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Moderation of Genetic Influences on Alcohol Involvement by Rural Residency among Adolescents: Results from the 1962 National Merit Twin Study

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Abstract

Adolescents in rural and urban areas may experience different levels of environmental restrictions on alcohol use, with those in rural areas experiencing greater monitoring and less access to alcohol. Such restrictions may limit expression of genetic vulnerability for alcohol use, resulting in a gene–environment interaction ($G \times E$). This phenomenon has previously been reported in Finnish and Minnesota adolescents. The current study used data from 839 same-sex twin pairs from the 1962 National Merit Scholarship Qualifying Test to determine whether the $G \times E$ interaction would be evident in this earlier time period. We also assessed whether the $G \times E$ interaction would be moderated by sex, and whether family socioeconomic status (SES; income and parental education) may mediate the $G \times E$ interaction. Findings showed the expected interaction among females, with a weaker contribution of genes (2 vs. 44%) and greater contribution of shared environment (62 vs. 29%) to variation in alcohol involvement among rural as compared to urban residents. The $G \times E$ interaction was not observed among males, and operated independently from differences in family SES among rural and urban adolescents. This study represents a partial replication in a novel setting of the moderation of the genetic contribution to alcohol use by rural/urban residency, and suggests that SES differences may not explain this effect.

Keywords

Gene; environment interaction; Rural residency; Alcohol involvement; Adolescents

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Compliance with ethical standards

Conflict of interest Christal N. Davis, Shanaliz S. Natta, and Wendy S. Slutske declare that they have no conflicts of interest.

Statement of Human and Animal Rights This article does not contain any studies with human participants performed by any of the authors.

Informed Consent No human data or sample were used in this study and informed consent is not required.

Introduction

Substance use patterns tend to emerge during adolescence, with increased levels of experimentation with a variety of substances. Among these substances, alcohol is the most widely used. Data from the Monitoring the Future study show that almost two-thirds (64%) of high school seniors engaged in alcohol use within the past year, with almost half (45%) reporting being intoxicated (Johnston et al. 2013 cited in Windle 2016). While the proportion of adolescents using alcohol is high, the numbers also indicate the diversity among individuals, whereby some adolescents do not engage in alcohol use at all or engage in only minimal alcohol use not resulting in intoxication. Untangling why some individuals avoid alcohol throughout adolescence while others engage in heavy use or drink to intoxication requires understanding the underlying risk and protective mechanisms.

Alcohol use among adolescents arises from a combination of genetic and environmental factors (Rhee et al. 2003; Seglem et al. 2016). A large meta-analysis of all of the published twin studies of alcohol-use-related phenotypes among adolescents aged 12–17 years of age, including over 40,000 twin pairs, obtained estimates of the contribution of genetic and shared environmental influences of 40 and 41%, respectively (Polderman et al. 2015a, b). Although evidence suggests genetic and environmental factors are important contributors when considered additively, an individual's genes and environment also interact to create greater or lesser susceptibility to alcohol use. The study of gene–environment interactions ($G \times E$) on alcohol use suggests that a person's genes interact with factors in their environment, and this interaction may be better able to account for alcohol use patterns than either factor alone (Vink 2016). A $G \times E$ refers to the phenomenon whereby some protective or risk factors have greater or lesser impact depending on a person's genetic vulnerability for a trait (Young-Wolff et al. 2011). Because some individuals are naturally at increased risk for alcohol use and problem drinking, it is important to understand environmental factors that moderate risk.

Two methods for studying the effects of such moderators include either using measured or inferred genotypic information (Dick 2011; Shanahan and Hofer 2005). Studies involving inferred genotypic information use familial relationships to estimate genetic contributions to risk, such as in twin studies. Monozygotic (MZ) twins have identical genes, while dizygotic (DZ) twins share only half of their segregating genes. Using this known relationship, genetic and environmental contributions are inferred, and differences in these estimates across measured environments can be examined as an indication of a potential $G \times E$ effect.

A review of $G \times E$ studies based on inferred genotypic information identified several types of environmental factors that have been studied in connection with alcohol use (Young-Wolff et al. 2011). The majority of studies assessed proximal environmental factors, such as those related to the individual themselves (e.g., age at first drink or involvement in prosocial activities), peers (e.g., deviant peer groups), or family (e.g., parental closeness). Of the 16 studies identified, only 5 involved more distal environmental factors like region of residence or neighborhood (Dick et al. 2009, 2001; Kendler et al. 2011; Legrand et al. 2008; Rose et al. 2001). With distal environmental factors, $G \times E$ may be less likely to be confounded by gene-environment correlation. Especially among adolescents, more distal environmental

factors will be less strongly correlated with the individual's phenotype and genotype than more proximal factors.

The first study to investigate whether living in a rural environment moderated genetic influences on alcohol use was conducted among Finnish adolescents. Data from a national Finnish sample of same-sex twin pairs were used to examine the contributions of genetic and environmental influences on drinking frequency at ages 16, 17, and 18.5 as a function of rural or urban residency (Rose et al. 2001). The researchers found genetic and unique environmental contributions to drinking frequency increased with age, and the impact of shared environmental factors was highest among adolescents at age 16 (Rose et al. 2001). With respect to urban or rural residency as a potential moderator, there was a greater genetic contribution to drinking frequency among those in urban environments than rural environments at all ages for both males and females (Rose et al. 2001). For example, at age 17, genetic factors accounted for 62 versus 49% of the variation in drinking frequency in urban versus rural environments, respectively. This finding might be explained by the social control model, which posits that a powerful or restrictive environment does not allow for the expression of a genetic predisposition, whereas a more permissive or enriching environment allows for the expression of one's genetic predisposition (Legrand et al. 2005; Rose et al. 2001; Shanahan and Hofer 2005).

It was not clear that the results obtained in Finland would generalize to other contexts (Dick et al. 2001). In Finland, there is a state-run alcohol monopoly that strictly regulates the licensing and availability of alcohol. Differences in alcohol availability in rural versus urban regions may also be accentuated because some of the rural municipalities in Finland have declined permission for retail alcohol outlets (Winter et al. 2002). Despite this, the Finnish study results were partially replicated in a United States study, suggesting the $G \times E$ observed in Finland may be more generalizable than expected.

The impact of rural or urban residency on a range of externalizing behaviors among adolescents was examined in the Minnesota Twin Family Study (Legrand et al. 2008). Twins living in a community with a population <10,000 were considered rural and the remainder were classified as urban. Alcohol use was assessed using a composite indicator of nine alcohol dependence symptoms and nine other alcohol use behavior items ranging from any prior use of alcohol to heavy consumption. These items yielded an alcohol-problems continuum (Krueger et al. 2004). The researchers found a greater contribution of genes to alcohol use in urban versus rural males (49 vs. 3%) and a nonsignificant difference in the same direction for females (19 vs. 3%; Legrand et al. 2008). The researchers suggested urban environments may allow for greater expression of genetic vulnerability, while rural environments may restrict the opportunities an individual has to express genetic propensity to use alcohol, a hypothesis in line with the social control model (Legrand et al. 2005).

An important next step is to determine the key aspects of living in rural versus urban environments that account for the moderation of genetic influences on alcohol involvement. Dick et al. (2001) conducted a follow-up of the Finnish study to better understand the underlying processes involved in the rural/urban $G \times E$ interaction effect. They found that the proportion of young adults in an area, alcohol sales, and migration in and out of the area

were all significantly higher in urban than in rural areas. After taking these three community-level environmental characteristics into account, there was no longer a significant moderation of the genetic influences on alcohol use by rural/urban residency.

There are a number of community and family-level environmental characteristics that might explain the moderation of genetic influences by rural/urban residency. For example, some research suggests rural environmental restrictions may be a product of increased community monitoring, whereby community members in rural areas work together to monitor behavior of adolescents in a way those in urban areas are unable to do as a result of a less cohesive community (Meier et al. 2008). Family-level differences in religiosity and socioeconomic status are also potential candidates for explaining the rural/urban moderation effect. Research conducted in Finland has shown rural adolescents were more religious than urban adolescents, and religiousness partially explained rural/urban differences in alcohol use (Winter et al. 2002). Family religiosity also moderated genetic influences on alcohol initiation among Dutch female adolescents (Koopmans et al. 1999). Families residing in rural areas are more likely to be living in poverty than families living in urban areas (Kusmin 2016; Miller and Rowley 2002). Although there is not a consistent association between socioeconomic status and alcohol use in adolescence (Hanson and Chen 2007; Slutske et al. 2016), it is plausible that the expression of the genetic propensity to use alcohol may be restricted among those with limited financial means to purchase alcohol.

The current study attempted to replicate the contemporary finding of the $G \times E$ among an adolescent United States sample (Legrand et al. 2008). The current study was based on a national United States sample comprised of primarily college-bound adolescents in their junior year of high school. Data were collected from same-sex twin pairs taking the 1962 National Merit Scholarship Qualifying Test (NMSQT). The aims for this study were threefold: (1) to assess whether genetic influences on alcohol involvement were moderated by rural/urban residency, such that there was a greater genetic contribution to alcohol use in urban areas, (2) to determine whether any $G \times E$ that emerged was consistent across sex, and (3) to determine whether differences in socioeconomic status can account for rural/urban differences in heritability. The National Merit Twin Study provided a glimpse into genetic and environmental contributions to alcohol use in a novel context—the United States in the 1960s.

Methods

Participants

The sample consisted of same-sex twin pairs who participated in the 1962 National Merit Scholarship Qualifying Test (NMSQT), a test which is largely taken by college bound high school students (Loehlin and Nichols 1976). In addition to the twins, a parent, stepparent, or guardian of the twin pair answered questions pertaining to the twins' family environment while growing up. In almost all cases (92.9%), the mother completed the parent questionnaire. The father completed the questionnaire in most other instances (5.6%), with the remainder of questionnaires completed by a stepparent (0.2%), guardian (0.4%), or another person responsible for care of the children (other; 0.8%). Twin pairs were identified from 596,241 high school juniors who completed the NMSQT; 1507 same-sex twin pairs

were recruited to respond to a questionnaire; of these, 1188 (79%) completed the questionnaire. Among the respondents were 509 MZ twin pairs and 330 DZ twin pairs. Participants completed a variety of questions regarding their personality, behavior, and alcohol involvement, in addition to the NMSQT itself. Participants were approximately 17 years old at the time of the NMSQT administration, and the sample was overwhelmingly (98%) Caucasian, with females being slightly over-represented (58.2%).

Measures

Measures of alcohol involvement and rural/urban residency were obtained from the twin questionnaire, and family income and parental education were obtained from the parent questionnaire.

Alcohol involvement—Ten items pertained to drinking behaviors. Eight of these items came from the Objective Behavior Inventory and two were from the California Psychological Inventory. Response options were coded dichotomously, such that ‘not at all’ was coded as ‘0’, and ‘frequently’ or ‘occasionally’ was coded as a ‘1’. The percentage of participants who endorsed each item is reported in Table 1. As the alcohol involvement items included a variety of both normative (drank beer) and problem drinking behaviors (drank before breakfast), exploratory and confirmatory factor analysis were used to assess whether items could be summed. Exploratory factor analysis in Mplus (Muthen and Muthen 2010) suggested that a single factor was the most parsimonious factor model of the data. Confirmatory factor analysis in Mplus was conducted to take into account the clustering of the twin data and obtain the standardized factor loadings reported in Table 1. The ten items were summed to obtain an alcohol composite score (Cronbach’s $\alpha = 0.79$). The alcohol composite scores were pro-rated to account for missing items, and the resulting scores were log transformed. After log transformation, the skewness and kurtosis for the full sample were 1.09 and 0.39, respectively.¹ The alcohol composite measure is similar to that reported in Loehlin (2010), except that three items that were not directly related to the participants’ own normative or problematic alcohol use were not included.

Rural versus urban residency—The following item assessed rural/urban residency: “Which of the following best describe the community which you think of as your home during high school days?” Response options ranged from a farm or open country to a central city in a metropolitan area or a city/suburb with varying population size (from less than 10,000 to over 2 million; see Table 2). Participants who lived on a farm or open country or in a city of less than 10,000 people were classified as rural (32.6%), and those who resided in a city with a population of more than 10,000 were classified as urban residents (67.4%). The 10,000-population cutoff for rural/urban residency was chosen to correspond with the previous study of Minnesota adolescents (Legrand et al. 2008).

Family income—Family income was assessed with the question “What is the family’s income before taxes?”. Response options ranged from “less than \$5000 per year” to

¹The kurtosis and skewness within groups were: rural males = 1.035, 0.118, rural females = 1.489, 1.767, urban males = 0.803, -0.469, urban females = 1.056, 0.537.

“\$25,000 and over” (see Table 3). Slightly more than one-tenth (11%) of the sample reported incomes below \$5000, while almost a quarter (23.8%) reported incomes in the range of \$5000–\$7499. At the time of data collection in 1962, the average family income was \$6000 (U.S. Department of Commerce, Bureau of the Census 1963). Family income levels were significantly different for those in rural versus urban areas, with those in rural areas having significantly lower incomes ($t(743) = 6.93, p < .0001$).

Parental education—Parental education was assessed with the item, “What is each parent’s highest educational attainment?”, with information obtained for both the mother and father’s education. Response options ranged from 8th grade or less to graduate or professional degree beyond the bachelor’s degree (see Table 3). To create a single parental education variable, an average was taken of the mother and father’s reported educational attainment. If only one parent’s education level was provided, that parent’s information was used for the parental education variable. Parental education was not significantly different among those in rural and urban areas ($t(801) = 0.74, p = .461$). Additionally, parental education and family income were not significantly correlated ($r = .058$).

Data analysis

Descriptive analyses were calculated using SPSS (v23.0). All other calculations were performed using the statistical software program Mplus (Muthen and Muthen 2010). Structural equation modeling was conducted to determine the proportions of variance accounted for by additive genetic influences (A), shared environmental influences (C), and unique environmental influences (E), and to examine whether these differed for males and females. Evidence of a $G \times E$ was based on comparing estimates of A, C, and E for rural-dwelling versus urban-dwelling adolescents. In order to rule out potential influence of gene-environment correlation, we controlled for mean differences in the alcohol composite measure between rural and urban residing adolescents. This removes variance in alcohol involvement due to rural/urban residency and any potential genetic effects shared between alcohol involvement and rural/urban residency (Purcell 2002). Subsequent models were fit with family income as a covariate, parental education as a covariate, and both family income and parental education as covariates to determine whether these variables partially explained rural moderation of genetic influences.

Results

As expected based on prior literature, males had significantly higher scores on the alcohol composite measure than females ($\chi^2 = 7.915, df = 1, p = .005$); individuals living in rural areas had significantly lower scores on the alcohol composite than those living in urban areas ($\chi^2 = 27.829, df = 2, p < .00001$). The reported rural versus urban residency differences were primarily found among females ($\chi^2 = 25.601, df = 1, p < .0001$), as the difference was not significant among males ($\chi^2 = 2.227, df = 1, p = .14$) (see Table 4). There were also variance differences; males had higher variances on the alcohol composite than females ($\chi^2 = 25.915, df = 1, p < .0001$), and females in urban areas had higher variances than females in rural areas ($\chi^2 = 12.453, df = 1, p = .0004$). However, the

difference in variance among males in urban and rural areas was not significant ($\chi^2 = 0.806$, $df = 1$, $p = .369$).²

Among both males and females, the MZ twin correlations on the alcohol composite were larger than the DZ twin correlations (0.70 vs. 0.56 for males; 0.70 vs. 0.59 for females). This finding suggests the importance of genetic influences on alcohol use. After dividing the sample into rural and urban dwelling twins, this pattern of a greater MZ than DZ twin correlation held true for both rural males and urban females, whereas the MZ and DZ correlations for urban males and rural females were approximately equal (see Table 5). These results indicate that genetic influences in alcohol use among rural males and urban females are greater than among urban males and rural females. To further explore this residency by sex difference, we conducted more rigorous model fitting analyses.

The results of fitting the univariate twin model to males and females are shown in Table 6, with both standardized and unstandardized estimates presented. Among males and females, approximately a third (33% for males; 32% for females) of the variance in alcohol involvement was due to genes, with a slightly larger share of the variance (38% for males; 40% for females) resulting from shared environmental factors. Slightly less than a third of the variance in alcohol involvement was due to unique environmental factors (29% for males; 28% for females). The overall model fit the data well ($\chi^2 = 10.25$, $df = 11$, $p = .51$). However, when we attempted to constrain the estimates for males and females to be equal, there was a significant deterioration in model fit ($\chi^2 = 40.65$, $df = 3$, $p < .0001$). Therefore, all subsequent model fitting was conducted allowing the estimates for males and females to differ.

We then applied the full model stratifying by rural versus urban residency ($\chi^2 = 28.47$, $df = 24$, $p = .24$). When we constrained the model within sex across rural versus urban residency, there was a significant deterioration in model fit ($\chi^2 = 26.06$, $df = 6$, $p = .0002$), suggesting a difference within males and females by residency status.³ For rural residing males, genes accounted for the majority (66%) of the variance in alcohol involvement, while the results for urban males showed the opposite pattern of results, with a majority (61%) of the variance accounted for by shared environment. For female twins, findings were the opposite, with shared environment among rural females accounting for almost two-thirds of the variance (62%) and genes accounting for almost half (44%) of the variance in alcohol involvement among urban females. We conducted follow up tests to determine whether these differences were significant among males, females, or both sexes. The difference between rural versus urban women were significant ($\chi^2 = 19.15$, $df = 3$, $p = .0003$), whereas the differences between rural versus urban men were not ($\chi^2 = 6.92$, $df = 3$, $p = .075$).

An alternate conceptualization of rural residency, including only those who endorsed living in a “farm or open country” community, yielded similar results. Those in rural areas had

²Overall variance differences were examined because they set the stage for examining differences in genetic and environmental variances. That is, if the overall variance is larger, than the genetic, shared, or unique environmental variances (or some combination of the three) will be larger in one group compared to another.

³Using the original alcohol composite variable instead of the log-transformed variable also resulted in a significant decrease in fit when constraining the model within sex across rural versus urban residency ($\chi^2 = 37.75$, $df = 6$, $p < .0001$).

lower alcohol involvement scores than those in urban areas ($\chi^2 = 11.37$, $df = 2$, $p = .003$). These differences were primarily found among females ($\chi^2 = 9.72$, $df = 1$, $p = .002$), as the difference was not significant among males ($\chi^2 = 1.53$, $df = 1$, $p = .255$). When we constrained the biometric model within sex across rural versus urban residency, there was a significant deterioration in model fit ($\chi^2 = 12.94$, $df = 6$, $p = .04$), suggesting there was still a difference in the contribution of genetic factors to alcohol involvement within males and females by residency status. The only significant change was found in urban males, who had a greater (but still non-significant) contribution of genetic factors (21%) and a lower contribution of shared environmental factors (49%) compared to the original results presented in Table 6. These findings are more in line with our hypotheses.

Including parental education and/or family income as covariates had little to no impact on the estimates of genetic, shared environmental, and unique environmental contributions to alcohol involvement among rural versus urban adolescents. These estimates changed no more than 2% when parental education, family income, or both were included as covariates.

Discussion

This study attempted to replicate prior research concerning the reduced impact of genetic factors on alcohol use among rural compared to urban adolescents (Legrand et al. 2008; Rose et al. 2001). Although our findings showed a similar pattern for females, the results for males were not replicated. The discrepancy of these findings might reveal how the social context impacts rural/urban differences in the heritability of alcohol involvement. There have been major changes in the physical and social barriers to using alcohol in the decades since 1962. For example, in previous studies conducted in present-day Finland and Minnesota, levels of alcohol involvement did not significantly differ for rural versus urban youth (Legrand et al. 2008; Rose et al. 2001). In the present study, rural youth scored significantly lower than urban youth on the measure of alcohol involvement, with urban–rural differences among females ($d = 0.42$) over twice as large as among males ($d = 0.16$). Trends in the Monitoring the Future study also suggest that prevalence rates of alcohol use among rural and urban areas have been converging since the study's inception in 1975 (Miech et al. 2016). This suggests urban/rural differences in access to alcohol were much more pronounced, especially among young women, for this study's participants compared to more contemporary samples (e.g., Cronk and Sarvela 1997). The presence of the $G \times E$ found among females despite these changes in rural and urban life suggests that the rural moderation of genetic influences is a robust effect found across different nations and time periods (Legrand et al. 2008; Rose et al. 2001).

Greater understanding of moderators of the $G \times E$ interaction would provide a more nuanced understanding of the rural moderation of genetic contributions to alcohol involvement. Country of residence may be an important moderator of the interaction that would explain why results obtained from other countries (e.g., Finland; Rose et al. 2001) differ from those in the United States. Rural and urban residency may more clearly imply differences in access to alcohol in some countries compared to others. Additionally, as this and previous findings (Legrand et al. 2008) have revealed, sex is likely another important moderator of this interaction. Different levels of environmental restriction for males and females might be

a potential mechanism explaining the sex difference, which may be particularly evident in conservative environments. Previous research has found neighborhood risk factors have a greater association with delinquent behavior in males than females (Meier et al. 2008), which may be because females receive more monitoring by parents and are therefore less exposed to risk factors in the neighborhood. Boys, who receive less community monitoring, may be more likely to be exposed to risk in their environment. Furthermore, community monitoring and high social cohesion are more characteristic of rural than urban neighborhoods (Scheer et al. 2000), and females who receive these increased levels of monitoring may be subject to greater restrictions on their access to alcohol, thereby increasing the restrictive impact of the environment on genetic liability to alcohol involvement.

This study found no evidence to suggest family income and parental education mediated the rural/urban differences in the heritability of alcohol use. This suggests that differences in heritability among rural and urban adolescents are not merely a reflection of differences in socioeconomic status. Therefore, an important next step in contemporary samples will be to continue to examine potential mediators of these rural/urban differences, such as religiosity, young adult migration, and regional alcohol sales. For example, some findings suggested increased religiosity among those in rural areas helped explain alcohol use patterns among residents (Winter et al. 2002). Prior research has found rural residency no longer moderated genetic and environmental contributions to alcohol use after effects of the proportion of young adults, migration patterns, and alcohol sales were statistically removed (Dick et al. 2001). Migration patterns may have increased relevance in present day findings as a result of population loss in rural areas that has been occurring in recent decades (Artz 2003). Examining mediating factors could help clarify why the rural moderation of genetic influence on alcohol involvement occurs and provide additional support for the social control model.

Research has also found evidence for the moderation of genetic influences by rural residency on other externalizing phenotypes, and this research may be crucial for ruling out potential mediators of the interaction. For example, research has shown among adolescents, rural residency moderates the genetic contribution to a variety of externalizing behaviors, including conduct disorder, oppositional defiant disorder, antisocial behavior, and drug use (Legrand et al. 2008). This finding across various externalizing behaviors suggests alcohol-specific mediators like alcohol outlet density might not be the best potential mediators for explaining this interaction. Instead, broader community factors may be implicated. These findings have important implications for determining which factors may be contributing to this $G \times E$ interaction.

Limitations

Although the use of data from 1962 United States allowed for the replication of the moderation of genetic liability for alcohol involvement by rural/urban residency in a novel setting, these data also were limited in a number of ways. The changes that have occurred in the rural landscape since these data were collected might reduce generalizability to adolescents in rural areas in today's United States, who may face substantially different

environments. Additionally, our sample primarily consisted of high-achieving, white adolescents. Those of other ethnicities or those who are not college-bound may show different patterns of $G \times E$ that could not be captured by this study. The use of a rural/urban continuum rather than a dichotomy might have provided more nuanced findings about the impact of residency on genetic expression of alcohol use behaviors (Lambert et al. 2008; Pedersen and Mortensen 2001). For example, assessing suburban or central city status might have implications for participants' access to alcohol.

The use of an alcohol composite measure, although used in previous studies (Legrand et al. 2008; Loehlin 2010; Polderman et al. 2015a, b), does not provide information about specific alcohol behaviors like quantity or frequency of use among adolescents. In the previous study conducted in Finland, the frequency of alcohol use was examined in a sample restricted to twins who endorsed some alcohol use (Rose et al. 2001), which was done to isolate the genetic and environmental influences on the frequency of alcohol use from those on alcohol use initiation. This study captured general adolescent alcohol use across a variety of dimensions and did not have sufficient power to include only those twins who were alcohol involved. The alcohol composite measure was also limited in that most participants had low levels of involvement, and many items were endorsed infrequently (see Table 1).

Directions for future research

Future studies involving the moderation of genetic influences by rural residency should attempt to further distinguish the conditions under which one can expect rural moderation of genetic influences on alcohol use among adolescents. To do this, data from different populations as well as different time periods should be analyzed with the inclusion of potential mediators in order to elucidate mechanisms explaining this phenomenon. Future studies should make use of a rural/urban continuum to reveal further nuances to this phenomenon, as urban-adjacent rural areas might show little environmental restriction of genetic expression compared to non-adjacent rural areas. More specific alcohol outcome measures, like quantity and frequency of use, may also be examined. As unique environmental influences accounted for almost a third of variance in alcohol involvement (29% for males; 28% for females) among adolescents, future studies should examine the role that these factors play in the development of alcohol use behaviors. Some prior findings suggest unique environmental factors may help explain the association between early alcohol use and later substance abuse and dependence (Grant et al. 2005). Overall these findings suggest that the changing rural landscape in the United States has important implications for understanding genetic and environmental risk factors for alcohol use.

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Table 1

Composite alcohol involvement scale in the 1962 National Merit Twin Study sample

Item	Prevalence (%)	Standardized factor loading
I have drunk wine	46.5	0.56
I have drunk liquor	31.9	0.86
I have drunk in a bar	10.0	0.79
I have had a hangover	10.0	0.94
I have drunk before breakfast	2.8	0.34
I have become intoxicated	12.4	0.97
I have drunk beer	33.9	0.86
I have gone on the wagon	3.6	0.57
I have never done any heavy drinking (r)	9.9	0.80
I have used alcohol excessively	3.9	0.73
Eigenvalue		6.00
%variance explained		58.55

r Reverse coded

Table 2

Residency status of participants in the 1962 National Merit Twin Study sample

Residency status	Frequency	Percent
Farm or open country	185	22.1
City of less than 10,000 population	88	10.5
City of 10,000-49,999	103	12.3
City of 50,000-99,999 <i>or</i> suburb or less than 100,000	130	15.5
City <i>or</i> suburb of 100,000-499,999	97	11.6
City <i>or</i> suburb of 500,000-2 million	98	11.7
City <i>or</i> suburb of >2 million	102	12.2
Total	803	95.7
Missing	36	4.3

Table 3

Demographic characteristics of rural & urban residents

	Frequency (%)		
	Full sample	Rural	Urban
Income			
<\$5000	11.8	21.7	7.3
\$5000-7499	25.7	30.9	22.8
\$7500-9999	21.4	20.9	21.4
\$10,000-14,999	23.6	18.1	26.2
\$15,000-19,999	9.4	4.4	12.3
\$20,000-24,999	3.0	0	4.2
\$25,000+	5.1	4.0	5.8
Mother's education			
8th grade or less	6.6	12.0	4.1
Part high school	12.8	13.9	12.7
High school graduate	37.2	34.1	38.0
Part college/junior college	23.8	24.7	22.8
College graduate	15.1	11.2	17.4
Graduate/professional degree	4.5	4.1	5.0
Father's education			
8th grade or less	11.0	19.5	7.2
Part high school	12.0	14.7	10.5
High school graduate	26.0	31.2	23.5
Part college/junior college	21.8	15.0	24.1
College graduate	15.0	7.9	18.7
Graduate/professional degree	14.1	11.7	16.0

Table 4

Means and variances for the alcohol involvement composite in the 1962 National Merit Twin Study sample

	<u>Males</u>		<u>Females</u>	
	Mean	Variance	Mean	Variance
Full sample	1.60	3.06	1.25	2.00
Rural	1.49	2.84	0.84	1.41
Urban	1.76	3.21	1.44	2.18

Table 5

Twin correlations for the alcohol involvement composite in the 1962 National Merit Twin Study sample

	<u>Men</u>		<u>Women</u>	
	MZ	DZ	MZ	DZ
Full sample	0.70	0.56	0.70	0.59
Rural	0.70	0.46	0.62	0.64
Urban	0.68	0.64	0.70	0.55

All correlations are significantly greater than zero at $p < .05$

Table 6

Portions of variation in the alcohol involvement composite explained by genetic and environmental influences in the 1962 National Merit Twin Study sample

	Men			Women		
	A	C	E	A	C	E
Unstandardized estimates						
Full sample	1.00 (0.52, 1.46)	1.21 (0.75, 1.66)	0.88 (0.76, 1.01)	0.64 (0.35, 0.93)	0.78 (0.49, 1.07)	0.57 (0.49, 0.65)
Rural dwelling	1.88 (0.64, 3.12)	0.25 (-0.88, 1.37)	0.72 (0.92, 1.82)	0.02 (-0.44, 0.49)	0.87 (0.42, 1.32)	0.52 (0.36, 0.67)
Urban dwelling	0.21 (-0.62, 1.05)	1.96 (1.10, 2.81)	1.04 (0.79, 1.28)	0.96 (0.41, 1.51)	0.63 (0.11, 1.16)	0.59 (0.47, 0.71)
Standardized estimates						
Full sample	0.33 (0.09, 0.56)	0.38 (0.16, 0.60)	0.29 (0.23, 0.36)	0.32 (0.14, 0.51)	0.40 (0.23, 0.57)	0.28 (0.23, 0.33)
Rural dwelling	0.66 (0.25, 1.08)	0.09 (-0.31, 0.48)	0.25 (0.16, 0.35)	0.02 (-0.31, 0.35)	0.62 (0.34, 0.89)	0.37 (0.25, 0.49)
Urban dwelling	0.07 (-0.19, 0.33)	0.61 (0.38, 0.84)	0.32 (0.24, 0.41)	0.44 (0.19, 0.69)	0.29 (0.06, 0.52)	0.27 (0.21, 0.33)

95% confidence intervals are in brackets. Parameter estimates that are statistically significant at $p < .05$ are denoted with bold. A genetic variation, C shared environmental variation, E unique environmental variation