Predictors of Recall Error in Self-Report of Age at Alcohol Use Onset

MELVIN D. LIVINGSTON, PH.D.,^{a,*} XIAOHUI XU, PH.D., M.P.H., M.D.,^b & KELLI A. KOMRO, M.P.H., PH.D.^c

^a*Department of Biostatistics and Epidemiology, School of Public Health, University of North Texas Health Science Center, Fort Worth, Texas*

^b*Department of Epidemiology and Biostatistics, School of Public Health, Texas A&M Health Science Center, College Station, Texas*

^c*Department of Behavioral Sciences and Health Education, Rollins School of Public Health, Emory University, Atlanta, Georgia*

ABSTRACT. Objective: The present study examined factors associated with recall error in the measurement of alcohol use onset and whether there was a tendency toward earlier or later self-reported age at alcohol use onset. **Method:** This study estimated the effect of predictors on the presence and direction of recall error for age at alcohol use onset. The sample ($n = 1,044$) was from an existing longitudinal alcohol prevention trial in urban Chicago. Estimates were derived from a series of logistic regression models comparing agreement between a retrospective and a prospective measure of age at alcohol use onset. **Results:** Eligibility for

free or reduced-price lunch in 6th grade, alcohol use in 6th grade, cigarette use in 12th grade, and alcohol use in 12th grade were significantly associated with recall error of age at alcohol use onset. Self-reported substance use (alcohol and tobacco) in 12th grade was also found to predict a later self-reported age at alcohol use onset when recalled. **Conclusions:** Those most at risk for the negative outcomes associated with early alcohol initiation are also those most likely to misreport their age at alcohol use onset. (*J. Stud. Alcohol Drugs*, 77, 811–818, 2016)

ALCOHOL USE IS WIDESPREAD AMONG American adolescents. According to 2014 reports from the Monitoring the Future study, more than 27% of adolescents have initiated alcohol use by 8th grade, more than 50% by 10th grade, and 66% by 12th grade (Johnston et al., 2015). There is also extensive literature on the harmful effects of alcohol use during adolescence. The literature strongly suggests that early initiation of alcohol use is associated with higher rates of subsequent high-risk behaviors (violence, substance misuse, academic problems, employment problems, and risky sex) (Greenblatt, 2000; Hingson et al., 2001, 2002; Warner & White, 2003) and consequent health problems (emotional problems, sexually transmitted infections, and injury) (DiClemente et al., 1996; Ellickson et al., 2003; Epstein & Tamir, 1984; Greenblatt, 2000; Hingson et al., 2002). Moreover, early onset increases the risk of alcohol dependence in adulthood. In short, early onset of alcohol use is a serious public health problem.

Often of necessity, data collected for the purpose of adolescent alcohol research rely on retrospective measures of age at onset, with the serious potential for systematic recall error (Collins et al., 1985; Feldman et al., 1989; Gmel & Daepfen, 2007; Liu et al., 1996; Parra et al., 2003; Simpura & Poikolainen, 1983). Collins et al. (1985) found that retro-

spective measures tended to underreport the extent of past drinking and that levels of current drinking were predictive of the extent of recall bias in high school students.

Estimates of the reliability of age at alcohol onset also have varied widely. Johnson and Mott (2001) found that just over half of their sample from the National Longitudinal Survey of Youth consistently reported age at first alcohol use within their 2-year surveying period. Only 4.6% of participants were consistent about their age at first alcohol use in a three-wave longitudinal study of secondary school students (Engels et al., 1997). An 11-year follow-up of incoming college freshmen found that 32% of participants reported the same age at first alcohol use in Years 1 and 11 (Parra et al., 2003). Inconsistencies in self-reported age at first alcohol use among adolescents tend to result in forward telescoping, with the age at onset increasing over time (Prause et al., 2007; Shillington & Clapp, 2000).

Prior research into understanding correlates of recall error in age at alcohol onset has focused primarily on the length of time since first use (Liang et al., 2012; Shillington et al., 2012). Golub et al. (2000) suggested that recall error may be attributable to a continuing redefinition of what constitutes first use. Parra et al. (2003) proposed that inability to recall the exact age at first alcohol use may be attributable to a combination of increasing awareness of the social undesirability of early alcohol use and lesser saliency of the event compared with more consistently recalled events such as illicit drug use.

Other studies have described participant characteristics associated with increased risk of age at alcohol onset recall error. Shillington et al. (2012) found that females were more likely to be consistent in their reporting of age at alcohol

Received: April 3, 2015. Revision: February 26, 2016.

The research was supported by the National Institute on Alcohol Abuse and Alcoholism (Grant R01 AA013458, principal investigator: Kelli A. Komro; Grant R01 AA016549, principal investigator: Kelli A. Komro).

*Correspondence may be sent to Melvin D. Livingston at 3500 Camp Bowie Blvd., Fort Worth, TX 76107, or via email at: melvin.livingston@unthsc.edu.

onset. Findings have been mixed on the associations between race/ethnicity and recall error of age at alcohol onset, with some studies finding lower consistency among African Americans (Johnson & Mott, 2001; Sartor et al., 2011), whereas another found no association with race (Shillington & Clapp, 2000).

Sartor et al. (2011) examined the association between age at alcohol onset reporting consistency and a variety of adolescent risk factors for alcohol misuse, including childhood abuse, mental health disorders, cigarette use, marijuana use, and heavy alcohol use. In addition, Sartor et al. (2011) estimated whether these associations were associated with a younger or older reported age at first use during follow-up and found that participants reporting an older age at first alcohol use than previously reported were less likely to report heavy episodic drinking than were consistent reporters.

We used data available from Project Northland Chicago (PNC), a longitudinal intervention trial to reduce adolescent alcohol use that followed participants from 6th to 12th grade (Komro et al., 2004, 2008), to replicate prior findings on demographic and substance use predictors of recall error for age at alcohol use onset. In addition, we included measures of family structure and eligibility for free/reduced-price lunch as proxies for socioeconomic status. Socioeconomic status has been previously associated with general memory errors and is a potential predictor of age at alcohol use onset (Farah et al., 2006).

Unlike previous research that relied on consistency of reporting on retrospective measures of age at alcohol onset, the cohort embedded in PNC enabled us to construct both prospective (assessed near the time of onset) and retrospective (assessed after onset) measures of the age at alcohol use onset and to assess how they agreed. This allowed us to directly assess which participants experienced poor recall and what variables were associated with recall error, and to estimate the direction of recall error. This study adds to the literature by providing much needed replication of previous findings while improving on prior studies by including a prospective measure of age at alcohol onset and a lengthy follow-up period of a young cohort.

By improving understanding of correlates of recall error, this study enables researchers to make better judgments about the possibility and extent of recall bias using retrospective self-report measures of age at alcohol use onset. By comparing our findings with the demographic and substance use characteristics found in other study samples, these results will aid researchers' ability to determine the possibility and extent of bias caused by using retrospective measures of age at first alcohol use in existing studies as well as the potential bias in using retrospective age at first alcohol use measures when designing new studies. When researchers are dependent on retrospective measures of age at first alcohol use in circumstances likely to lead to bias, our results will also give guidance on conducting necessary sensitivity analyses.

Method

Study design

PNC was a longitudinal group-randomized trial of Chicago public schools aiming to reduce alcohol and other drug use in a multiethnic high-poverty urban setting. Sixty-one schools agreed to participate in the study. Data collection protocols and analyses were approved by Institutional Review Boards at the University of Minnesota and the University of Florida.

The core data collection consisted of four waves of school-based surveys, following a cohort of youth from 6th to 8th grade. A baseline survey of 6th graders was conducted in fall 2002, with three follow-up surveys in spring 2003, spring 2004, and spring 2005. Of the eligible students, 91% ($n = 4,259$) completed the baseline survey in 2002; 94% ($n = 4,240$) completed the spring 2003 survey; 93% ($n = 3,778$) completed the spring 2004 survey; and 95% ($n = 3,802$) completed the spring 2005 survey. These survey waves resulted in a series of repeated cross-sections with an embedded cohort of participants. The cohort follow-up rates were 89% for the baseline to spring 2003 survey, 67% for the baseline to spring 2004 survey, and 61% for the baseline to spring 2005 survey. For the 5,711 students who completed at least one survey during the intervention period, attempts were made to recruit them as part of a long-term follow-up conducted during their 12th-grade year (2009). The overall response rate for the long-term follow-up survey was 53.1% ($n = 3,032$) (Tobler & Komro, 2011). However, only 1,159 completed every survey from both the original trial and the long-term follow-up.

To assess predictors of recall error, it was necessary to construct a prospective measure of age at alcohol use onset for comparison with the retrospective measure included as part of PNC's long-term follow-up survey. To facilitate this, the 1,159 students responding to every survey were further restricted to only those who responded to the alcohol use questions in both the original PNC surveys and the long-term follow-up survey in 2009. The resulting study cohort included 1,044 African American (43.1%), Hispanic (37.5%), and White (19.5%) youth who completed alcohol use questions in 6th, 7th, 8th, and 12th grades. The sample was 44.6% male, 69.9% spoke English at home, and 74.5% were low income.

Measures

Retrospective measure. Age at alcohol use onset was assessed retrospectively by means of a single item on the 12th-grade follow-up survey. Participants were asked, "About how old were you when you first started drinking, not counting small tastes or sips?" Participants could respond as follows: *never, 8 years old or younger, 9 or 10 years old, 11 or 12*

years old, 13 or 14 years old, 15 or 16 years old, or 17 years or older.

Prospective measure. The prospective age at alcohol use onset variable was created by combining information from eight variables over the five survey time points. During the baseline, 6th-, 7th-, 8th-, and 12th-grade surveys, students were asked, "During the last 12 months, on how many occasions, or times, have you had alcoholic beverages to drink?" Students were instructed not to count small tastes or sips. During the 12th-grade survey, students were also asked, "A year ago, about how often did you drink alcohol"; "Two years ago, about how often did you drink alcohol"; and "Three years ago, about how often did you drink alcohol." From these responses, age at alcohol use onset was assigned as the participant's age at the time of the survey the first time the respondent indicated using alcohol. This prospective age at alcohol use onset was then categorized to match the categories of the retrospective measure as follows: *never, 8 years old or younger, 9 or 10 years old, 11 or 12 years old, 13 or 14 years old, 15 or 16 years old, or 17 years or older.* Because of the inclusion of the recall questions from 12th grade that covered Grades 9–11, this measure is not fully prospective. However, it is the most prospective measure possible that matches categories described in the purely retrospective measure.

Agreement measures. If the retrospective and prospective alcohol measures were found to have equal values, then the agreement measure was categorized as *agree*, and if they were unequal, the agreement measure was categorized as *disagree*. We preferred a binary indicator of agreement because of the common practice of using cutoffs to dichotomize age at alcohol onset. Disagreements of even a single year can lead to substantial misclassification when age at alcohol onset is measured categorically. A second indicator was coded to show whether the retrospective measure indicated an earlier or later age at alcohol use onset compared with the prospective measure among those who disagreed.

Age. Date of birth was recorded as part of the original PNC surveys during Grades 6–8. Age was dichotomized based on the median value at baseline (11.7 years old).

Race/ethnicity. Race/ethnicity was measured with a single item. Participants were asked, "How do you describe yourself?" From the possible responses, race/ethnicity was categorized as White, Black, or Hispanic.

Free/reduced-price lunch. Free or reduced-price lunch was measured at baseline by a single item. Participants were asked, "Do you receive free or reduced-price lunches at school?" Participants could respond *yes*, *no*, or *don't know*. Responses of *don't know* were recoded as missing.

Family structure. Family structure was measured at baseline by a single item. Participants were asked, "Who do you live with most of the time?" The possible responses were dichotomized to reflect categories of *mother and father together* and *other*.

Baseline and 12th-grade substance use. Participants were asked their frequency of alcohol use, heavy alcohol use, cigarette use, and marijuana use at both baseline and 12th grade. Responses were dichotomized to reflect categories of *yes* or *no* for all substance use items.

Statistical analysis

Analyses were conducted in two phases. During Phase 1, logistic regression was used to examine factors associated with agreement between the retrospective and prospective measures. During Phase 2, we assessed direction of the bias attributable to each significant predictor. All predictor variables were dichotomized to account for extreme skew as well as differential predictive sensitivity between naturally dichotomous and continuous variables. Intervention status was not considered in the modeling process because no intervention effect was found in the parent trial (Komro et al., 2008).

The parent trial recruited students through their schools, and observations cannot be assumed to be independent. As a result, standard regression techniques can lead to incorrect inferences (Liang & Zeger, 1993). Robust standard errors using Taylor linearization were calculated using PROC SURVEYLOGISTIC in SAS Version 9.3 (SAS Institute Inc., Cary, NC), where school is treated as a cluster.

Phase 1. Bivariate logistic regressions were used to estimate the crude association between each independent variable and agreement between the prospective and retrospective measures. A series of multivariable logistic regressions was estimated to assess the relative importance of each independent variable. An added-in-order procedure was used to eliminate individual terms from the full model. The ordering of the term elimination process was based on a combination of chronology (Figure 1) and model hierarchy rather than any automated statistical procedure (Muller & Fetterman, 2003).

The first candidate variable for elimination was the theorized most chronologically proximal risk factor. Each variable was then tested in sequence from the next most chronologically proximal, ending with the most chronologically distant (Golub et al., 2000). Variables were removed from the model if both their *p* value exceeded .05 and their removal did not suggest confounding, as measured by a change in estimate criterion of 10% in any of the remaining variables. Variables retained in this phase were further explored in Phase 2.

Phase 2. The retained predictors were tested to see whether they were associated with the direction of bias in self-reported age at alcohol use onset. To test this, the sample was restricted to only respondents whose retrospective and prospective measure disagreed. Next, a series of bivariate logistic regression models was used to estimate the associations between the retained predictors and whether the

FIGURE 1. Hypothesized covariate chronology

retrospective measure indicated a later age at alcohol onset compared with an earlier age at alcohol onset.

Loss to follow-up. Because of the necessary restriction of participants to those with both a baseline and long-term follow-up survey, it is possible that the results could be attributable to selection bias caused by loss to follow-up. To address this concern, all analyses were conducted again using inverse probability of censoring weighting. The probability of completion was modeled by means of a logistic regression with family structure, socioeconomic status, race/ethnicity, gender, and a baseline score of alcohol risk as predictors of completion. The complete cases were then weighted by the inverse of their modeled probability of completion. Inverse probability weighting has been shown to produce similarly unbiased results to multiple imputation when dealing with survey attrition (Kristman et al., 2005; Seaman & White, 2013).

Results

Missing data

PNC participants who were lost to follow-up were more likely to be older at baseline, $t(3524) = 7.42, p < .001$; non-White, $\chi^2(2) = 28.92, p < .001$; and male, $\chi^2(1) = 39.12, p < .001$. In addition, they were more likely to be smokers, $\chi^2(1) = 5.15, p = .02$. There were no significant differences found

between those lost to follow-up and those who completed a 12th-grade survey on qualifying for a free or reduced-price lunch, living in a home with both a mother and father, baseline alcohol use, or baseline marijuana use. Inverse probability of censoring weighting had no substantive effect on the results. Thus, results presented are from the unweighted analyses.

Model results

Agreement between the prospective and retrospective measures of age at alcohol onset was found in 39% of respondents. In 40% of respondents, the retrospective measure indicated a later age at alcohol onset and, in 21%, an earlier age at first alcohol use. A full cross-tabulation of the retrospective and prospective measures of age at alcohol use onset is shown in Table 1.

Table 2 presents the results from the bivariate models estimating the association between each predictor and the odds of disagreement between the prospective and retrospective measure of age at alcohol onset. Statistically significant associations were found for both being older than the median age (odds ratio [OR] = 1.32, 95% CI [1.02, 1.72]) and being male (OR = 1.28, 95% CI [1.01, 1.63]). However, the strongest associations were found with substance use measures, as follows: baseline alcohol use (OR = 8.28, 95% CI [5.06, 13.54]), baseline heavy drinking (OR = 2.48, 95% CI [1.05,

TABLE 1. Cross-tabulation of prospective and retrospective measures of age at alcohol onset

Retrospective measure	Prospective measure						
	I have never had an alcoholic drink, <i>n</i> (%)	8 years old or younger, <i>n</i> (%)	9–10 years old, <i>n</i> (%)	11–12 years old, <i>n</i> (%)	13–14 years old, <i>n</i> (%)	15–16 years old, <i>n</i> (%)	17 years or older, <i>n</i> (%)
I have never had an alcoholic drink	263 (25.2%)	0 (0.0%)	0 (0.0%)	92 (8.8%)	69 (6.6%)	13 (1.3%)	3 (0.3%)
8 years old or younger	0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (0.3%)	3 (0.3%)	0 (0.0%)	0 (0.0%)
9–10 years old	0 (0.0%)	0 (0.0%)	0 (0.0%)	4 (0.4%)	0 (0.0%)	2 (0.2%)	1 (0.1%)
11–12 years old	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (1.9%)	9 (0.9%)	0 (0.0%)	1 (0.1%)
13–14 years old	1 (0.1%)	0 (0.0%)	0 (0.0%)	62 (5.9%)	41 (3.9%)	7 (0.7%)	1 (0.1%)
15–16 years old	1 (0.1%)	0 (0.0%)	1 (0.1%)	124 (11.9%)	117 (11.2%)	58 (5.6%)	3 (0.3%)
17 years or older	1 (0.1%)	0 (0.0%)	1 (0.1%)	58 (5.6%)	29 (2.8%)	26 (2.5%)	30 (2.9%)

5.86]), baseline cigarette use (OR = 2.11, 95% CI [1.24, 3.57]), baseline marijuana use (OR = 2.55, 95% CI [1.01, 6.47]), 12th-grade alcohol use (OR = 4.88, 95% CI [3.77, 6.32]), 12th-grade heavy alcohol use (OR = 2.78, 95% CI [1.90, 4.07]), 12th-grade cigarette use (OR = 2.79, 95% CI [2.25, 3.47]), and 12th-grade marijuana use (OR = 2.83, 95% CI [2.21, 3.63]).

Table 3 presents the results from the final model of the previously described added-in-order procedure. The added-in-order procedure produced a model including eligibility for free or reduced-price lunches, baseline alcohol use, alcohol use in 12th grade, and cigarette use in 12th grade as significant predictors. Students reporting baseline alcohol use had seven times the odds of the retrospective and prospective age

at alcohol onset measures disagreeing compared with nonusers (OR = 6.73, 95% CI [3.95, 11.47]), whereas students reporting 12th-grade alcohol use had four times the odds of the retrospective and prospective age at alcohol onset measures disagreeing compared with nonusers (OR = 3.90, 95% CI [2.91, 5.23]).

Table 4 presents results from the Phase 2 models exploring whether the retained predictors were associated with a particular direction of the recall bias among those with discrepant measures. For both eligibility for free or reduced-price lunches and baseline alcohol use, there was no statistically significant difference in the odds of the retrospective measure indicating later self-reported age at alcohol onset compared with the prospective measure. There was a statistically significant increase in the odds of the retrospective measure indicating later self-reported age at alcohol onset for both alcohol use in 12th grade (OR = 23.53, 95% CI [15.71, 35.24]) and cigarette use in 12th grade (OR = 3.39, 95% CI [2.35, 4.88]).

Discussion

This study was designed to assess the validity of retrospective recall of age at alcohol use onset and to determine predictors and direction of recall error. Our assumption is that the prospective age at alcohol use onset measure is more accurate than the retrospective measure. This assumption is consistent with prior literature on retrospective questionnaires because the cognitive burden of recalling past events increases as the length of the recall timeframe increases (Bachman & O'Malley, 1981). Based on this assumption, we treat disagreement between the prospective and retrospective measures of age at alcohol onset as evidence of recall error.

Eligibility for free or reduced-price lunch at baseline was significantly associated with an increase in recall error for age at alcohol onset, although the direction of recall error was not consistent. This finding is consistent with a prior study that found that low-socioeconomic-status respondents were particularly susceptible to memory errors (effect size = 0.6) (Farah et al., 2006). Because there was no consistent

TABLE 2. Bivariate model results predicting disagreement between the retrospective and prospective age at alcohol onset measures

Variables	OR [95% CI]
Age	
Older vs. younger	1.32 [1.02, 1.72]
Race	
Black vs. White	0.98 [0.67, 1.41]
Hispanic vs. White	1.19 [0.76, 1.88]
Gender	
Male vs. female	1.28 [1.01, 1.63]
Eligible for free/reduced-price lunch	
Yes vs. no	1.25 [0.91, 1.73]
Family structure	
Mother and father together vs. other	0.84 [0.66, 1.07]
Baseline alcohol use	
Yes vs. no	8.28 [5.06, 13.54]
Baseline heavy alcohol use	
Yes vs. no	2.48 [1.05, 5.86]
Baseline cigarette use	
Yes vs. no	2.11 [1.24, 3.57]
Baseline marijuana use	
Yes vs. no	2.55 [1.01, 6.47]
12th-grade alcohol use	
Yes vs. no	4.88 [3.77, 6.32]
12th-grade heavy alcohol use	
Yes vs. no	2.78 [1.90, 4.07]
12th-grade cigarette use	
Yes vs. No	2.79 [2.25, 3.47]
12th-grade marijuana use	
Yes vs. no	2.83 [2.21, 3.63]

Notes: OR = odds ratio; CI = confidence interval.

TABLE 3. Final added-in-order model results predicting disagreement between the retrospective and prospective age at alcohol onset

Variable	OR [95% CI]
Eligible for free/reduced-price lunch	1.60 [1.13, 2.26]
Baseline alcohol use	6.73 [3.95, 11.47]
12th-grade alcohol use	3.90 [2.91, 5.23]
12th-grade cigarette use	1.43 [1.09, 1.87]

Notes: OR = odds ratio; CI = confidence interval.

direction found in the recall error associated with eligibility for free or reduced-price lunch, we do not expect this recall error to result in biases for effect estimates in the case of meta-analysis, although bias may exist in any given study. Further, researchers studying the effects of alcohol use onset in low-income samples should be aware that recall error will decrease the statistical power of any inferential test, and they should compensate by increasing their sample size.

Baseline alcohol use was associated with an increase in recall error for age at alcohol onset. This is consistent with prior research showing that as recall period increases, the first use becomes less salient, leading to an increase in recall errors. Shillington et al. (2012) discussed that although the majority of reported recall errors tend to be toward a later age at first alcohol use (termed *forward telescoping*), this may be a function of the relatively short follow-up time in previous research. Our results found no difference in the odds of self-reported baseline alcohol users reporting a later age at alcohol onset on the retrospective measure compared with the prospective measure after 6 years of follow-up, supporting Shillington's assertion.

Twelfth-grade alcohol and cigarette use was associated with an increase in recall error for age at alcohol onset. Twelfth-grade substance use items had a consistent and statistically significant pattern of increasing the odds of the retrospective measure showing a later age at alcohol onset. Later substance use is a common outcome in the etiological literature relying on retrospective recall of age at alcohol onset (Collins et al., 1985; Feldman et al., 1989; Gmel & Daepfen, 2007; Liu et al., 1996; Parra et al., 2003; Simpura & Poikolainen, 1983). For example, Gruber et al. (1996) used recalled age at alcohol onset to predict later alcohol misuse. Our results imply that differential misclassification may be present in Gruber et al.'s and similar studies that use age at first alcohol use to predict subsequent alcohol use. The finding that students who drink by 12th grade are more likely to report an inaccurate and later age at alcohol onset may result in an underestimation of the risk of early onset of alcohol use in these studies. This underestimation occurs by shifting relatively more of the current alcohol users into later age at alcohol onset categories.

These findings underscore the importance of prospective study design when studying the effects of alcohol use onset. Given the strong association between current alcohol use

TABLE 4. Predictors of the retrospective age at first alcohol measure indicating a later age at alcohol onset

Variables	OR [95% CI]
Eligible for free/reduced-price lunch	0.76 [0.52, 1.13]
Baseline alcohol use	1.30 [0.86, 1.98]
12th grade alcohol use	23.53 [15.71, 35.24]
12th grade cigarette use	3.39 [2.35, 4.88]

Notes: OR = odds ratio; CI = confidence interval.

and recall error for age at first alcohol use, researchers are encouraged to use prospective measures whenever possible. When this is not feasible, we recommend that researchers use Monte Carlo simulations to perform probabilistic sensitivity analyses to determine if the results can be explained because of measurement error. To prevent worsening bias, probabilistic sensitivity analyses require estimates of both likelihood and direction of measurement error (Gilbert et al., 2014). Using the estimates from our study, simulations similar to those described by Fox et al. (2005) can be used to estimate the ultimate effect of recall error.

Our results differ from the results found by Sartor et al. (2011) in the Missouri Adolescent Female Twin Study (MAFTS), who found that participants who reported higher frequencies of heavy drinking were less likely to report a later age at first alcohol use during follow-up. The discrepancy between our results and Sartor et al.'s may be explained by our PNC participants being younger at both baseline (11.7 vs. 15.5 years old) and follow-up (17.9 vs. 21.7 years old) than were their MAFTS participants. Because of the relatively older age of participants at the start of the MAFTS, it is probable that participants had initiated alcohol use before the study, resulting in a comparison of the stability of two different retrospective measures of age at alcohol onset. Because of the PNC sample's young age, it is more likely that our prospective measure captured actual alcohol initiation. An alternative explanation is that the effect of current alcohol use on the direction of recall error varies greatly depending on age at current use.

Prior research has theorized that age at alcohol onset is more prone to error because it becomes less salient compared with more recent use of other, less normative substances. Similar to the results of Sartor et al. (2011), we found a bivariate association between both marijuana use and heavy alcohol use with recall error in the age at first alcohol use. Surprisingly, neither marijuana nor heavy alcohol use was associated with recall error in our model controlling for 12th-grade alcohol use. Our results imply that it is not the more extreme substance use but simply current alcohol use that drives the saliency effect, possibly because of the number of alcohol use events after onset.

The primary limitation of this study is the lack of a gold standard for age at alcohol onset with which to compare the retrospective measure. Although the variables used to con-

struct the prospective measure during the 6th- to 8th-grade window have been shown to have high test-retest reliability (Bailey et al., 1992; Barnea et al., 1987; Brener et al., 2003; O'Malley et al., 1983; Shillington & Clapp, 2000), the prospective measure is also composed of variables that use recall questions that cover the gap in surveying between the core 6th- to 8th-grade PNC surveys and the later long-term follow-up occurring in 12th grade. This problem is mitigated by the fact that the prospective measure is still more accurate than the fully retrospective measure. The variables used to create the prospective measure have substantially shorter recall periods than do those of the retrospective measure, which has been found to result in a lower rate of recall error (Parra et al., 2003). This makes our prospective measure a useful proxy for the purposes of this study; however, future studies should continue to further improve on measurement of age at alcohol onset.

Future research should seek to build on this study in several other ways. First, results should be replicated in data sets with different demographic groups and other settings. The present sample was drawn from an entirely urban setting and included a majority-minority population. To increase generalizability of these findings, they should be replicated using studies performed in rural settings, middle- and upper-class students, and perhaps predominantly White populations. Second, results should be replicated with data that include a fully prospective measure of age at alcohol onset. Although further research is needed, these results provide important practical information facilitating the correct interpretation and implementation of research involving retrospective measures of age at alcohol onset. Most notably, those most at risk for the negative outcomes associated with early alcohol initiation are also those most likely to misreport their age at alcohol onset.

References

- Bachman, J. G., & O'Malley, P. M. (1981). When four months equal a year: Inconsistencies in student reports of drug use. *Public Opinion Quarterly*, 45, 536–548. doi:10.1086/268686
- Bailey, S. L., Flewelling, R. L., & Rachal, J. V. (1992). The characterization of inconsistencies in self-reports of alcohol and marijuana use in a longitudinal study of adolescents. *Journal of Studies on Alcohol*, 53, 636–647. doi:10.15288/jsa.1992.53.636
- Barnea, Z., Rahav, G., & Teichman, M. (1987). The reliability and consistency of self-reports on substance use in a longitudinal study. *British Journal of Addiction*, 82, 891–898. doi:10.1111/j.1360-0443.1987.tb03909.x
- Brener, N. D., Billy, J. O., & Grady, W. R. (2003). Assessment of factors affecting the validity of self-reported health-risk behavior among adolescents: Evidence from the scientific literature. *Journal of Adolescent Health*, 33, 436–457. doi:10.1016/S1054-139X(03)00052-1
- Collins, L. M., Graham, J. W., Hansen, W. B., & Johnson, C. A. (1985). Agreement between retrospective accounts of substance use and earlier reported substance use. *Applied Psychological Measurement*, 9, 301–309. doi:10.1177/014662168500900308
- DiClemente, R. J., Lodico, M., Grinstead, O. A., Harper, G., Rickman, R. L., Evans, P. E., & Coates, T. J. (1996). African-American adolescents residing in high-risk urban environments do use condoms: Correlates and predictors of condom use among adolescents in public housing developments. *Pediatrics*, 98, 269–278.
- Ellickson, P. L., Tucker, J. S., & Klein, D. J. (2003). Ten-year prospective study of public health problems associated with early drinking. *Pediatrics*, 111, 949–955. doi:10.1542/peds.111.5.949
- Engels, R. C. M. E., Knibbe, R. A., & Drop, M. J. (1997). Inconsistencies in adolescents' self-reports of initiation of alcohol and tobacco use. *Addictive Behaviors*, 22, 613–623. doi:10.1016/S0306-4603(96)00067-6
- Epstein, L., & Tamir, A. (1984). Health-related behavior of adolescents: Change over time. *Journal of Adolescent Health Care*, 5, 91–95. doi:10.1016/S0197-0070(84)80005-4
- Farah, M. J., Shera, D. M., Savage, J. H., Betancourt, L., Giannetta, J. M., Brodsky, N. L., . . . Hurt, H. (2006). Childhood poverty: Specific associations with neurocognitive development. *Brain Research*, 1110, 166–174. doi:10.1016/j.brainres.2006.06.072
- Feldman, Y., Koren, G., Mattice, K., Shear, H., Pellegrini, E., & MacLeod, S. M. (1989). Determinants of recall and recall bias in studying drug and chemical exposure in pregnancy. *Teratology*, 40, 37–45. doi:10.1002/tera.1420400106
- Fox, M. P., Lash, T. L., & Greenland, S. (2005). A method to automate probabilistic sensitivity analyses of misclassified binary variables. *International Journal of Epidemiology*, 34, 1370–1376. doi:10.1093/ije/dyi184
- Gilbert, R., Martin, R. M., Donovan, J., Lane, J. A., Hamdy, F., Neal, D. E., & Metcalfe, C. (2014). Misclassification of outcome in case-control studies: Methods for sensitivity analysis. *Statistical Methods in Medical Research*. doi:10.1177/0962280214523192
- Gmel, G., & Daepfen, J.-B. (2007). Recall bias for seven-day recall measurement of alcohol consumption among emergency department patients: Implications for case-crossover designs. *Journal of Studies on Alcohol and Drugs*, 68, 303–310. doi:10.15288/jsad.2007.68.303
- Golub, A., Labovvie, E., & Johnson, B. D. (2000). Response reliability and the study of adolescent substance use progression. *Journal of Drug Issues*, 30, 103–118. doi:10.1177/002204260003000106
- Greenblatt, J. (2000). *Patterns of alcohol use among adolescents and associations with emotional and behavioral problems*. Rockville, MD: Office of Applied Studies, Substance Abuse and Mental Health Services Administration.
- Gruber, E., DiClemente, R. J., Anderson, M. M., & Lodico, M. (1996). Early drinking onset and its association with alcohol use and problem behavior in late adolescence. *Preventive Medicine*, 25, 293–300. doi:10.1006/pmed.1996.0059
- Hingson, R., Heeren, T., Levenson, S., Jamanka, A., & Voas, R. (2002). Age of drinking onset, driving after drinking, and involvement in alcohol related motor-vehicle crashes. *Accident Analysis and Prevention*, 34, 85–92. doi:10.1016/S0001-4575(01)00002-1
- Hingson, R., Heeren, T., & Zakocs, R. (2001). Age of drinking onset and involvement in physical fights after drinking. *Pediatrics*, 108, 872–877. doi:10.1542/peds.108.4.872
- Johnson, T. P., & Mott, J. A. (2001). The reliability of self-reported age of onset of tobacco, alcohol and illicit drug use. *Addiction*, 96, 1187–1198. doi:10.1046/j.1360-0443.2001.968118711.x
- Johnston, L., O'Malley, P., Miech, R., Bachman, J., & Schulenberg, J. (2015). *Monitoring the Future national survey results on drug use: 1975-2014: Overview, key findings on adolescent drug use*. Ann Arbor, MI: The University of Michigan.
- Komro, K. A., Perry, C. L., Veblen-Mortenson, S., Bosma, L. M., Dudo-vitz, B. S., Williams, C. L., . . . Toomey, T. L. (2004). Brief report: The adaptation of Project Northland for urban youth. *Journal of Pediatric Psychology*, 29, 457–466. doi:10.1093/jpepsy/jsh049
- Komro, K. A., Perry, C. L., Veblen-Mortenson, S., Farbaksh, K., Toomey, T. L., Stigler, M. H., . . . Williams, C. L. (2008). Outcomes from a ran-

- domized controlled trial of a multi-component alcohol use preventive intervention for urban youth: Project Northland Chicago. *Addiction*, 103, 606–618. doi:10.1111/j.1360-0443.2007.02110.x
- Kristman, V. L., Manno, M., & Côté, P. (2005). Methods to account for attrition in longitudinal data: Do they work? A simulation study. *European Journal of Epidemiology*, 20, 657–662. doi:10.1007/s10654-005-7919-7
- Liang, K. Y., & Zeger, S. L. (1993). Regression analysis for correlated data. *Annual Review of Public Health*, 14, 43–68. doi:10.1146/annurev.pu.14.050193.000355
- Liang, W., Chikritzhs, T., & Lee, A. H. (2012). Modest time-dependent misclassification in recalling age at first use of alcohol and tobacco. *Contemporary Drug Problems*, 39, 147–154. doi:10.1177/009145091203900107
- Liu, S., Serdula, M. K., Byers, T., Williamson, D. F., Mokdad, A. H., & Flanders, W. D. (1996). Reliability of alcohol intake as recalled from 10 years in the past. *American Journal of Epidemiology*, 143, 177–186. doi:10.1093/oxfordjournals.aje.a008727
- Muller, K. E., & Fetterman, B. A. (2003). *Regression and ANOVA: An integrated approach using SAS software*. Hoboken, NJ: Wiley.
- O'Malley, P. M., Bachman, J. G., & Johnston, L. D. (1983). Reliability and consistency in self-reports of drug use. *International Journal of the Addictions*, 18, 805–824. doi:10.3109/10826088309033049
- Parra, G. R., O'Neill, S. E., & Sher, K. J. (2003). Reliability of self-reported age of substance involvement onset. *Psychology of Addictive Behaviors*, 17, 211–218. doi:10.1037/0893-164X.17.3.211
- Prause, J., Dooley, D., Ham-Rowbottom, K. A., & Emptage, N. (2007). Alcohol drinking onset: A reliability study. *Journal of Child & Adolescent Substance Abuse*, 16, 79–90. doi:10.1300/J029v16n04_05
- Sartor, C. E., Bucholz, K. K., Nelson, E. C., Madden, P. A. F., Lynskey, M. T., & Heath, A. C. (2011). Reporting bias in the association between age at first alcohol use and heavy episodic drinking. *Alcoholism: Clinical and Experimental Research*, 35, 1418–1425. doi:10.1111/j.1530-0277.2011.01477.x
- Seaman, S. R., & White, I. R. (2013). Review of inverse probability weighting for dealing with missing data. *Statistical Methods in Medical Research*, 22, 278–295. doi:10.1177/0962280210395740
- Shillington, A. M., & Clapp, J. D. (2000). Self-report stability of adolescent substance use: Are there differences for gender, ethnicity and age? *Drug and Alcohol Dependence*, 60, 19–27. doi:10.1016/S0376-8716(00)80004-6
- Shillington, A. M., Woodruff, S. I., Clapp, J. D., Reed, M. B., & Lemus, H. (2012). Self-reported age of onset and telescoping for cigarettes, alcohol, and marijuana across eight years of the National Longitudinal Survey of Youth. *Journal of Child & Adolescent Substance Abuse*, 21, 333–348. doi:10.1080/1067828X.2012.710026
- Simpura, J., & Poikolainen, K. (1983). Accuracy of retrospective measurement of individual alcohol consumption in men: A reinterview after 18 years. *Journal of Studies on Alcohol*, 44, 911–917. doi:10.15288/jsa.1983.44.911
- Tobler, A. L., & Komro, K. A. (2011). Contemporary options for longitudinal follow-up: Lessons learned from a cohort of urban adolescents. *Evaluation and Program Planning*, 34, 87–96. doi:10.1016/j.evalprogplan.2010.12.002
- Warner, L. A., & White, H. R. (2003). Longitudinal effects of age at onset and first drinking situations on problem drinking. *Substance Use & Misuse*, 38, 1983–2016. doi:10.1081/JA-120025123