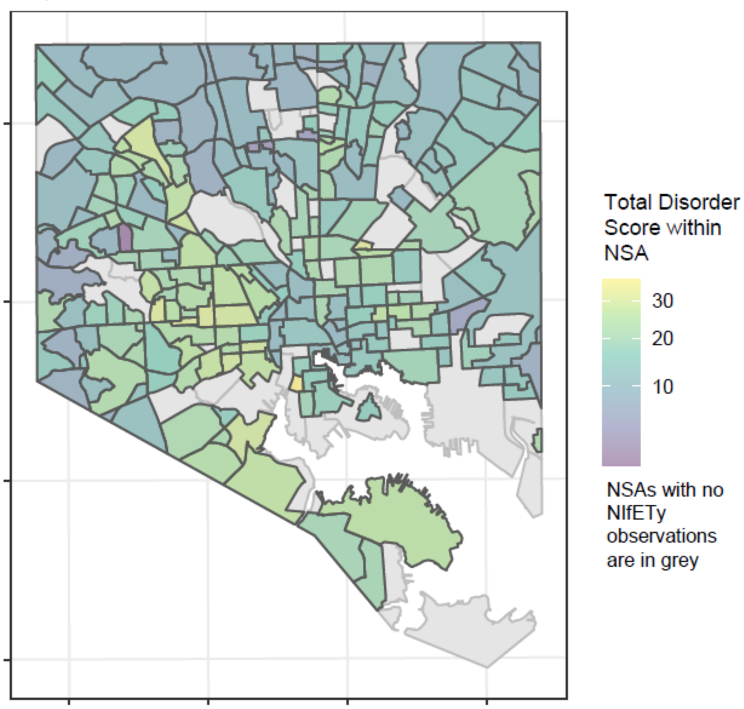


Figure A4.4. Distribution of percent of time in Baltimore prior to sample restriction (n=480)

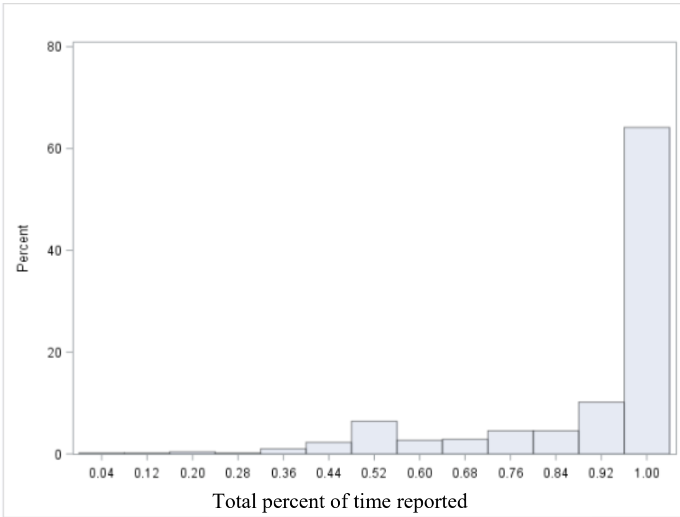


Figure A4.5. Scatter plot of live/sleep neighborhood disorder exposure score versus activity-weighted neighborhood disorder score, total and subdomains (n=406)

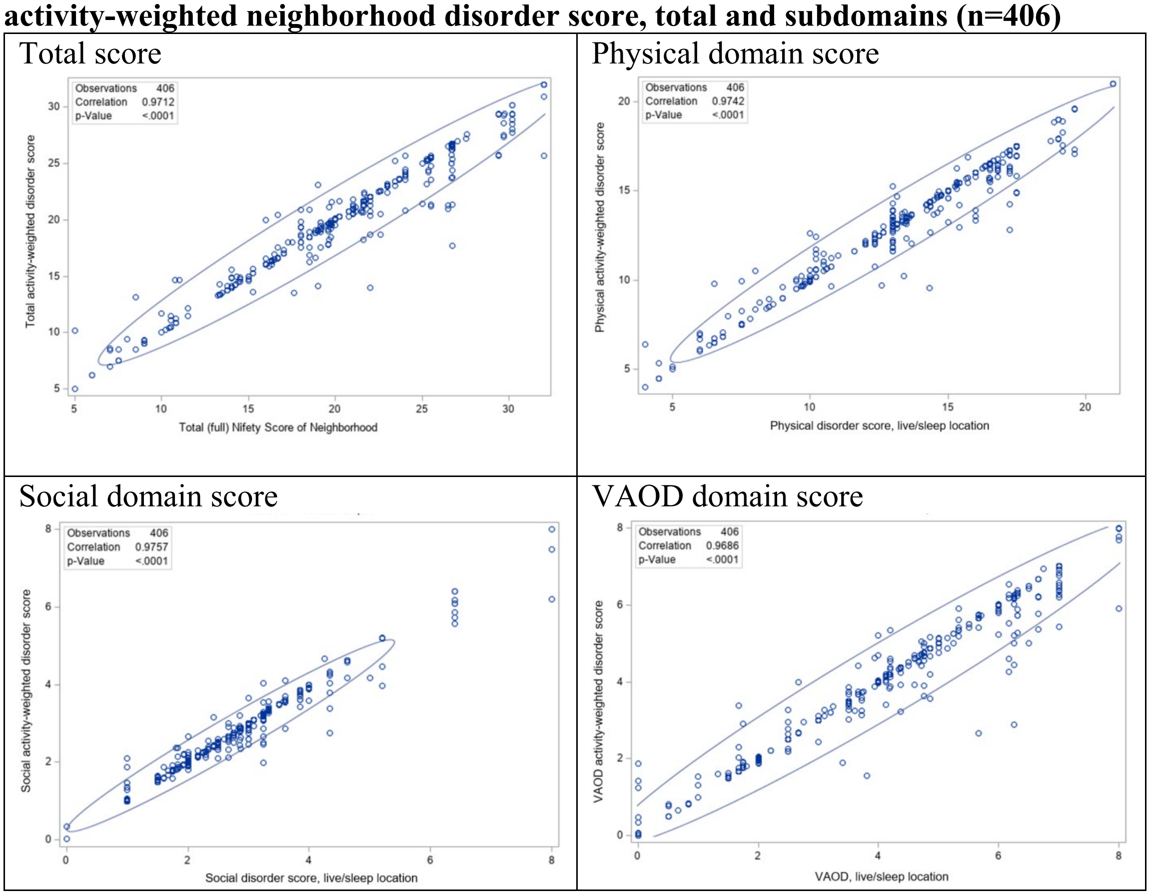


Table A4.3. General demographics among the overall analytic sample by total disorder percentile (n=406)

Variable	Bottom 75% Total Disorder Score (n=302)		Top 25% Total Disorder Score (n=104)	
	n	% or Mean (SD)	n	% or Mean (SD)
Age (yrs.)		49.9 (9.1)		47.5 (10.9)
Assigned male sex at birth	169	56.0	61	58.7
Gender Identity				
Male	165	54.6	59	56.7
Female	133	44.0	43	41.4
Transgender	4	1.3	2	1.9
Other	0	0.0	0	0.0
Sexual Orientation				
Heterosexual	237	78.5	84	80.8
Bisexual	34	11.3	10	9.6
Homosexual, Gay, Same Gender loving, Queer, Questioning, Other	31	10.3	10	9.6
Race				
Black or African American	270	89.4	99	95.2
White	27	8.9	4	3.9
Other, Mixed, or Multiracial	5	1.7	1	1.0
Grade 12, GED or Higher	194	64.2	55	52.9
Living Situation				
Own Place	157	52.0	55	52.9
Parent/Family	71	23.5	23	22.1
Someone else's	31	10.3	11	10.6
Rooming, boarding, hallway house, shelter/welfare hotel	37	12.3	13	12.5
On the street(s)	2	0.7	0	0.0
Other	4	1.3	2	1.9
Length in living situation				
3 months or less	38	12.6	15	14.4
4-6 months	29	9.6	14	13.5
7 months – 1 year	41	13.6	18	17.3
Over a year	194	64.2	57	54.8
Homeless in past 6 months	64	21.2	21	20.2
Squatted for 1 week or more in past 6 months	55	18.2	20	19.2
Unemployed	252	83.4	88	84.6

Income past year (total personal)[a]				
Less than $5,000	120	40.3	45	43.3
$5,000 - $10,000	101	33.9	27	26.0
$10,000 - $19,999	50	16.8	23	22.1
$20,000 - $29,999	18	6.0	8	7.7
Greater than $30,000	9	3.0	1	1.0
Worry about enough money for basics (past 6 months)				
Never	72	23.8	24	23.1
Once in a while	97	32.1	29	27.9
Fairly Often	45	14.9	19	18.3
Very Often	88	29.1	32	30.8

[a] n=402 due to 4 individuals missing data on income (3 bottom 75th, 1 top 25th percentile)

Table A4.4. Health demographics among the overall analytic sample by total disorder percentile (n=406)

Variable	Bottom 75% Total Disorder Score (n=302)		Top 25% Total Disorder Score (n=104)	
	n	% or Mean (SD)	n	% or Mean (SD)
Currently has insurance / medical coverage	263	87.1	86	82.7
Self-rated health, General				
Poor	16	5.3	3	2.9
Fair	104	34.4	47	45.2
Good	101	33.4	33	31.7
Very Good	55	18.2	13	12.5
Excellent	26	8.6	8	7.7
Mental health interference in social life				
Not at all	141	46.7	56	53.9
A bit	117	38.7	36	34.6
A lot	44	14.6	12	11.5
CES-D Score		15.7 (10.7)		16.3 (10.9)
CES-D Score (23+)	78	25.8	30	28.9
HIV positive	175	58.0	66	63.5
Last HIV Medical care				
Never	3	1.7	2	3.0
Over 1 year ago	4	2.3	4	6.1
Past year	8	4.8	3	4.6
Past 6 months	14	8.0	6	9.1
Past 3 months	146	83.4	51	77.3
Hepatitis C positive	101	33.4	37	35.6
Last Care for Hepatitis C[a]				
Never	49	49.0	16	44.4
More than a year ago	21	21.0	7	19.4
In the past year	7	7.0	2	5.6
In the past 6 months	6	6.0	4	11.1
In the past 3 months	17	17.0	7	19.4

[a] Among Hepatitis C positive but missing 2 so n=136

Table A4.5. Frequency of participant-reported activity space locations by analytic sample

Activity-space Location	Overall analytic sample n=406		Treatment seeking sample n=280		Injection behaviors sample n=70	
	n	%	n	%	n	%
Live/sleep	406	100.0	280	100.0	70	100.0
Socialize	324	79.8	237	84.6	65	92.9
Work/earn money	104	25.6	78	27.9	20	28.6
Inject	94	23.2	91	23.5	67	95.7

Table A4.6. Total number of activity locations and number of these locations that were contained within a unique NSA reported by a participant (n=406)

	Total number of locations reported by the individual				
Unique NSA	1 Location n=66 (n)	2 Locations n=187 (n)	3 Locations n=124 (n)	4 Locations n=29 (n)	Percent of participants n=406
Same NSA	66	108	39	10	54.9%
2 Unique NSAs	-	79	64	13	38.4%
3 Unique NSAs	-	-	21	3	5.9%
4 Unique NSAs	-	-	-	3	0.7%

Table A4.7. Overlap in activity space location types in the main analytic sample among those reporting two or more activity-space locations

	Sleep (n=406)	Inject (n=94)	Socialize (n=324)	Money (n=104)
Sleep	-	61 (64.9%)	184 (56.8%)	31 (29.8%)
Inject	61 (15.0%)	-	58 (17.9%)	18 (17.3%)
Socialize	184 (45.3%)	58 (61.7%)	-	38 (36.5%)
Money	31 (7.6%)	16 (17.0%)	38 (11.7%)	-

Note: an individual has to identify an additional activity-space. As such the counts represent whether or not the location noted for that additional activity overlapped and what proportion of the overall sample that encompassed

Table A4.8. Accounting for percent of time spent at residential live/sleep location as a model covariate

Outcome		
Harmful Alcohol Use (AUDIT 8+), N=406	**PR[b]**	**95% CI**
Adjusted only for sleep percent		
Total Disorder	1.16	0.93, 1.44
Time at live/sleep location[a]	0.20	0.01, 2.80
Confounder Adjusted[c] & Adjusted for sleep percent		
Total Disorder	1.16	0.94, 1.43
Time at live/sleep location[a]	0.47	0.03, 7.20
Non-alcohol treatment in the past 6 months, N=280	**PR[b]**	**95% CI**
Adjusted only for sleep percent		
Total Disorder	0.99	0.89, 1.09
Time at live/sleep location[a]	0.78	0.42, 1.44
Confounder Adjusted[c] & Adjusted for sleep percent		
Total Disorder	0.96	0.88, 1.06
Time at live/sleep location[a]	0.75	0.42, 1.35
Injection drug use in the past 6 months, N=406	**PR[b]**	**95% CI**
Adjusted only for sleep percent		
Total Disorder	1.03	0.87, 1.22
Time at live/sleep location[a]	0.36	0.13, 0.99
Confounder Adjusted[c] & Adjusted for sleep percent		
Total Disorder	1.04	0.88, 1.22
Time at live/sleep location[a]	0.56	0.19, 1.62

PR = prevalence ratio, CI = confidence interval

[a] One-unit higher percent of time spent at live/sleep location

[b] Log binomial model estimating relative risk of the outcome with a 1 standard deviation higher disorder score (conceptually considered prevalence ratios); accounting for clustering by neighborhood

[c] Adjusted for age, sex at birth, high school completion status, homelessness status, and degree of worry about money

[d] Negative binomial regression estimating increase in log AUDIT score with a 1 standard deviation higher disorder score; accounting for clustering by neighborhood

Table A4.9. Effect modification by time at live/sleep location on associations between live/sleep disorder and harmful alcohol use, treatment, and injection drug use

	Spends **75% or more of time** at live/sleep location		Spends **less than 75% of time at** live/sleep location	
	PR[a]	95% CI	PR[a]	95% CI
Harmful alcohol use, N=406				
Unadjusted	1.17	0.94, 1.46	1.01	0.70, 1.46
Adjusted[b]	1.18	0.96, 1.45	1.02	0.70, 1.50
Treatment in the past 6 months (among those with a history of drug use), N=280				
Unadjusted	1.00	0.90, 1.10	0.96	0.79, 1.16
Adjusted[b]	0.97	0.90, 1.06	0.99	0.83, 1.18
Injection drug use in the past 6 months, N=406				
Unadjusted	1.02	0.86, 1.20	1.15	0.73, 1.81
Adjusted[b]	1.00	0.85, 1.17	1.12	0.74, 1.69

PR = prevalence ratio, CI = confidence interval

[a] Log binomial model estimating relative risk of the outcome with a 1 standard deviation higher disorder score (conceptually considered prevalence ratios); accounting for clustering within neighborhoods

[b] Adjusted for age, sex at birth, high school completion status, homelessness status, and degree of worry about money

Table A4.10. Comparing model fit for main results (Tables 4.5-4.7)

	Total Disorder	Physical Disorder	Social Disorder	VAOD Disorder
Alcohol use				
Harmful Alcohol Use[a] (AUDIT 8+)				
Live/Sleep, Unadjusted	446.9	447.3	447.8	447.4
Live/Sleep, Adjusted[b]	447.3	447.6	448.4	447.4
Activity-weighted,[c] Unadjusted	447.6	447.7	448.1	448.1
Activity-weighted,[c] Adjusted[b]	447.7	448.1	448.3	447.8
AUDIT Score[d]				
Live/Sleep, Unadjusted	-6859.0	-6817.4	-6871.4	-6932.4
Live/Sleep, Adjusted[b]	-6464.6	-6445.5	-6424.2	-6502.3
Activity-weighted,[c] Unadjusted	-6862.4	-6824.6	-6879.9	-6930.2
Activity-weighted,[c] Adjusted[b]	-6444.6	-6434.0	-6427.4	-6472.0
Treatment Related				
Any non-alcohol related treatment in the past 6 months, among those with a history of drug use (n=280)[a]				
Live/Sleep, Unadjusted	376.9	376.6	376.8	376.7
Live/Sleep, Adjusted[b]	375.0	374.3	375.6	375.4
Activity-weighted,[c] Unadjusted	376.9	376.8	376.3	376.7
Activity-weighted,[c] Adjusted[b]	375.4	375.0	375.3	375.5
Injection drug use, past 6 months[b]				
Live/Sleep, Unadjusted	417.0	417.0	416.6	417.1
Live/Sleep, Adjusted[b]	407.5	407.7	406.9	407.4
Activity-weighted,[c] Unadjusted	416.5	416.6	415.9	416.9
Activity-weighted,[c] Adjusted[b]	406.9	407.4	406.4	407.1

Note: QICu was examined as well but not reported as QIC and QICu typically suggested the same model preference.

[a] Log binomial model

[b] Adjusted for age, sex at birth, high school completion status, homelessness status, and degree of worry about money

[c] Activity-weighted includes where they slept/lived, earned money, injected drugs (if applicable), and socialized; only those locations reported and unique from residential location were used in the calculation.

[d] Negative binomial regression

Table A4.11. Model Results for activity-weighted disorder score: exploring the impact of accounting for missing within-Baltimore location data using the population minimum, average, and maximum total disorder scores

		Total Disorder Score, Accounting for missing time with minimum		Total Disorder Score, Accounting for missing time with average		Total Disorder Score, Accounting for missing time with maximum	
	N	**PR[a]**	**95% CI**	**PR[a]**	**95% CI**	**PR[a]**	**95% CI**
Harmful Alcohol Use (AUDIT 8+)							
Activity-weighted, Unadjusted	406	1.10	0.89, 1.35	1.12	0.91, 1.38	1.14	0.93, 1.39
Activity-weighted, Adjusted[b]	406	1.10	0.90, 1.35	1.13	0.93, 1.37	1.14	0.95, 1.38
Any drug treatment (non-alcohol) in past 6 months[c]							
Activity-weighted, Unadjusted	280	1.01	0.91, 1.11	1.00	0.91, 1.11	1.00	0.91, 1.11
Activity-weighted, Adjusted[b]	280	0.99	0.90, 1.08	0.99	0.90, 1.09	0.99	0.90, 1.09
Injection drug use in the past 6 Months							
Activity-weighted, Unadjusted	406	1.07	0.90, 1.26	1.07	0.91, 1.27	1.08	0.91, 1.27
Activity-weighted, Adjusted[b]	406	1.07	0.91, 1.26	1.07	0.91, 1.25	1.07	0.91, 1.25

PR = prevalence ratio, CI = confidence interval

Note: Activity-weighted includes where they slept/lived, earned money, injected drugs (if applicable), and socialized; only those locations reported and unique from residential location were used in the calculation.

[a] Log binomial model estimating relative risk of the outcome with a 1 standard deviation higher disorder score (conceptually considered prevalence ratios); accounting for clustering within neighborhoods

[b] Adjusted for age, sex at birth, high school completion status, homelessness status, and degree of worry about money

[c] Among those with a history of drug use (n=280)

Table A4.12. Model results by exposure exploring the impact of: no sample restriction based on time spent in Baltimore, updating the disorder score to exclude potentially positive and contingent items, and estimating disorder exposure using nearest NIfETy location (rather than NSA)

	No restrictions on time in Baltimore, original total disorder score[a]			Disorder score removing potentially positive and contingent items[b]			Total disorder score, nearest NIfETy block match[c]		
	N	PR[d]	95% CI		PR[d]	95% CI		PR[d]	95% CI
Harmful Alcohol Use									
Live/Sleep, Unadjusted	494	1.14	0.95, 1.37	406	1.18	0.96, 1.45	401	0.97	0.83, 1.14
Live/Sleep, Adjusted[e]	493	1.12	0.95, 1.32	406	1.19	0.97, 1.46	401	0.97	0.82, 1.13
Activity-weighted,[f] Unadjusted	494	1.15	0.95, 1.37	406	1.16	0.95, 1.42	401	1.01	0.85, 1.21
Activity-weighted,[f] Adjusted[e]	493	1.13	0.96, 1.33	406	1.18	0.97, 1.44	401	1.01	0.85, 1.21
Any drug treatment (non-alcohol) in past 6 months[g]									
Live/Sleep, Unadjusted	340	1.01	0.92, 1.10	280	1.00	0.90, 1.11	277	1.05	0.96, 1.15
Live/Sleep, Adjusted[e]	340	0.98	0.91, 1.06	280	0.99	0.90, 1.09	277	1.07	0.98, 1.17
Activity-weighted,[f] Unadjusted	340	1.02	0.93, 1.12	280	1.01	0.91, 1.12	277	1.01	0.92, 1.10
Activity-weighted,[f] Adjusted[e]	340	1.00	0.92, 1.08	280	1.00	0.91, 1.10	277	1.01	0.93, 1.11
Injection drug use in the past 6 Months									
Live/Sleep, Unadjusted	494	0.98	0.83, 1.15	406	1.05	0.88, 1.26	401	1.04	0.89, 1.21
Live/Sleep, Adjusted[e]	493	0.96	0.83, 1.11	406	1.07	0.90, 1.26	401	1.07	0.94, 1.22
Activity-weighted,[f] Unadjusted	494	1.02	0.87, 1.19	406	1.08	0.91, 1.30	401	1.09	0.89, 1.33
Activity-weighted,[f] Adjusted[e]	493	1.01	0.87, 1.16	406	1.11	0.94, 1.31	401	1.13	0.94, 1.35

PR = prevalence ratio, CI = confidence interval

[a] Updating the sample size to include those spending less than 75% of their time in Baltimore city limits. Note: in adjusted models one individual was missing data on an adjustment variable.

[b] Excluding items from the total score that were potentially positive (indicating order rather than disorder) and those items that were contingent on the presence of another item. See Appendix Table A4.1 for item list.

[c] Assigning disorder score based on NIfETy sampling location nearest to the participant's activity location with a maximum reach of 1 mile. Note: 4 addresses couldn't be matched as there was no sampling point within the 1-mile buffer

[d] Log binomial models looking at one standard deviation higher disorder score; accounting for clustering within neighborhood.

[e] Adjusted for age, sex at birth, high school completion status, homelessness status, and degree of worry about money
[f] Activity-weighted includes where they slept/lived, earned money, injected drugs (if applicable), and socialized; only those locations reported and unique from residential location were used in the calculation.
[g] Among those with any non-alcohol drug treatment in the past 6 months

Table A4.13. Associations for injection location disorder score and injection drug-related outcomes in the past 6 months with a standard deviation higher disorder score, among those who inject (n=68)

	Total Disorder		**Physical Disorder**		**Social Disorder**		**VAOD Disorder**	
	PR[a]	**95% CI**	**PR[a]**	**95% CI**	**PR[a]**	**95% CI**	**PR[a]**	**95% CI**
Lent a needle								
Injection, Unadjusted	0.84	0.62, 1.15	0.87	0.64, 1.18	0.78	0.55, 1.11	0.88	0.62, 1.26
Injection, Adjusted[b]	0.79	0.54, 1.15	0.85	0.59, 1.22	0.79	0.53, 1.18	0.81	0.55, 1.21
Shared a cooker								
Injection, Unadjusted	1.04	0.88, 1.22	1.06	0.88, 1.26	1.06	0.94, 1.19	0.98	0.83, 1.15
Injection, Adjusted[b]	1.00	0.79, 1.25	1.03	0.81, 1.31	1.05	0.87, 1.27	0.94	0.75, 1.16
Shared cotton								
Injection, Unadjusted	1.01	0.83, 1.26	1.02	0.82, 1.27	1.07	0.94, 1.21	0.93	0.77, 1.11
Injection, Adjusted[b]	1.01	0.83, 1.24	1.02	0.82, 1.26	1.05	0.91, 1.20	0.97	0.78, 1.20

PR = prevalence ratio, CI = confidence interval
[a]Log binomial model estimating relative risk of the outcome with a 1 standard deviation higher disorder score (conceptually considered prevalence ratios)
[b]Adjusted for age, sex at birth, high school completion status, homelessness status, and degree of worry about money

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