Published in final edited form as:

J Child Psychol Psychiatry. 2010 September ; 51(9): 1067–1075. doi:10.1111/j.1469-7610.2010.02219.x.

Mothers' maximum drinks ever consumed in 24 hours predicts mental health problems in adolescent offspring

Stephen M. Malone, Matt McGue, and William G. Iacono

University of Minnesota — Twin Cities

Abstract

Background—The maximum number of alcoholic drinks consumed in a single 24-hr period is an alcoholism-related phenotype with both face and empirical validity. It has been associated with severity of withdrawal symptoms and sensitivity to alcoholism, genes implicated in alcohol metabolism, and amplitude of a measure of brain activity associated with externalizing disorders in general. In a previous study we found that the maximum number of drinks fathers had ever consumed in 24 hrs was associated with externalizing behaviors and disorders in preadolescent and adolescent children. The purpose of the present study was to determine whether maternal maximum consumption has similar correlates.

Method—We examined associations between maternal maximum consumption and alcohol dependence, respectively, and disruptive disorders and substance-related problems in two large independent population-based cohorts of 17-year-old adolescents.

Results—Maximum consumption was associated with conduct disorder, disruptive disorders in general, early substance use and misuse, and substance disorders in adolescent children regardless of sex. Associations were consistent across cohorts, providing internal replication. They also paralleled our previous findings regarding paternal status. They could not be explained by maternal alcohol dependence, effects of drinking during pregnancy, or paternal maximum consumption. They were not simple artifacts of the fact that maximum consumption is a continuous measure while alcohol dependence is dichotomous.

Conclusions—Despite deriving from a single question about *lifetime behavior*, parental maximum consumption appears to reflect vulnerability for mental health problems, especially substance-related ones, more directly than a diagnosis of alcohol dependence.

Keywords

Maximum drinks; maternal alcoholism; externalizing; adolescence

Introduction

The maximum number of alcoholic drinks ever consumed in a single 24-hr period appears to have face and empirical validity as a phenotype related to alcoholism. Consuming large quantities in one sitting likely reflects acute or chronic tolerance. Maximum alcohol consumption helps to distinguish alcoholism with physiological features from alcoholism without such features (Schuckit et al., 1998) and is associated with more severe withdrawal symptoms (Schuckit, Tipp, Reich, Hesselbrock, & Bucholz, 1995). It also appears to reflect relative insensitivity to alcohol's negative effects (Schuckit et al., 2005). Furthermore, some

alcoholics report that once having had one drink they are unable to resist subsequent drinks. Even nonalcoholic individuals may be susceptible if their risk for alcoholism is elevated; nonalcoholic males with a positive family history of alcoholism rated themselves as less confident in their ability to resist another drink after a placebo than subjects without such a family history (Kaplan, Hesselbrock, O'Connor, & DePalma, 1988). The maximum consumption phenotype may be related to this type of loss-of-control drinking, long considered a cardinal feature of alcoholism (Jellinek, 1960).

Maximum consumption is related to genes involved in metabolizing alcohol, and these genes are perhaps those most robustly implicated in alcoholism to date. For instance, individuals with a polymorphism of the gene for aldehyde dehydrogenase, typically found only in those of East Asian descent, are relatively unable to metabolize acetaldehyde, an intermediate product of alcohol. The resulting accumulation of acetaldehyde causes them to experience intense facial flushing and other uncomfortable reactions to alcohol, and they are less likely to become alcoholic. A recent study found that Asian-American college students with this gene were as likely to become inebriated as those without it. However, they drank less in a 24-hr period (Wall, Shea, Chan, & Carr, 2001), suggesting that maximum consumption reflects their genotype more closely than other measures of drinking. Maximum consumption has also been linked to a region of chromosome 4 containing the genes for alcohol dehydrogenase (Saccone et al., 2000), another enzyme involved in alcohol metabolism and similarly implicated in alcoholism risk.

Maximum consumption is also related to amplitude of the P300 wave of the event-related brain potential, a neurophysiologic indicator of liability for externalizing disorders in general, such as antisocial behavior and substance use disorders (SUDs) (Iacono, Malone, & McGue, 2003). P300 amplitude in a visual discrimination task is reduced in male offspring of fathers in the most deviant decile of the distribution on maximum consumption, but who did not meet diagnostic criteria for alcohol dependence (Iacono, Carlson, Malone, & McGue, 2002). The magnitude of reduction was comparable to that observed in offspring of alcoholic fathers, suggesting that alcoholism and maximum consumption reflect much the same neurophysiologic vulnerability. In addition, the simplicity of the maximum consumption phenotype makes it especially attractive; because it consists in a single question, it can be assessed more easily than alcohol dependence. Understanding the degree to which it confers risk to offspring may have clinical utility in addition to scientific value.

We previously found that the maximum number of drinks fathers had ever consumed in a single 24-hr period was associated with their children's risk for a number of troublesome outcomes: conduct disorder in particular and disruptive disorders in general; early substance initiation, misuse, and clinically significant problems in middle adolescence; and substance use disorders in late adolescence (Malone, McGue, & Iacono, 2002). Paternal maximum consumption thus predicted many of the problems most often observed in adolescent children of alcoholics. These are also the types of problem behaviors in adolescents that represent a highly heritable tendency toward disinhibited psychopathology (Krueger et al., 2002; Young, Stallings, Corley, Krauter, & Hewitt, 2000). Results held even after we statistically adjusted for effects of paternal alcoholism, whereas the reverse was not true, suggesting that the maximum number of drinks consumed at one time taps the liability for alcoholism more directly than a psychiatric diagnosis of alcohol dependence.

Our purpose in the present report was to extend this line of investigation by evaluating effects of mother's maximum consumption on substance misuse and mental health in adolescent offspring. Maternal alcoholism is a significant risk factor for mental health problems in children and adolescents (Christensen & Bilenberg, 2000; Dawson, 1992; Hill & Muka, 1996; Werner, 1986), and children with two alcoholic parents have higher rates of

problems than those with a single alcoholic parent (Hill & Muka, 1996; Iacono et al., 2003; Nordberg, Rydelius, & Zetterstrom, 1993), indicating that maternal drinking confers additional risk. Yet much of the work on alcoholism risk has focused on the father's role in transmitting genetic liability for alcoholism. This owes in part to difficulties ruling out effects of drinking during pregnancy when considering the mother's role. Because our assessment included questions about drinking during pregnancy, we were able to address this potential confound. Our primary research question was whether the maximum number of drinks a woman consumed in any 24-hr period in her lifetime would be associated with the same types of characteristics of her adolescent children as paternal maximum alcohol consumption. In addition, we determined whether maternal alcohol dependence diagnoses or paternal maximum consumption might mediate any such associations. Two different large, population-based samples of 17-year-old adolescents were included, providing the opportunity to replicate observed effects and conferring substantial generality to any findings that might obtain.

Method

Participants

Study participants were enrolled in the Minnesota Twin Family Study (MTFS), a longitudinal population-based study of genetic and environmental influences on substance abuse and related psychopathology. All were identified from public birth records covering twin births in Minnesota between 1972 and 1984. The MTFS sample consists of two cohorts, one initially assessed when the twins turned 17 and the other when they turned 11. The 1,383 families whose twins completed an age-17 assessment, whether an intake assessment for the older cohort or a follow-up assessment for the younger one, and whose biological mothers completed a clinical assessment served as subjects for the current report. Twins and parents gave written assent or consent to participate, as appropriate, with parents also providing consent for minor children. Consistent with the demographic profile of Minnesota during this period, the vast majority of participants were white (97.1% in the combined sample). Family demographic characteristics are given in Table 1, while a more detailed description of the study aims, design, ascertainment procedure, and sample bias is available elsewhere (Iacono, Carlson, Taylor, Elkins, & McGue, 1999).

Approximately 85% of the younger-cohort intake sample completed their age-17 follow-up assessment. Mothers of younger-cohort subjects who did not participate at the age-17 assessment were more likely to have alcohol dependence than mothers of participating subjects (22.1% vs. 9.6%; $\chi^2_1 = 12.1, p < .001$) and were more likely to have consumed more drinks at one time, $F(1, 736) = 6.44, p < .05$. Thus, high-risk adolescents were somewhat underrepresented in the second follow-up assessment, indicating some attrition bias in the younger cohort. However, the assessment of older-cohort twins was their intake assessment; by definition there is no attrition bias. Because our analytic strategy was predicated on obtaining replicated effects across both cohorts, the overall effect of any bias in the younger cohort is likely to be minimal.

Diagnostic Interviews and Substance Use Assessment

Diagnostic assessment—Interviewers with Bachelor's or Master's degrees in psychology or related disciplines collected information using structured clinical interviews designed to yield diagnoses from the Diagnostic and Statistical Manual, 3rd Edition (DSM-III-R), the standard in place when the MTFS began. Interviewer training includes an apprenticeship with a more experienced interviewer, a written examination regarding DSM disorders, and a proficiency test. Interviewers also receive ongoing feedback about interview quality from diagnosticians reviewing audiotapes of each interview. A slightly modified

version of the Structured Clinical Interview for DSM-III-R (SCID II) (Spitzer, Williams, Gibbons, & First, 1987) was used to assess antisocial behavior, including symptoms of conduct disorder, while the SCID I (Spitzer, Williams, Gibbon, & First, 1992) was used to assess major depression. The revised Diagnostic Interview for Children and Adolescents (DICA-R) (Reich, 2000) was used to diagnose ADHD and oppositional defiant disorder (ODD). The Substance Abuse Module (SAM) of the Composite International Diagnostic Inventory (Robins et al., 1988), modified to include questions about drinking frequency and quantity, was used to diagnose nicotine dependence, alcohol abuse or dependence, and illicit drug abuse or dependence. The adolescent's primary caretaker, typically the mother, was also interviewed about each twin using the parent version of the DICA-R. Mothers were interviewed as well about their own mental health; maternal lifetime alcohol dependence was assessed using the SAM.

We assessed several measures of early use and misuse in addition to SUDs. Because early substance use predicts a variety of mental health problems (Grant & Dawson, 1997), we created binary measures reflecting whether adolescents had used alcohol (without permission), tobacco, or illicit drugs before age 15 (cf. McGue & Iacono, 2005). We also included two measures of early misuse: whether one had been intoxicated by this age and a count of the number of different substance classes used by age 15. To improve stability of estimates, we combined responses of four or more (different categories of drugs), none of which individually represented as much as 1% of the sample, into one category. We also assessed the adolescents' own lifetime maximum alcohol consumption in 24 hours at the time of the age-17 assessment.

Assignment of diagnoses—Pairs of students at advanced stages of graduate training in clinical psychology reviewed each interview to achieve consensus about whether a given symptom was present. Consensus teams consisted of different individuals than those who had conducted the diagnostic interview, and each team was blind to subject identity. Different teams were assigned different family members. Computer algorithms based on DSM-III-R requirements were subsequently used to assign lifetime diagnoses. For the twins, these were best-estimate diagnoses combining information from the twin and parent (Kosten & Rounsaville, 1992; Leckman, Sholomskas, Thompson, Belanger, & Weissman, 1982). For the younger cohort information was aggregated across assessments. Because adolescents in this study were not through the risk period for most disorders assessed, we used a probable certainty level to assign offspring diagnoses, meaning that all diagnostic criteria but one had to be met. Several hundred interviews were reviewed by independent, blind teams to assess reliability. Kappa coefficients were all greater than .74, with coefficients for SUDs greater than .90. Every 25th case is evaluated in an ongoing way to insure continued reliability and protect against drift.

Maximum 24-Hr Alcohol Consumption—A question on the modified SAM asks, “What is the largest amount of alcohol you ever consumed in a 24-hour period?” This information was missing for nine mothers. In addition, we did not include mothers who never drank, leading to the exclusion of three to eight families in each of the different age-sex cohorts. The final sample is characterized in Table 1. The distribution of responses on this measure appears in Figure 1, plotted separately for mothers with and without a diagnosis of alcohol dependence. We used a log transformation to compensate for the positive skew in the distribution and standardized the measure for a more straightforward interpretation of the results from regression analyses.

Alcohol Consumption During Pregnancy—A question on the SAM asks how much women drank per occasion in an average week during pregnancy. This was dichotomized to reflect whether women drank regularly (weekly) while pregnant. A second question asks

about the largest amount consumed at any time during pregnancy, which served as a measure of drinking density, analogous to our measure of maximum consumption. We used a log transformation in analyses to compensate for its positive skew.

Data Analysis

The sample consisted of twin pairs, who do not constitute independent observations. We therefore fit regression models producing robust standard errors based on the clustered nature of the sample via generalized estimating equations (GEE) (Liang & Zeger, 1986) in SAS/STAT software, version 9.1.3 for Windows. We used logistic regression for dichotomous dependent measures (measures of diagnostic status, yes/no measures of early substance use and misuse), a Poisson regression for breadth of early substance experimentation, and a linear regression for the twins' own maximum drinks consumed. The latter was log transformed for analysis, although untransformed values are used for descriptive purposes.

We conducted a series of analyses guided by the framework of Baron and Kenny (1986) for assessing whether one variable mediates the association between two others. This allowed us to determine whether any effects of maternal maximum consumption might be explained, or *fully* mediated, by effects of maternal alcoholism. We first determined whether maternal maximum drinks and alcohol dependence separately were significantly associated with each offspring outcome measure. Analyses included offspring gender to adjust for sex differences in the outcome measures. We next included an interaction between maternal characteristic and offspring gender to assess whether gender moderates associations between maternal predictor and offspring outcome. If not significant, this term was dropped. The third step included both maternal characteristics as predictors. This allowed us to determine whether maternal alcohol dependence might explain any significant associations between maternal maximum consumption and offspring characteristics. If so, then significant associations between maternal maximum drinks and offspring characteristics should become nonsignificant net the effects of maternal alcohol dependence. We used the same approach to determine whether measures of drinking during pregnancy might account for any associations we found.

Results

The lifetime prevalence of maternal alcohol dependence was 11.2% and 7.9% in the younger and older cohorts, respectively. As expected (see Figure 1), the maximum number of drinks mothers consumed was correlated with dependence ($r = .39$ in the younger cohort, $r = .41$ in the older cohort, $p < .001$ for both). Table 2 gives the prevalence of the various offspring characteristics.

Results of regression analyses are presented in Figure 2 and Table 3 for maternal maximum consumption and dependence, respectively, both by themselves and net any effects of the other measure. Because interactions between offspring gender and either maternal maximum drinks or alcohol dependence were not significant, and effects for males and females were typically quite similar, these are for male and female adolescents combined. The exception is for ODD: there was a significant interaction between maternal maximum drinks and offspring gender for this outcome in the older age cohort, $\chi^2 = 4.41$ with 1 df, $p = .036$, with the association between the two being significant only for females. In Figure 2 the OR for ODD is for females only; for males, it was effectively 1, indicating no association. For this outcome measure, we included an interaction term between offspring gender and maximum drinks when testing for effects of maternal alcohol dependence.

Maternal maximum consumption was not associated with major depression or ADHD. It was significantly associated with ODD but this effect replicated only among females. However, it was associated with conduct disorder, having any disruptive disorder, and all 10 of the substance disorder and early or problematic use measures, even when adjusted for effects of maternal alcohol dependence, and all such effects replicated across cohorts. Differences between adjusted and unadjusted ORs were minimal. Adjusted ORs associated with significant effects ranged from 1.23 to 1.79, indicating a 23% to 79% increase in odds of the relevant disorder or of early substance use for each standard deviation increase in maternal maximum consumption. The effects of maternal maximum consumption on breadth of early substance experimentation and maximum drinks consumed similarly indicate that maternal maximum consumption was strongly related to both offspring outcomes net effects of maternal dependence (Table 3).

Effects for maternal alcohol dependence were generally weaker and less consistent. Twenty of the 30 analyses conducted (13 diagnostic or use variables, one count, and one quasi-continuous measure in two cohorts) yielded significant results. Although the magnitude of association between dependence and disruptive disorders in particular was not trivial, these effects did not replicate consistently when adjusted for maternal maximum consumption. Only six of the 20 significant associations remained significant net the effects of maximum consumption, and only one (for ODD) replicated across cohorts.

In summary, maternal maximum consumption was consistently associated with conduct disorder, ODD in females, any disruptive disorder, and all substance-related outcomes, and the magnitude of associations was relatively unaffected when adjusted for maternal dependence. Dependence itself was somewhat less consistently associated with these same outcome measures. Moreover, only the association with ODD was significant in both cohorts when adjusted for effects of maximum drinks. Partial (adjusted) regression coefficients associated with substance-related outcomes tended toward zero, indicating independence between dependence and offspring outcome once maternal maximum drinks were accounted for.

Effects of maximum drinks or teratogenic effects of drinking during pregnancy?

Associations with measures of maternal alcohol consumption might reflect teratogenic effects related to drinking during pregnancy rather than to the maximum drinks phenotype *per se*. To address this possibility, we entered a dummy variable coding for weekly alcohol use during pregnancy and the log of the maximum drinks consumed during pregnancy in separate regression analyses. We first examined effects of each measure of drinking during pregnancy by itself to assess the sensitivity of the measures. The (log of) the maximum number of drinks consumed during pregnancy was associated with virtually all outcomes in the younger cohort. We subsequently examined the replicated associations with maternal maximum consumption from our primary analyses – conduct disorder, ODD in females, any disruptive disorder, and all substance-related phenotypes – with each measure of drinking during pregnancy as a covariate. If drinking during pregnancy accounts for associations between lifetime maximum consumption and these outcome measures, maximum consumption's effects should become nonsignificant when adjusted for effects of drinking during pregnancy. This was not the case; all of the significant effects of maximum consumption remained significant when adjusted for drinking during pregnancy. Indeed, adjusted regression coefficients were virtually identical to unadjusted coefficients.

Advantage of a continuous predictor over a categorical one?

The robustness of associations between maternal maximum consumption in these models might stem from the fact that it is a quasi-continuous measure while maternal alcohol

dependence is dichotomous. We therefore considered a log-transformed count of alcohol abuse and dependence symptoms in place of the diagnostic variable. The dependent measures were again those consistently associated with maternal maximum consumption across cohorts: conduct disorder, ODD in females, any disruptive disorder, and all substance-related measures. Adjusting for the symptom count variable had inconsistent effects on the coefficients associated with maximum consumption; partial coefficients increased in magnitude over unadjusted ones as often as they decreased while remaining significant.

Paternal maximum consumption as a potential mediator

The effects of maternal maximum drinks paralleled those of paternal maximum drinks in our previous investigation (Malone et al., 2002). This raises the possibility that effects of maternal maximum drinks might actually be due to the father's status on this measure. Maternal and paternal maximum consumption were correlated, $r = .29$ and $r = .34$ ($p < .001$) in the two respective age cohorts. We included both parents' scores as independent variables (in addition to offspring gender) and conduct disorder, ODD in females, any disruptive behavior disorder and all substance-related outcomes as dependent measures. To increase stability of estimates, we combined age cohorts, including cohort as a covariate. Because there was greater variability in age of younger-cohort subjects, we also included age at assessment as a covariate. All analyses were preceded by tests of interactions between parental status and cohort, conducted separately for maternal and paternal measures. Two such tests were significant: effects of paternal maximum consumption on early drug use and on twin maximum consumption differed by age cohort, $\chi^2 = 4.60$, $p = .032$, and $\chi^2 = 7.25$, $p = .007$, respectively. In both cases, effects were stronger in the older cohort. We assessed interactions between maternal and paternal status separately in each cohort for these two outcomes.

Maternal maximum drinks predicted all outcome variables net paternal status; all regression coefficients were significant when adjusted for paternal status. The reverse was not true: five effects of paternal status were not quite significant when adjusted for maternal status. Partial regression coefficients were nevertheless quite similar for the two parents, ranging from .175 to .515 (Mdn, .314) for mothers and from .110 to .544 (Mdn, .361) for fathers. Summing the partial regression coefficients associated with each parent yielded an effect that was 25% to 83% larger than the (unadjusted) effect of paternal status alone, with a median increase of 53%.

To determine whether maternal and paternal maximum consumption have independent effects, we examined interactions between them. Only one of 17 tests was significant – the interaction for early drug use in the older cohort – and then only marginally, $\chi^2 = 3.85$, $p = .050$ with 1 df. The coefficient was opposite in sign to what would be expected and was accompanied by inflated coefficients for the main effects, indicating that estimates were likely unstable. All other effects produced χ^2 values less than 1.

Discussion

The maximum number of drinks ever consumed by mothers in a 24-hr period was associated with offspring conduct disorder diagnoses in particular and with disruptive behavior diagnoses in general. It was also associated with a variety of substance-related measures: initiation of substance use, having ever been intoxicated, breadth of substance experimentation, all by age 15, and with SUDs and offspring's own maximum drinks consumed in 24 hours, both by the time of the age-17 assessment. The characteristics associated with maternal maximum consumption are among those most consistently observed in children of alcoholics. These associations were independent of offspring gender.

(There was also a replicated association with ODD in females only.) They were also independent of maternal alcohol dependence, whether a diagnosis or a symptom count. They replicated across the two age cohorts of MTFs twins. Furthermore, these findings almost exactly parallel our previous findings with respect to fathers' status on this measure of drinking density (Malone et al., 2002).

As with paternal status, maternal maximum consumption effects were not secondary to a primary effect of alcohol dependence. In fact, associations with substance-related outcomes in particular were unaffected by adjustment for effects of alcohol dependence; adjusted and unadjusted effects were virtually identical. By contrast, associations between maternal alcohol dependence and substance-related phenotypes were entirely mediated by maximum consumption; partial (adjusted) regression coefficients tended toward zero. Although a diagnosis of alcohol dependence may reflect functional impairment, these results indicate that the maximum number of drinks consumed may more closely reflect the underlying vulnerability for substance-related problems.

Maternal maximum consumption's effects were not explained by paternal maximum consumption, and effects of maternal and paternal status on offspring externalizing behavior and problems were similar in magnitude. They also combined additively, and raw regression coefficients associated with maternal and paternal status together were as much as 80% larger than those associated with (unadjusted) paternal status only, and the median increase due to combining both parents' status was approximately 50%. Thus, considering both parent's maximum consumption together yielded greater power to predict offspring mental health problems.

This investigation of course suffers some limitations. Although broadly representative of the population of Minnesota when our participants were born, the sample is ethnically relatively homogeneous; results may not readily generalize to other populations. Our assessment of drinking during pregnancy consisted of retrospective self-report, which is obviously vulnerable to recall and social desirability effects. To minimize the latter, our interview introduces these questions by acknowledging that drinking during pregnancy was once relatively common. Reports of the number of drinks consumed on one occasion ranged as high as 15 drinks, fully 40% reported any drinking, and 10% reported weekly use, suggesting that participants were not overly minimizing their use. In addition, our other work with this measure supports its construct validity (Disney, Iacono, McGue, Tully, & Legrand, 2008). Moreover, maximum consumption during pregnancy was associated with the majority of mental health outcomes we investigated in the younger cohort. It seems unlikely therefore that the failure of these measures to account for our findings is due to insensitivity of the measures.

One might similarly question the reliability of our measure of lifetime maximum consumption. Self-reports of drinking behavior generally agree with reports of other informants (Guze, Tuason, Stewart, & Picken, 1963; Maisto, Sobell, & Sobell, 1979). If anything, alcoholics are more likely to report significant problems than others (Guze et al., 1963), suggesting greater knowledge of their own problematic drinking (Maisto et al., 1979). An assessment of the lifetime maximum consumption measure used here found good test-retest reliability over a 10-week period ($r = .70$) (Grant et al., 2003). However, to our minds the best evidence for the *validity* of this measure, even if estimates may not be perfectly accurate, comes from the fact that its associations replicated so faithfully across our two cohorts and that parallel effects were found for both parents.

The degree of consistency across age cohort, offspring gender, and now the parent's gender with respect to the pattern of associations we have observed is striking. The consistency of

findings is likely due in part to the size and representative nature of the MTFS sample. That one item from a long and comprehensive structured interview predicts anything, let alone so consistently, is impressive. In addition, this question is aimed at ascertaining the maximum number of drinks consumed *at any time* in the parents' lifetime. For the majority of them, the occasion of their maximum alcohol consumption was likely when they were quite a bit younger, even before the birth of their first child. For instance, the median age of onset of heaviest drinking for the mothers in this sample was 20 and the median duration of heaviest drinking was two years. Although reflecting an episode that for most women occurred before their children were born, then, maximum consumption was consistently and independently associated with a variety of mental health and substance-related problems in their adolescent offspring.

Key points

- This is the second of a complementary pair of investigations examining associations between parental lifetime maximum alcohol consumption in a 24-hr period and adolescent offspring outcomes. We have now found that the number of drinks either parent has ever consumed in a single 24-hr period is associated with conduct disorder, disruptive behavior disorders, and substance-related problems in their adolescent children. These findings can not be explained by a primary diagnosis of alcohol dependence, teratogenic effects of drinking during pregnancy, or advantages of a quasi-continuous measure over a dichotomous measure of diagnostic status.
- The maximum number of drinks consumed in a 24-hr period is associated with tolerance and physiological features of alcoholism as well as with genes implicated in alcohol metabolism. It is also likely related to loss of control over drinking, a cardinal feature of alcoholism. Our findings suggest as well that this phenotype taps the underlying liability for externalizing disorders and problems more directly than a diagnosis of alcohol dependence.
- Because maternal and paternal maximum drinks have independent effects, greater predictive power obtains by considering both parents' status on this measure.

Acknowledgments

Preparation of this manuscript was supported by NIH grants R01 DA 05147, R01 AA 09367, and K01 AA 015621.

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Figure 1.

The distribution of the maximum number of drinks is plotted for women with and without a diagnosis of alcohol dependence. A nonparametric Gaussian kernel was used to smooth the distributions, which are also given in the form of box plots at the top of the figure. Open circles represent observations between the inner and outer “fences,” where the inner fences are given by the median plus or minus 1.5 times the interquartile range and the outer fences are given by the median plus or minus three times the interquartile range. Filled circles represent observations outside the outer fences.

Figure 2.

Odds ratios (black circles) and 95% confidence intervals around them (gray lines, one for each cohort) representing the magnitude of association between maternal maximum consumption and alcohol dependence, respectively, and offspring outcomes. ORs whose confidence intervals include 1 (the y-axis) are not significant ($p > .05$). The upper panels give unadjusted ORs, the bottom panels give ORs adjusted for effects of the other maternal characteristic. The association between maternal maximum consumption and ODD was significant for females, which is plotted, but not for males, where it was essentially nil. ADHD = attention deficit/hyperactivity disorder; ODD = oppositional defiant disorder; Early Use measures indicate use before age 15 (without parental permission in the case of alcohol); Any SUD = any substance disorder.

Table 1

Demographic Characteristics of the Sample

Cohort	Adolescents				Mothers			
	N	Age (Range)	Age (Range)	Yrs Education	College Degree	Occupation	Maximum Drinks	Alcohol Dependence
Younger male	629	18.0 (16.6–20.1)	39.0 (27–52)	13.6 (1.7)	25.3%	3.8 (1.5)	7.4 (4.7)	12.1%
Younger female	657	18.3 (16.8–20.3)	39.7 (28–52)	14.0 (2.1)	26.6%	3.7 (1.5)	8.2 (6.1)	10.0%
Older male	562	17.5 (16.6–18.5)	44.4 (33–59)	13.6 (1.8)	26.5%	3.8 (1.6)	6.5 (4.7)	5.5%
Older female	660	17.5 (16.5–18.5)	44.2 (33–60)	13.7 (2.0)	23.2%	3.7 (1.7)	7.1 (5.7)	9.5%

Note: Numbers for continuous measures are means. Unless explicitly noted as ranges, parenthesized numbers are standard deviations. Occupational status is coded according to Hollingshead's 7-point scale, with 1 representing highest-prestige occupations, such as executives of large companies, lawyers, physicians, and other "major" professionals, and 7 representing unskilled laborers. Mothers who considered themselves homemakers were not included (8.9% to 11.8% of mothers).

Table 2
Prevalence of Offspring Disorders and Frequency or Magnitude of Early Substance Use

Outcome	Younger	Older
Major Depression	.133	.130
ADHD	.069	.061
ODD	.232	.196
Conduct Disorder	.204	.224
Any disruptive disorder	.349	.311
<i>Early Use and Misuse (Before Age 15)</i>		
Tobacco	.358	.361
Alcohol	.188	.228
Any illicit drugs	.095	.049
Any substance	.405	.419
Ever intoxicated (Alcohol)	.117	.114
Number of drugs tried	0.54 (0.99)	0.66 (0.95)
<i>Substance Use Disorders (SUDs)</i>		
Nicotine dependence	.248	.159
Alcohol abuse/dependence	.196	.156
Drug abuse/dependence	.158	.068
Any SUD	.343	.241
Maximum consumption	8.11 (9.22)	6.28 (7.77)

Note: Entries for diagnostic variables and yes/no variables are proportions. Those for number or drugs tried and maximum consumption are means (with SDs).

Table 3
Regression Analysis Results for Count and Continuous Outcomes

Offspring measure	Maternal Maximum Consumption		Maternal Alcohol Dependence	
	Unadjusted	Adjusted	Unadjusted	Adjusted
Number of drugs, younger	0.251 (0.120–0.382) ***	0.231 (0.102–0.360) ***	0.414 (0.044–0.785) *	0.140 (–0.228–0.507)
Number of drugs, older	0.225 (0.136–0.314) ***	0.225 (0.130–0.320) ***	0.341 (0.036–0.645) *	0.003 (–0.312–0.319)
Maximum drinks, younger	0.207 (0.133–0.281) ***	0.195 (0.114–0.276) ***	0.347 (0.105–0.588) **	0.115 (–0.150–0.380)
Maximum drinks, older	0.258 (0.182–0.333) ***	0.239 (0.155–0.323) ***	0.540 (0.270–0.811) ***	0.171 (–0.119–0.460)

Note: Numbers are raw regression coefficients (with 95% confidence intervals), unadjusted and adjusted for effects of the other maternal characteristic. "Number of drugs" is a measure of breadth of experimentation that refers to the number of substance classes tried by age 15. "Maximum drinks" refers to the number of drinks consumed by adolescent offspring in a single 24-hr period by the age-17 assessment.

*
p < .05

**
p < .01

p < .001