The Effect of Sibling Gender on Substance Use During Adolescence: Evidence from Dizygotic Twins*

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Abstract

This paper examines the impact of sibling gender on substance use during adolescence. I analyze a sample of dizygotic twins, leveraging the exogenous variation in their assigned sex at birth. This design helps me to address some methodological concerns in studying sibling gender effects and provide robust causal estimates. I find that among male adolescents, having a brother increases the probabilities of using cigarettes, alcohol, and marijuana. Regarding potential mechanisms, I find that the results are consistent with the channel of direct sibling influences, but not with the channels of differential parental investment or family structure.

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1 Introduction

Peer influences among adolescents have captured the attention of parents, educators, policymakers, and researchers striving to optimize the production of human capital. One important related question is which peers matter, or more specifically, what peer characteristics impact one's own human capital. By exploring various peer characteristics, such as gender, race, and family environments, economists have discovered significant effects of peer characteristics on adolescents' socioeconomic outcomes, including educational and labor market outcomes.[1]

Among various peer characteristics, the gender of peers is particularly important. Adolescents are more likely to form close friendships with peers of the same gender (Poulin and Pedersen, 2007), potentially leading to stronger peer influences among same-gender peers. For outcomes with a large gender disparity, such as STEM participation (Brenøe and Zölitz, 2020), greater exposure to a specific gender of peers may exacerbate the existing gender gap.[2]

In this paper, I investigate how the gender of siblings, a notably important peer group, affects adolescent substance use. They share a substantial amount of time together (Claes, 1998), sometimes even more than the time with their friends.[3] Accordingly, prior studies have found that siblings markedly influence each other (Black et al., 2021; Dahl et al., 2014). By investigating the impact of sibling gender, I aim to shed light on how the gender of peers, with whom adolescents

[1]Examples of the impact of peers' characteristics on one's own outcomes include peers' gender and race on one's test scores (Hoxby, 2000); race on test scores (Angrist and Lang, 2004); exposure to family violence on test scores (Carrell and Hoekstra, 2010) and on college completion and earnings (Carrell et al., 2018); immigration status on test scores (Gould et al., 2009); maternal educational attainment on college attendance (Bifulco et al., 2011); and the number of siblings on later-life fertility (Bethencourt and Santos-Torres, 2023).

[2]For instance, Brenøe and Zölitz (2020) suggests that having more female peers changes the gender gap in high school GPA in favor of males, which may lead women to perceive themselves as less equipped for STEM studies.

[3]By surveying adolescents aged 11-18 years, the paper examines the daily time allocation with siblings and close friends. The findings underscore the important role of siblings among adolescents. In Italy, the time spent with siblings was substantial, with 4.80 hours for brothers, 4.65 hours for sisters, while close friends received 2.09 hours. Similarly in Belgium, adolescents spent 3.70 hours for brothers and 3.95 hours for sisters, but 3.00 hours for close friends.

share substantial time, can shape adolescent behaviors.

The outcome variable of interest is adolescent substance use. Despite its detrimental effects on human capital formulation and later-life outcomes,[4] adolescent substance use is prevalent in the United States. In 2010, 75.6 percent of high school students had tried cigarettes, alcohol, or other drugs, and 46.1 percent of high school students were current users (National Center on Addiction and Substance Abuse, 2011). Yet, the causal effect of peer gender on adolescent substance use, a domain where a large gender gap is consistently observed (Gruber, 2009), has not been well-established. This paper fills the gap in our understanding on the causal effects of peer gender.

There are two key challenges in estimating the causal effects of sibling gender. First, the sibling gender composition can be biased by selective parental fertility decisions. Parents often have specific preferences on their children's gender composition, which influences their subsequent fertility (Angrist and Evans, 1998; Dahl and Moretti, 2008). In some cases, this preference may even result in sex-selective abortions (Yamaguchi, 1989; Lin et al., 2014). These behaviors bias the observed sibling gender composition. Second, it is difficult to address the birth order effect and its interaction with the sibling gender effect. For example, as Averett et al. (2011) noted, later-born children receive less parental supervision than first-born children, and this effect is further pronounced when they have a same-sex older sibling. Failure to address such an interaction can result in biased estimates, but addressing all potential interactions is very challenging.

I address these two challenges by utilizing dizygotic twins, formed from the fertilization of two separate eggs by two separate sperm, in the National Longitudinal Study of Adolescent Health (Add Health). First, the sex of dizygotic twins at birth is randomly assigned in the absence of

[4] For more details, see the followings: academic performances (Ellickson et al., 2001; DeSimone, 2010; Balsa et al., 2011), educational attainments (Cook and Moore, 1993; Dee and Evans, 2003; Chatterji, 2006a,b), criminal activities (Sen et al., 2009; Chalfin et al., 2023) and labor market outcomes (MacDonald and Pudney, 2000; Van Ours, 2004).

in vitro fertilization or sex-selective abortion. These methods were not widely utilized when my sample respondents were born. This feature provides a natural and random setting for investigating sibling gender effects, free from parental fertility selection. Second, the design minimizes birth order effects and effectively circumvents the intricate interactions between birth order and sibling gender effects, as twins share the same age, birth timing, and environment at each age.

I examine the sibling gender effects on adolescent substance use by gender. In other words, I compare males with a twin brother to males with a twin sister, and compare females with a twin brother to females with a twin sister. This separate analysis is due to the fact that sibling gender effects differ depending on an individual's own gender, and is in line with the literature.

I find that males with a twin brother are more likely to smoke cigarettes, drink alcohol, and use marijuana than males with a twin sister. The magnitudes of these effects are large. For example, males with a twin brother are more likely to be current smokers, alcohol drinkers, and marijuana users than males with a twin sister by 9.9 percentage points (30.2 percent compared to the mean), 15.5 percentage points (31.6 percent) and 5.5 percentage points (33.3 percent), respectively. On the other hand, sibling gender has little impact on females. The negative effects of having a twin brother for males (while no significant effects for females) are consistent with prior findings on peer effects: males are both more influential on peers and are more influenced by peers than females.[5]

I then explore potential mechanisms underlying the sibling gender effects: parental investment (Cools and Patacchini, 2019; Brenøe, 2021), family structure including parental marriage stability and number of total siblings (Cools and Patacchini, 2019), and direct sibling interactions (Peter et al., 2018). While I find no evidence of differential parental investment or changes in family

[5] Examples include: non-cognitive skills among siblings (Cyron et al., 2017; Golsteyn and Magnée, 2017), academic performance (Hoxby, 2000; Lavy and Schlosser, 2011; Gottfried and Graves, 2014; Lee et al., 2014; Hu, 2015; Hill, 2017) and disruptive behaviors among school peers (Clark and Lohéac, 2007; Carrell and Hoekstra, 2010) , and crime among juvenile prisoners (Stevenson, 2017).

structure by sibling gender, I argue that the results align with the sibling interactions channel. Specifically, I propose two examples of sibling interactions with suggestive evidence: by sharing a friend network for substance access and by serving as a reference point for substance use.

This paper contributes to the literature on sibling gender effects in three important ways. First, by utilizing dizygotic twins, it effectively addresses two key methodological concerns: selective parental fertility decisions and complex interactions between birth order and sibling gender. Prior studies have traditionally included both older and younger siblings in the sample and compared those with sisters to those with brothers.[6] To address the two concerns, particularly selective parental fertility, more recent studies have focused on the effects of the younger sibling's gender on the older sibling, as it is random given the birth of the younger sibling. Yet, this recent approach is less intuitive in the context of substance use where older siblings exert higher influence on younger siblings than vice versa (Rowe and Gulley, 1992). In the context of substance use, the twin research design offers a more suitable solution to these methodological concerns.

Second, this paper studies the causal effects of sibling gender on substance use, which are not well-established in the literature despite its far-reaching negative impacts on human capital. While sibling gender has been found to significantly impact various outcomes,[7] prior studies have paid little attention to its effects on substance use. To the best of my knowledge, there are only two relevant works. Cools and Patacchini (2019) briefly explores sibling gender effects on disruptive behaviors only among females in their mechanism section. Argys et al. (2006), which examines birth order effects on risky behaviors, compares the effect of having older sisters to that of having older brothers among younger siblings in their heterogeneity section. However, their approach

[6] For instance, see Butcher and Case (1994), Kaestner (1997), Hauser and Kuo (1998), Conley (2000), Brunello and De Paola (2013), Anelli and Peri (2015), Cyron et al. (2017), and Rao and Chatterjee (2018).

[7] The literature suggests causal effects of sibling gender on occupations (Brenøe, 2021), earnings (Peter et al., 2018; Cools and Patacchini, 2019), family formation (Peter et al., 2018), and personality (Golsteyn and Magnée, 2020).

to this comparison contrasts with what recent studies on sibling gender do to address parental selective fertility. By providing the first causal evidence on how sibling gender affects substance use, this paper fills the gap in the literature on sibling gender.

Third, this paper sheds light on an underexplored mechanism of sibling gender effects—direct sibling interactions—by providing suggestive evidence. While prior studies have extensively examined channels of parental investment and family structure,[8] the channel of direct sibling interactions has been less explored due to data limitations. Utilizing extensive survey data on adolescent behaviors in Add Health, this paper provides suggestive evidence on how siblings directly influence each other, deepening our understanding of sibling gender effects.

This paper also contributes to the broader literature on peer gender effects. Investigating the causal effect of "friend" gender is very challenging due to the selective nature of friendships. To avoid this selection, prior studies have relied on measures such as gender composition within specific peer groups.[9] However, it remains uncertain whether these measures accurately capture the impact of friends with whom adolescents spend substantial time together, as these measures may include peers with infrequent interactions. In contrast, twins are more likely to view each other as their friends, compared to non-twin full siblings (Fraley and Tancredy, 2012) and school peers (McGuire and Segal, 2013). Twins (and their parents) in my sample are not able to choose each other's sex, free from selecting friends of a particular gender. Twins share the same family environment at each developmental stage, which eliminates selective friendship based on family environments. By utilizing twins, this study offers valuable insights into the effect of friend gender.

The remainder of this paper proceeds as follows. Section 2 introduces the identification strategy

[8] Examples include Butcher and Case (1994), Oguzoglu and Ozbeklik (2016), Cools and Patacchini (2019), Golsteyn and Magnée (2020), and Brenøe (2021).

[9] Such peer groups include individuals in the same classroom (Hoxby, 2000; Gottfried and Graves, 2014; Lee et al., 2014), school-grade (Lavy and Schlosser, 2011; Hu, 2015; Hill, 2017), and neighborhood (Hill, 2015).

and describes the data. Section 3 presents the results and checks their robustness. Section 4 explores potential mechanisms behind the findings. Section 5 discusses the results in non-twin siblings and their biases. Section 6 concludes.

2 Empirical Strategy and Data

2.1 Twin Research Design

This study utilizes dizygotic twins who, on average, share approximately 50 percent of their genes, similar to full siblings. Dizygotic twins, resulting from the fertilization of two separate eggs by two separate sperm, have been widely recognized in biology as having randomly determined sexes in nature. For instance, Weinberg's differential method, a commonly used approach for estimating the number of dizygotic twins and different-sex twins, assumes that the sex of each twin in a dizygotic pair is *independently* determined from the other twin's sex. Numerous empirical studies have provided substantial support for this method and particularly, its underlying assumption of independence (Vlietinck et al., 1988; Husby et al., 1991; Fellman and Eriksson, 2006).

In my twin research design, it is crucial to determine the zygosity of twin pairs and focus on dizygotic twins. This is because monozygotic twins, formed when a single zygote splits, are always of the same sex. As a result, given one's sex, there is no variation in the co-twin's sex to explore, making it impossible to investigate the effect of having a same-sex co-twin. Furthermore, monozygotic twin pairs share 100 percent of their genes, setting them apart genetically from dizygotic twins or non-twin full siblings who, on average, share 50 percent of their genes. This genetic dissimilarity poses challenges when comparing them with same-sex dizygotic twins or same-sex non-twin full siblings.[10] Therefore, it is essential to have accurate information on zygosity and limit the analysis to dizygotic twins (Peter et al., 2018).[11]

The twin research design has several advantages. First, it addresses the parental selection bias on the gender composition of their children. The traditional approach is to compare those with a brother to those with a sister regardless of their birth order (see footnote 4). However, it has been found that parents in the United States may want to have at least one son and one daughter (Angrist and Evans, 1998) or at least one son (Dahl and Moretti, 2008). This implies that parents who plan another birth after having a son and those after having a daughter may have different preferences and even different parenting styles. In the research design of using dizygotic twins, however, I can circumvent the parental selection bias: twins are born at the same time, the sexes of twins are determined independently, and parents cannot choose one child's birth based on the sex of the other child.

Second, the design allows me to explore the sibling gender effect separately from their birth order. Among non-twin siblings, there is always a birth order, and thus we need to consider the birth order effect and its interaction with the sibling gender effect. For example, Price (2008) finds that the differences in time spent with the father among siblings are the greatest when the father has the first-born son and second-born daughter. It is also found that parents supervise their younger child less if there is a same-sex older child, potentially leading to younger children being

[10]For example, Table A1 indicates that the correlation in substance use is considerably higher among monozygotic twins than among dizygotic same-sex twins across all measures. This finding underscores the influence of genetic factors in shaping substance use behaviors among twin pairs.

[11]For readers who may be interested in comparing monozygotic twins and same-sex dizygotic twins, Table A2 reveals that monozygotic twins are notably less likely to engage in substance use compared to dizygotic same-sex twins, particularly among males. This finding is consistent with the prior studies that monozygotic twins are known to exhibit better behaviors and outcomes compared to same-sex dizygotic twins or non-twin full siblings: they are more likely to have stable marriage relationship (Heller et al., 1988), higher educational level and net worth (Felson, 2014), and better health outcomes (Kanazawa and Segal, 2019) and lower mortality rate (Sharrow and Anderson, 2016).

supervised by their same-sex older siblings (Averett et al., 2011). In contrast, twins share the same age, birth timing, and environment at each age, effectively circumventing the intricate interactions between birth order and sibling gender effects.

Third, in a broader sense, the twin research design offers an exceptional framework to explore the effects of "friend" gender. Twins are more likely to regard each other as their friends than non-twin full siblings (Fraley and Tancredy, 2012) or school peers (McGuire and Segal, 2013). Meanwhile, the twin design eliminates two selection biases in friendships. Twins and their parents cannot choose the gender composition of the twin pair, leading to a causal estimate that avoids selection biases in friend gender.[12] Also, they are of the same age and share the same family environment at each age, which eliminates selective friendship based on family environments.

While the twin design offers notable advantages, it is important to exercise caution when extrapolating the findings of this paper to non-twin families. First, twinning can be influenced by various factors. Although the respondents in my sample were born at a time when in vitro fertilization (IVF) was not widely employed, as detailed in subsection 2.2, a natural multiple pregnancy itself can be influenced, albeit to a minor extent, by maternal age and parity (MacGillivray et al., 1988), race (Oleszczuk et al., 2001), and maternal BMI (Basso et al., 2004). Also, less complex assisted reproductive technologies, including ovulation-inducing drugs that were available during my sample respondents' birth, have been associated with an increased twinning rate (Lamont, 1982) and have links to parents displaying a stronger desire to have a child (Hirsch and Mosher, 1987) and higher socioeconomic status (Wilcox and Mosher, 1993).

Parents of twins may also have different family environments, parenting styles, and levels of

[12] Non-twin full siblings cannot choose each other's gender but their parents may do, which results in the parental selective fertility decisions.

investments in children. Prior studies on parenting, however, have proposed two distinct perspectives. On one hand, raising twins is perceived as a unique experience by parents and family members, potentially leading to heightened emotional attachment (Holditch-Davis et al., 1999; Leonard and Denton, 2006). However, it also presents challenges such as time constraints and greater parenting demands (Beck, 2002; Damato and Burant, 2008; Bolch et al., 2012; Heinonen, 2016). Consequently, parents of twins may lean towards adopting stricter parenting approaches and exhibit less nurturing behaviors (Anthony et al., 2005).

2.2 Data

This study utilizes data from the National Longitudinal Study of Adolescent to Adult Health Health (Add Health), a comprehensive survey conducted in the United States. The survey employed a stratified sampling method by selecting a random sample of high schools across the country in 1994. The sample included adolescents in grades 7 through 12 during the 1994-1995 school year, aiming to create a nationally representative cohort. The survey has since followed up with participants through five waves: Wave I (1994-1995), Wave II (1996), Wave III (2001-2002), Wave IV (2008-2009), and Wave V (2015-2017).

The Add Health dataset is highly suitable for this analysis due to its unique features. First, Add Health over-sampled twins and siblings and has a large twin sample size of 784 twin pairs, making it a valuable resource for twin research. While administrative data covering the entire population of twins would be optimal for twin research due to the low twinning rate, such sources often lack detailed information on substance use, particularly during adolescence. In contrast, Add Health stands out as the largest and most comprehensive longitudinal survey of US adolescents' health behaviors. By deliberately oversampling twins, Add Health ensures a sufficient number of twin participants, enabling rigorous examination of substance use outcomes among twins.

Second, 99.92 percent of the Add Health respondents were born between 1974 and 1983 when in vitro fertilization (IVF) or prenatal sex discernment techniques were not available or commonly utilized. The first instance of a child conceived with IVF in the United States occurred in 1981 (Barnhart, 2013). Prenatal sex discernment became available in the mid-70s, but their prevalence was not substantial enough to influence the sex ratios among children born in the United States until 1990, even among individuals whose parents hailed from countries with a high prevalence of sex-selective abortion (Almond and Edlund, 2008).[13] This temporal context strongly supports the suitability of my twin research design to investigate the sibling gender effect.

Third, it provides comprehensive information on the health behaviors, specifically substance use, of the respondents during adolescence. The primary objective of the survey was to facilitate research on the determinants of health and health behaviors among adolescents (Harris, 2013). As a result, the survey has collected extensive data on substance use across all waves, making it a valuable resource for studying this topic.

Among the twin pairs in the Add Health data, however, not all twin pairs are suitable for my analysis. To begin with, I restrict to dizygotic twins, following the classification criteria of zygosity by the Add Health data team.[14] Then I require them to list their co-twin in the household roster

[13] Citro et al. (2014) also found that the prohibition of sex-selective abortions in Illinois and Pennsylvania—implemented in 1984 and 1989, respectively—had no discernible impact on sex ratios.

[14] All twins with an different-sex co-twin were classified as dizygotic, as they are always dizygotic by nature. Then the same-sex twins were classified as dizygotic or monozygotic, based on their responses to the confusability of their appearance with the co-twin. (Questions about confusability include whether they looked like two peas in a pod when young children and whether strangers, teachers, or family members were confused by them.) If the information on self-reported appearance confusability was missing, then the data team used the responses of their mother to the questions on confusability. If all these responses are still not enough to classify the twin pairs, then the zygosity was determined by DNA tests (performed at Wave III and IV). Despite these efforts, 5.7 percent of twin pairs were not certainly classified. I drop these unclassified twin pairs in my analyses.

in Wave I (based on the age and sex information of the household members), resulting in the exclusion of 48 pairs of dizygotic twins.[15] This restriction is in place to ensure that they live in the same household and, therefore, have the opportunity to interact with each other. Table 1 displays the count of dizygotic twins in the final sample by sex and co-twin's sex.[16]

Table 2 presents summary statistics of numerous observables, including individual demographic characteristics, parental backgrounds, and school characteristics. Notably, these variables are hardly correlated with the sex of the co-twin, affirming the validity of the identification assumption that the co-twin's sex can be treated as random.[17]

2.3 Measures of Substance Use

Add Health includes extensive information about substance use among adolescents. I specifically focus on three substances that exhibit the highest prevalence among adolescents: cigarette, alcohol, and marijuana (Volkow, 2011).[18]

To protect the confidentiality of the data and reduce self-reporting bias on sensitive topics

[15] For pairs who do not satisfy this condition, there can be two possibilities: (1) the twins do not live in the same household, or (2) the twins do live in the same household, but either one or both of the twin pairs forgot to report the other. Among the 48 pairs, 36 pairs attended the same schools, indicating that many of them are likely to fall into the latter category. The probability of not satisfying this condition is found not to be correlated with my treatment variable, the sex of the co-twin (correlation = 0.0276 for males; 0.0366 for females).

[16] In Table 1, the probability of being female in my sample (i.e., dizygotic twins living together) is calculated at 0.4802 (95 percent confidence interval = [0.4457, 0.5147]). To assess the potential bias in my sample's sex ratio, I utilized the Natality Data for 1979, where 1979 is the median birth year of Add Health respondents. Unfortunately, the Natality data lacks zygosity information for multiple births, rendering it impossible to provide a probability exclusively for dizygotic twins. Nevertheless, leveraging the finding of James (1975) that dizygotic twins tend to maintain sex ratios akin to singletons, I compared the probability for singletons in the Natality Data, which was 0.4872 – falling within the aforementioned 95 percent confidence interval in my sample. Consequently, the sex ratio observed in my sample aligns with the national distribution, suggesting an unbiased sample selection at least in terms of sex ratio.

[17] Although some race indicators appear to be marginally significant for males in Table 2, the joint F-test fails to reject the null hypothesis, with a p-value of 0.12.

[18] Add Health also examined the usage of other substances, which includes cocaine (including powder, freebase, or crack cocaine) and illegal drugs (such as LSD, PCP, ecstasy, mushrooms, speed, ice, heroin, or pills). Nevertheless, the prevalence of these substances is very low; only 29 respondents (2.16 percent) and 82 respondents (6.12 percent) indicated having ever tried cocaine and illegal drugs, respectively.

including substance use, Add Health interviews were conducted through audio-computer assisted self-interview (ACASI) on laptop computers: respondents wore headphones, listened to pre-recorded questions, and answered on the laptop by themselves. The questions and answers were not heard or observed by the interviewer or any other people. The ACASI method has been found to improve the quality of self-reporting of sensitive information, making it widely favored and extensively utilized in research (Turner et al., 1998; Kumar et al., 2016).

Despite the adoption of the ACASI method, self-reported measures for substance use can still be subject to measurement errors. For example, prior studies in the United States suggest that girls are more likely to accurately report their substance use compared to boys (Siddiqui et al., 1999; Shillington and Clapp, 2000; Johnson and Mott, 2001). However, it is important to note that as long as this measurement error is not systematically associated with the sex of the co-twin, any potential effects of such error would be nullified in equation (1).

My primary focus centers on high school students aged 14 to 18, encompassing Wave I and II of the Add Health dataset. This specific age range is selected for two key reasons. First, considering that siblings generally begin living separately after completing the 12th grade, individuals older than 18 years old are excluded from the sample. Second, as substance consumption tends to be positively associated with age, I exclude individuals who are too young.

The survey construction resulted in two distinct groups of respondents: those who were aged 14–18 years old in either Wave I or Wave II, and those who were aged 14–18 years old in both waves. For the former group, I analyze data from the wave that corresponds to their 14–18 age range. In the case of the latter group, I incorporate data from both waves, applying a weight of 1/2 to each observation.

Table 3 displays the summary statistics for these measures. The results indicate a significant gender disparity, with male adolescents demonstrating a higher likelihood of substance consumption compared to their female counterparts across all measures. This finding aligns with previous studies that utilized the Monitoring the Future (MTF), the National Longitudinal Survey of Youth (NLSY), and the Youth Risk Behavior Survey (YRBS) to examine adolescent behavior in the 1990s (Cook et al., 2001; Gruber and Zinman, 2001; Pacula et al., 2001).

2.4 Specification

Following the existing literature on sibling gender effects, I conduct separate analyses for males and females, taking into account the potential differential impact of sibling gender on each group. Specifically, I compare males (or females) with a twin brother to males (or females) with a twin sister by employing the following ordinary least squares (OLS) regression model:

$$Y_i = \beta_0 + \beta_1 SS_i + X_i \Gamma + e_i \tag{1}$$

where Y_i is a measure of substance use of the respondent i and SS_i is a dummy variable which is equal to 1 if the respondent i has a same-sex twin sibling. The control variables X_i include region dummies, race dummies, age, age squared, residential mother's age, residential mother's college degree status, a dummy variable for missing maternal educational attainment, residential father's college degree status, and a dummy variable for missing paternal educational attainment.[19] The results, however, remain robust even when control variables are excluded.

[19] In my analysis, I have chosen not to include family size as a control variable in the main specification. Family size has been shown to impact substance use among adolescents, indicating a potential effect through this channel. However, considering that the gender composition of older children can also influence parents' fertility decisions, family size becomes an endogenous variable in equation (1). As a result, I have decided to separately examine the family size channel in subsection 4.2. The findings from this analysis indicate that the family size channel indeed does not significantly impact my results.

Standard errors are clustered at the school level. This is because Add Health used a school-based design when sampling and because substance use can be correlated within school (Powell et al., 2005; Lundborg, 2006; Clark and Lohéac, 2007; Fletcher, 2012; Fletcher and Ross, 2018). Almost all twin pairs (92 percent) attended the same school and therefore will be in the same cluster. The results are, nonetheless, robust when standard errors are clustered at the family level instead.

Note that for each regression for males (or females), both males (or females) from a same-sex twin pair and one male (or female) from a mixed-sex twin pair are used. In principle, this would not bias the estimates as long as the inclusion into my sample is not correlated with the sex of the co-twin. In subsection 3.2, I show the results are robust even when applying a weight of 1/2 to those with a same-sex twin sibling or when using only one observation per twin pair.

3 Effects of Having a Same-Sex Co-Twin

3.1 Main Results

Figure 1 shows unadjusted substance consumption of the dizygotic twins in my sample. It reveals that males with a twin brother are more likely to be engaged in substance use than males with a twin sister. In contrast, there are no differences observed among females for any of the measures.

Table 4 presents the estimates on the effects of having a same-sex co-twin, represented by the dummy variable SS in the main specification. The results align with Figure 1. For males, having a brother is associated with a higher probability of consuming substances. For example, having a brother is associated with higher probability of smoking during the last 30 days by 9.9 percent points, drinking alcohol during the last 12 months by 15.5 percent points, and any binge drinking ($\geq$ 5 drinks per day) during the last 12 months by 7.6 percent points.These estimates indicate 30 percent to 33 percent difference compared to the means .

The coefficients for males exhibit considerably larger magnitudes than those for females.[20] These negative effects of having a male co-twin on males, with little influence observed among females, are consistent with previous literature on peer effects. Studies have shown that adolescents are more negatively influenced by brothers (compared to sisters) (Cyron et al., 2017; Golsteyn and Magnée, 2020) or male school peers (compared to female peers) (Hoxby, 2000; Clark and Lohéac, 2007; Kremer and Levy, 2008; Carrell and Hoekstra, 2010; Lavy and Schlosser, 2011; Gottfried and Graves, 2014; Lee et al., 2014; Hu, 2015; Hill, 2017; Carrell et al., 2018).

Estimates for male adolescents are economically meaningful. Comparisons with family environment literature highlight the importance of sibling gender, which is on par with other environmental factors. For example, regarding birth order, second-born boys have a 9.0 percent higher likelihood of trying smoking compared to first-born boys (Argys et al., 2006), similar to the 8.4 percent estimate in Table 4.[21] Furthermore, according to See (2016), every extra weekly hour of engaged activities with the father reduces the chance of current cigarette smoking by 2.0 percent. Translating these results, my estimates for smoking imply that spending approximately 5.0 additional weekly hours with the father would yield similar effects. In addition, drawing on Chalfin and Deza (2018), which identified that each additional year of parental education reduces child

[20] Table A3 further checks whether the coefficients for SS among males differ statistically from those among females. The results indicate statistical significance for two measures: having ever tried marijuana and drinking in the last 12 months. The remaining findings largely align with those in Table 4, whose format is more straightforward and consistent with prior studies.

[21] Comparing the estimates in Table 4 with birth order effects on alcohol and marijuana use reveals even larger magnitudes. Fifth-born (or higher) boys exhibit a 10.3 percent higher likelihood of ever drinking alcohol and a 13.4 percent higher likelihood of ever using marijuana compared to first-born boys, while the corresponding estimates in Table 4 are 12.3 percent and 16.0 percent.

binge drinking by 4.1 percent, the estimates for binge drinking are roughly equivalent to a nearly 1.8 years of parental education.

My estimates also reveal substantial impacts in magnitude when comparing them with the effects of other peer influence on substance use. For example, using classmates' parental educational attainment as an instrument variable, Powell et al. (2005) suggests that moving a high school student from a school where no children smoke to a school where 25 percent of the youths smoke increases the probability of smoking by 14.5 percent points. This implies that my estimate for smoking among male adolescents, 9.9 percent, corresponds to a 17.1 percent points increase in smoking among peers if the effects are proportional. Similarly, by exploiting the variation in alcohol consumption between classes within schools and grades, Lundborg (2006) suggests that a 10 percent point increase in classmates' binge drinking raises own binge drinking by 2.3 percent points. This translates my estimate for binge drinking among male adolescents, which is 7.6 percent points, to a 33.0 percent point increase in classmates' binge drinking. These findings underscore the influential role of co-twins (or close friends), emphasizing their strong bond compared to their classmates or school peers.

The findings presented in Table 4 reveal considerable magnitudes, even when compared to policy interventions. For instance, in terms of price, my estimates for current cigarette smoking and alcohol consumption among male adolescents are approximately equivalent to a $0.98 (1994 dollars) increase per pack of cigarettes or a $1.83 (1993 dollars) increase in the price per six-pack of alcohol, based on the results of Gruber and Zinman (2001) and Cook et al. (2001). Another example is related to an education program, where my estimate for binge drinking corresponds to approximately 40 percent of the effect observed in the intensive education program implemented in a school as studied by Botvin et al. (2001)[22], which resulted in a 57 percent reduction in binge drinking. Furthermore, when comparing my findings with the impact of community anti-smoking legislation, my estimate for having ever tried smoking is comparable to approximately 26 percent of the effect achieved through the legislation (Jason et al., 1991).

3.2 Additional Analysis

I run a series of robustness checks to confirm the reliability of the results across various specifications. Table 5 presents the estimated coefficients of the dummy variable SS in different specifications for males and females. Columns (1) and (2) provide the estimates without and with control variables, respectively, and the results are similar. Clustering the standard errors at the family level in column (3) of Table 4 shows minimal changes in the significance of the coefficients. To address over-representation of same-sex sibling pairs, column (4) further applies a weight of 1/2 to those with a same-sex twin sibling, and column (5) includes only one respondent per household. The coefficients and their significance remain similar. Additionally, column (6) examines the marginal effects using a probit model, yielding comparable results in terms of magnitude and significance.

To address the family-wise type I error associated with testing multiple hypotheses, I employ summary standardized indices that aggregate information across multiple outcome variables, enhancing statistical power (Kling et al., 2007; Anderson, 2008). The summary indices are calculated by averaging the standardized z-scores for each outcome and then re-standardizing the average. Four summary indices are used: all substances summary index (comprising all outcome variables in Table Table 4), the cigarette summary index, the marijuana summary index, and the

[22]This intervention involves instructing skills to resist alcohol and drug consumption, promoting norms discouraging such behaviors, and enhancing essential personal and social skills.

alcohol summary index. The results presented in Table A4 indicate that among males, having a same-sex co-twin is associated with higher scores of substance use in all indices, leading to an increase ranging from 0.23 to 0.28 standard deviations. However, this effect is not observed among females, except in the case of marijuana.

4 Potential Mechanisms

Several mechanisms may underlie the results in Section 3. In this section, I explore three potential mechanisms of sibling gender effects that have been suggested by prior studies: parental investment, family structure, and social interactions between siblings. More specific definitions of the variables used in this section are given in Table A5.

4.1 Parental Investment

Sibling gender may indirectly affect adolescents through differential parental treatment (Lundberg et al., 2007; Price, 2008; Mammen, 2011). I examine three categories of parental investment: time spent with children, allowance, and preventive care, following Cools and Patacchini (2019).

Columns (1) and (2) in Table 6 investigate parental time investment. The results suggest that sibling gender has little impact on parental time investment from both parents. Further analysis in Table A6 also fails to find such evidence in terms of parental warmth, which has been shown by prior studies in sociology to impact children's emotional well-being (Gray and Steinberg, 1999; Wolfradt et al., 2003) and substance use (Mak and Iacovou, 2019).

One interesting observation is that parents of mixed-sex twins do not seem to gender-specialize their parenting time. For non-twin siblings, parents of mixed-sex children are reported to allocate their time more gender-specifically compared to parents of same-sex children, resulting in women with a brother adopting more traditional gender roles (Brenøe, 2021). Although comprehensive questions related to gendered parenting in adolescence are unfortunately limited within the Add Health dataset, the findings from Table 6 and Table A6 concerning twins indicate no evidence supporting gender specialization at least in parental time investment and parenting style.

Column (3) examines the weekly allowance in dollars received by adolescents between the ages of 14 and 18. This variable is particularly relevant for adolescents who may have a limited budget for purchasing substances. However, the results indicate minimal differences in allowance by sibling gender.[23]

Columns (4) and (5) examine two preventive care measures from the previous year: whether the adolescents received a physical check-up and a dental check-up. These measures, albeit limited and confounded, may offer insights into parental concern for child health, which could also relate to their attitudes towards children's substance use. The coefficients show no evidence suggesting differences in preventive care based on sibling gender.

To summarize, Table 6 suggests little evidence on differential parental investment. Nevertheless, it is important to note that this does not rule out the possibility of unobservable differences in parental investment.

4.2 Family Structure

Another indirect pathway that the gender of a sibling can matter is through family structure. Particularly, I examine the influence of co-twin gender on the number of siblings and parental cohabitation. The analysis is performed at the household level, using one observation per household.

[23]Similarly, no significant differences are found when testing for the presence of an allowance.

In Table 7, column (1) indicates that having a twin brother does not significantly affect the number of siblings, contrasting with singleton siblings (Angrist and Evans, 1998; Dahl and Moretti, 2008). Additionally, I investigate the probability of living with both biological parents until age 5 (column (2)) and the number of marriages or marriage-like relationships of the respondent parent until the survey wave (column (3)). The results again show no evidence of differential parental marriage stability based on the sex of the co-twin, contrary to non-twin siblings (Dahl and Moretti, 2008; Blau et al., 2020).

To address concerns about sample size, I also utilize the 1990 Census Public Use Microdata Sample (PUMS)[24], which represents 5 percent of the US population from all states. Within this sample, I identify women who are likely to be mothers of twins[25] and explore their marital stability in Table A7, following the methodology of Dahl and Moretti (2008). Variables such as legal living without the father, practical living without the father, never-married status, and divorce or separation at the time of the survey are considered among mothers who had ever married, with specific definitions available in Table A5. All coefficients in Table A7 are statistically insignificant, indicating limited evidence of differential marriage stability by co-twin's sex.

In summary, family structure does not explain the effects of having a same-sex co-twin on substance consumption. However, it is worth noting that the data lacks detailed information about the relationship dynamics between the two parents, such as their level of harmony.

[24]In 1990, the Add Health respondents were at ages 6–16 and hence were likely to live with their parents.

[25]The mother sample is restricted to women who were between the ages of 18 and 40, had at least one child with the oldest being younger than 18 years old, and were living with all the children they ever reported having delivered. Twins are identified as children in a household with an age below 18 who have a sibling with the same birth year, birthplace, and age in years. The analysis excludes triplets and higher-order multiples for simplicity, but cannot distinguish monozygotic twins and dizygotic twins.

The condition of mothers living with all the children having ever delivered is essential to identify twins due to the data limitation. This condition aligns with the prevailing trend of child custody being predominantly awarded to mothers in the 1990s. However, it should be noted that this restriction excludes divorced women who awarded custody of some of their children to the father, which may limit the generalizability of the findings to divorced households.

4.3 Direct Sibling Influences

In this subsection, I explore if siblings can directly affect each other and propose two examples of such direct influences with suggestive evidence: by providing a network for access to substances or by serving as a reference point for substance consumption.

4.3.1 Sibling's Network

Direct sibling influence can occur through the utilization of each other's network for access to substances. Sibling gender may play a role in this network if brothers have more friends who use substances than sisters, and if it is easier for an adolescent to access the same-sex sibling's network compared to the different-sex sibling's network.

The prediction of this network channel is clear for males but unclear for females. For males, twin brothers' networks would have a higher number of substance users and be more easily accessible than twin sisters' networks. This suggests that twin brothers may contribute to an increase in males' substance consumption. However, for females, the twin sister's network may be easier to access but have fewer substance users compared to the twin brother's network. Hence, the overall impact on females' substance use is less clear.

Ideally, examining where or from whom adolescents obtain substances and whether these patterns differ by sibling gender would provide a more direct understanding of this dynamic. Unfortunately however, such a question is not available in Add Health. Instead, I provide suggestive evidence concerning the two elements of this channel: the higher prevalence of substance-using friends among brothers than sisters, and the ease of accessing same-sex sibling networks relative to different-sex sibling networks.

First, Table 8 indicates that female adolescents report having fewer best friends who smoke, use marijuana, or drink alcohol out of their top three best friends. Additionally, females are less likely to have male friends and are more likely to have female friends, which suggests that their friends would also have fewer substance users in their network.

Second, I provide suggestive evidence on whether adolescents would find it easier to utilize the same-sex co-twin's network than the different-sex co-twin's. The first column of Table 9 shows that for both males and females, having a same-sex co-twin is associated with a higher probability of having a friend in common.[26] Additionally, the other two columns in Table 9 suggest that twins spend more time with their co-twin and their common friends if they are the same-sex than if they are different-sex.

Next, I investigate whether the gender of the co-twin not only affects the co-twin's friend network but also *own* friend network. The first five columns in Table 10 suggest that the gender of the co-twin is related to the respondent's friend network as well. For males, having a same-sex co-twin is associated with a higher number of own best friends who smoke or drink alcohol. For females, the gender of the co-twin is not directly related to own number of substance-using best friends but is associated with the likelihood of having at least one male friend.

[26]This measure is derived from self-reported lists of five best friends, and it is coded as 1 if any common friend is reported within a twin pair; otherwise, it is coded as 0. Siblings cannot be listed as friends, and if any respondent inadvertently included their sibling as a friend, I excluded the sibling from their friend list. Unfortunately however, this measure may not be the most reliable one for studying friendships within the sample of twins, given its relatively small size; Friends attending non-sampled schools cannot be identified, leading to a substantial reduction in the sample size. Nevertheless, this measure still provides suggestive evidence regarding how accessible it would be to utilize a sibling's network.

4.3.2 Siblings as Reference Points

Another way that siblings can directly influence each other is by serving as a reference point, comparing themselves and shaping each other's preferences and behaviors (Schmitt, 1972).[27] Peter et al. (2018) propose two reasons why sibling gender matters as a reference point. First, for outcomes with a notable gender gap, brothers and sisters represent different reference points. Second, same-sex siblings serve as more salient reference points compared to different-sex siblings, in particular, if they consist of boys (Conley, 2000; Grose, 2021). This argument is also consistent with the existing literature, which reports stronger spillover effects among same-sex siblings than among different-sex siblings in various outcome variables (Eriksson et al., 2016; Joensen and Nielsen, 2018; Nicoletti and Rabe, 2019; Dahl et al., 2020; Gurantz et al., 2020; Bingley et al., 2021).

In the context of substance use, observing a sibling engaging in substance use may reduce hesitancy or feelings of guilt among adolescents.[28] The predictions align with those detailed in subsubsection 4.3.1. For males, they are less reluctant to use substances when their twin brothers do compared to when twin sisters do, and indeed, twin brothers have a higher prevalence of substance use than twin sisters. As a result, the presence of twin brothers might contribute to an increase in substance consumption among males. Conversely, for females, they are less reluctant to use substances when their twin sisters do than when their twin brothers do, but twin sisters have a lower prevalence of substance use than twin brothers. Consequently, the overall impact is less

[27] For example, studies have found that a higher income than siblings is associated with higher life satisfaction (Kuegler, 2009), educational spillovers are driven by sibling rivalry (Joensen and Nielsen, 2018), and food consumption habits may be influenced by siblings (Farrell and Shields, 2001)

[28] Conversely, adolescents might also be inclined to cease substance consumption if their siblings discontinue such behavior. However, as highlighted by Harris and López-Valcárcel (2008), social influences tend to be asymmetric. Specifically, each smoking sibling in a household is linked to a 7.6 percent increase in the probability of smoking, while each non-smoking sibling is associated with a 3.5 percent reduction in that probability.

clear for females. These predictions consistently align with both my findings in Table 4 and prior studies such as Peter et al. (2018) and Joensen and Nielsen (2018).[29]

A direct approach to assess this channel involves investigating the extent to which an adolescent compares oneself with their twin siblings, particularly concerning substance use, and whether this tendency varies based on the gender of the sibling. However, such detailed information is hardly available in a dataset. Instead, two observations can provide indicative evidence addressing the two dimensions of this channel.

First, brothers tend to be a more significant reference point for substance consumption due to the observed higher likelihood of substance use among males, not only in Table 3 but also in previous research (Cook et al., 2001; Gruber and Zinman, 2001; Pacula et al., 2001). Second, under the assumption that the amount of time spent together is associated with the saliency of the reference point, the final two columns of Table Table 9 indicate that same-sex siblings hold more influence as reference points.

5 Twins vs Non-Twins

In this section, I investigate the sibling gender effects among non-twin siblings and discuss the differences between twins and non-twins.

The Add Health dataset includes a sample of non-twin sibling pairs who, like the twin pairs, were in grades 7 through 12 during the 1994-95 school year. To create a sample of non-twin sibling pairs comparable to the sample of twin pairs, certain criteria were applied. Specifically, I ensured

[29] Peter et al. (2018) find that men earn more when they have a brother (while the effect of having a brother on earnings is small or insignificant for women) and women give birth earlier when they have a sister. They argue that these findings are driven by stronger competition between same-sex siblings and differential level of reference points by sibling gender. Joensen and Nielsen (2018) also find larger peer effects on education for brothers, supporting the notion of heightened competition between male siblings.

that the non-twin pairs were full siblings (sharing the same biological parents), resided in the same household at Wave I (similar to the twin pairs in my sample), were the closest in age among their siblings based on household rosters (as twins were), and had an age spacing more than one year.[30] The number of the non-twin full siblings in the final sample is provided in Table A8.

Recent studies on sibling gender have primarily focused on how the *younger* sibling's gender affects the *older* sibling (Peter et al., 2018; Cools and Patacchini, 2019; Golsteyn and Magnée, 2020; Brenøe, 2021). This approach aims to address selection biases stemming from parental fertility choices, assuming the younger sibling's gender to be random given the presence of a younger sibling. To obtain causal estimates which are comparable to other causal studies, I investigate the effect of the younger sibling's gender on the older sibling's substance use in Table 11.[31] The analysis uses equation (1) with the age difference between siblings as an additional control.

The findings in Table 11 reveal striking differences between twins and non-twin siblings. Among males, the coefficients for non-twin siblings, while still generally positive, exhibit substantially smaller magnitudes compared to those in Table 4 for twins. Furthermore, these coefficients fail to attain statistical significance. In contrast, for females, the coefficients for non-twin siblings are predominantly *negative* with notably larger magnitudes, contrasting with the mostly modest positive coefficients observed among twins. The result is consistent with the mechanism section in Cools and Patacchini (2019).

To understand this difference, I explore the same three channels outlined in Section 4. First,

[30]Non-twin siblings with an age difference of less than an year are excluded from the analysis. This decision is based on the understanding that pregnancies typically last around 9 months, and parents of children born within a 12-month interval may have distinct characteristics and parenting styles or preferences.

[31]The analysis of the older sibling's gender impact on the younger sibling's substance use is shown in Table A14 This may be of interest, given that in the context of substance use, older siblings are expected to exert greater influence on their younger counterparts than vice versa. However, with the selection biases from differential parental fertility choices, Table A14 reveals mostly null effects.

unlike in twins, prior research suggests that parental investment can differ by sibling gender. For instance, as indicated by Brenøe (2021), the presence of a different-sex sibling can lead to gender-specific parental investment patterns, wherein children with a different-sex sibling tend to spend more time with the same-sex parent, potentially leading to a more pronounced transmission of gender norms. Correspondingly, Table A9 provides evidence, albeit statistically insignificant, that having a same-sex sibling is associated with reduced time spent with the same-sex parent and increased time with the different-sex parent. If these parents consider substance use as masculine, then having a same-sex sibling could weakly correlate with decreased substance use among males and increased use among females, when compared to individuals with a different-sex sibling.

Second, concerning the family structure of non-twin siblings, previous research has indicated that parents often desire to have at least one son and one daughter (Angrist and Evans, 1998) or at least one son (Dahl and Moretti, 2008). Consistent to these studies, Table A10 implies that having a same-sex sibling is associated with a higher number of siblings, especially among females. Given that having more siblings has been linked to increased child substance use (Black et al., 2005; Booth and Kee, 2009), this finding suggests that adolescents with a same-sex sibling may be more prone to use substances than those with a different-sex sibling, particularly among females.[32]

Third, I examined direct sibling influence pathways—substance access networks and reference points. Among males, these pathways continue to predict the same direction but with considerably weaker effects due to lower interdependence among non-twin siblings compared to twins (Fortuna et al., 2010; Fraley and Tancredy, 2012). The analysis of common friends and sibling time for non-twin males reveals smaller means and coefficients than those in Table 9 for twin males.

[32] Regarding the respondent parent's number of marriages, the coefficients are statistically insignificant, despite the substantial magnitude observed for females. This lack of significance aligns with the findings of Lundberg and Rose (2003), which similarly reported no significant effect of child gender on the mother's remarriage probabilities when the children are born within a previous marriage.

Additionally, in Table A13, coefficients regarding substance-using friends by sibling gender for non-twin full males are mostly insignificant, unlike in Table 10 for twin males, except for the likelihood of having at least one female friend. This indicates minimal sibling gender impact on friend networks among non-twin males.

For females, the analysis in Table A12 again reveals substantially smaller means and coefficients compared to those in Table 9 for twin females. Furthermore, the coefficients related to common friends no longer achieve statistical significance. Given the substantial disparity in substance use between males and females, the lack of significance in the coefficients suggests that, among non-twins, having a brother predicts higher substance consumption among females compared to having a sister, contrary to the pattern observed among twin females.[33] This prediction aligns with the findings in Table A13, which indicate that female non-twins with a brother have a greater number of substance-using friends than female non-twins with a sister. Consequently, this is consistent with the result in Table 11 indicating that female non-twins with a brother use more substances than their counterparts with a sister.

In summary, unlike twins, the analysis involving non-twin siblings reveals that the influence of sibling gender can be neutralized through various channels. Among male non-twins, having a same-sex sibling is linked to marginally reduced substance use in the first channel and weakly increased use in the other two channels. Conversely, among female non-twins, having a same-sex sibling is associated with heightened substance use in the first two channels and reduced substance use in the last channel. These results indicate the challenges in distinguishing the divergent effects

[33] More specifically, in terms of the network pathway, non-twin females find it easy to access the sister's network as much as they do the brother's network, while there are more substance users compared to the brother's network. Similarly, in the reference point pathway, non-twin females feel a similar extent of reluctance to consume substances when their sisters do compared to when their brothers do, and indeed brothers use substances more than sisters. So in both pathways, the overall impact is now clearer than the case for twin females: non-twin females with a brother are expected to use substances more than those with a sister.

of different channels in the context of non-twin siblings, unlike the context of twins.

6 Conclusion

This study explores the effects of having a same-sex sibling on substance use during adolescence by utilizing a dataset of dizygotic twins in the United States. The twin design offers several advantages for studying the causal impact of having a same-sex sibling on substance use. First, the sex of a co-twin is, in nature, randomly assigned. Second, this approach overcomes potential selection biases stemming from parental fertility decisions influenced by older children's gender. Third, twins share birth age, timing, and environment at each stage, minimizing the sibling birth order effects and circumventing complex interactions between birth order and sibling gender effects. Lastly, since twins cannot choose each other as peers, yet they view each other as their friends, this setup enables studying substance consumption among "friends" without being influenced by selection biases.

Among males, I observe that having a twin brother increases the probability of smoking, drinking alcohol, and using marijuana. In contrast, among females, there is no significant difference in substance use between those with twin brothers and those with twin sisters. An examination of potential mechanisms indicates that these findings align with direct sibling interactions and are hardly driven by parental investment and family structure. I further propose two examples of how siblings directly influence each other: by sharing a network for substance access and by serving as a reference point for substance use.

The magnitudes of the estimates, especially for male adolescents, are sizable. The comparison with the estimates in the prior studies suggests that siblings are one of the most influential factors in adolescent substance use. The results underscore the crucial role of siblings and influential peers in shaping substance-related beliefs and consumption behaviors.

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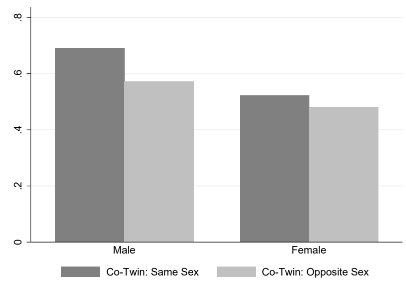
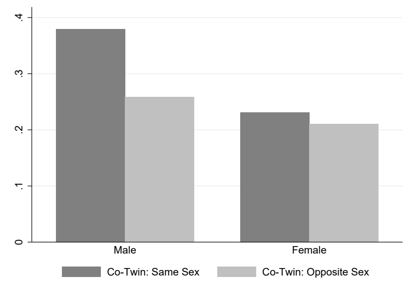
Figures and Tables

Figure 1. Substance Use by Sibling Gender Composition Among Dizygotic Twins

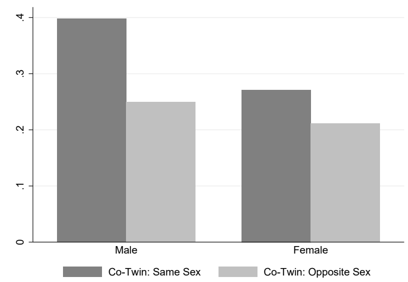
(a) Ever tried smoking



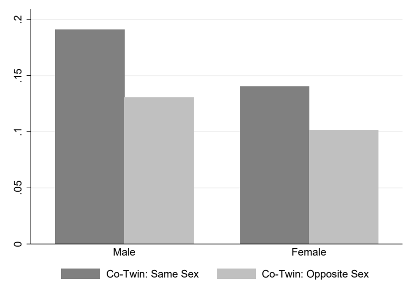
(b) Smoked during the last 30 days



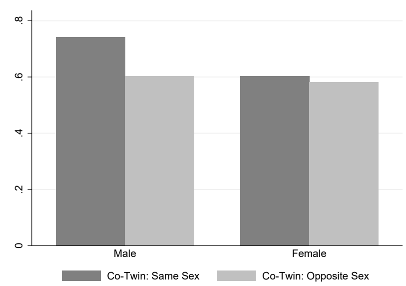
(c) Ever tried marijuana



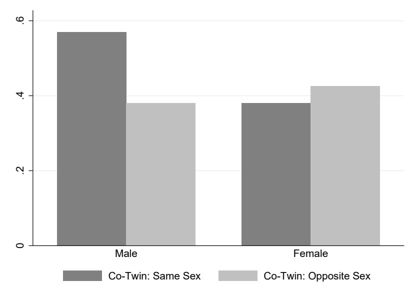
(d) Used marijuana in the last 30 days



(e) Ever tried alcohol



(f) Drunk during the last 12 months



(g) Any binge drinking during the last 12 months

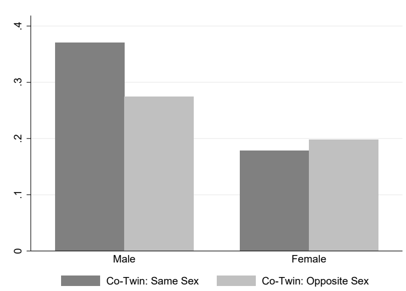


Table 1. Number of Dizygotic Twin Respondents

	Male	Female	**Total**
Having a different-sex twin	180	180	360
Having a same-sex twin	240	208	448
Total	420	388	808

Notes: The twin sample consists of all respondents who were identified as dizygotic twins by Add Health and reported each other in their household roster at Wave I.

Table 2. Randomness of the Sex of the Co-Twin

Variables	Male			Female		
	(1) Same Sex	(2) Different Sex	(3) (1)-(2)	(4) Same Sex	(5) Different Sex	(6) (4)-(5)
Age in years	16.558	16.461	0.096	16.325	16.463	-0.137
			(0.156)			(0.172)
Race:						
Black	0.200	0.294	-0.094**	0.327	0.296	0.031
			(0.045)			(0.057)
Hispanic	0.125	0.122	0.003	0.106	0.123	-0.017
			(0.039)			(0.039)
Others	0.675	0.583	0.092*	0.567	0.581	-0.014
			(0.051)			(0.060)
Region:						
West	0.260	0.205	0.055	0.185	0.206	-0.021
			(0.046)			(0.051)
Midwest	0.166	0.193	-0.027	0.283	0.200	0.083
			(0.042)			(0.066)
South	0.444	0.494	-0.050	0.387	0.487	-0.100
			(0.058)			(0.070)
Northeast	0.130	0.108	0.022	0.145	0.106	0.038
			(0.039)			(0.042)
Residential mother's age	42.960	42.488	0.471	41.980	42.509	-0.529
			(0.673)			(0.685)
Residential mother: college degree or more	0.283	0.267	0.017	0.221	0.251	-0.030
			(0.051)			(0.051)
Residential father's age	45.659	45.322	0.337	44.492	45.240	-0.747
			(1.148)			(0.978)
Residential father: college degree or more	0.317	0.272	0.044	0.202	0.263	-0.061
			(0.050)			(0.049)

	Male			Female		
Variables	(1) Same Sex	(2) Different Sex	(3) (1)-(2)	(4) Same Sex	(5) Different Sex	(6) (4)-(5)
Household income (unit: $1,000)	43.622	46.489	-2.868	45.617	43.640	1.977
			(4.995)			(4.564)
Urbanicity:						
Urban	0.339	0.368	-0.029	0.344	0.367	-0.023
			(0.056)			(0.067)
Suburban	0.575	0.534	0.041	0.574	0.538	0.036
			(0.057)			(0.069)
Rural	0.086	0.098	-0.012	0.082	0.095	-0.013
			(0.030)			(0.036)
School not selected from the sampling frame	0.029	0.033	-0.004	0.063	0.056	0.007
			(0.005)			(0.010)
School size:						
Small (1-400 students)	0.069	0.075	-0.006	0.067	0.071	-0.004
			(0.030)			(0.032)
Medium (401-1000 students)	0.403	0.437	-0.033	0.405	0.450	-0.045
			(0.055)			(0.067)
Large (1001-4000 students)	0.528	0.489	0.039	0.528	0.479	0.049
			(0.057)			(0.069)
Percentage of White students in the school	80.924	78.114	2.811	79.128	78.006	1.122
			(2.193)			(3.797)
Average class size in the school	26.911	26.790	0.121	27.078	26.722	0.356
			(0.534)			(0.701)
N	393	298	691	365	294	659

Notes: This table shows descriptive statistics for dizygotic twins by sex composition and t-tests of differences in means by sex composition (columns (3) and (6)). Clustered standard errors are in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3. Summary Statistics of Substance Use Among Dizygotic Twins

	Male	Female	Male-Female
Variables	mean (sd)	mean (sd)	diff (se)
Cigarette			
Ever tried smoking	0.641	0.503	0.137***
	(0.274)	(0.314)	(0.037)
Smoked during the last 30 days	0.328	0.221	0.107***
	(0.249)	(0.225)	(0.030)
Marijuana			
Ever tried marijuana	0.335	0.244	0.091***
	(0.230)	(0.258)	(0.030)
Used marijuana during the last 30 days	0.165	0.123	0.043*
	(0.177)	(0.201)	(0.024)
Alcohol			
Ever tried alcohol	0.683	0.594	0.089**
	(0.299)	(0.339)	(0.040)
Drunk during the last 12 months	0.490	0.401	0.089**
	(0.294)	(0.276)	(0.034)
Any binge drinking during the last 12 months	0.330	0.187	0.142***
	(0.274)	(0.217)	(0.031)
N	686	656	1342

Notes: This table shows descriptive statistics for dizygotic twins by gender and t-tests of differences in means by gender (columns (3)). Means are weighted by the reciprocal of the observation count for each respondent. Standard errors clustered at the school level are indicated within parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4. Effects of Having a Same-Sex Co-Twin on Substance Use During Adolescence

	Cigarette		Marijuana	
	Ever Tried Smoking	Smoked During the Last 30 Days	Ever Tried Marijuana	Used Marijuana During the Last 30 Days
Panel 1: Male				
SS	0.084*	0.099**	0.160***	0.055
	(0.046)	(0.041)	(0.047)	(0.037)
Mean	0.641	0.328	0.335	0.165
N	644	636	625	634
Panel 2: Female				
SS	0.048	0.028	0.062	0.048*
	(0.052)	(0.045)	(0.044)	(0.027)
Mean	0.503	0.221	0.244	0.123
N	625	623	607	616

	Alcohol		
	Ever Tried Alcohol	Drunk During the Last 12 Months	Any Binge Drinking During the Last 12 Months
Panel 1: Male			
SS	0.123**	0.155***	0.076*
	(0.050)	(0.043)	(0.040)
Mean	0.683	0.490	0.330
N	644	641	639
Panel 2: Female			
SS	0.052	-0.016	-0.011
	(0.066)	(0.050)	(0.040)
Mean	0.594	0.401	0.187
N	628	624	623

Notes: Each cell represents a separate regression of the corresponding measure of substance use among dizygotic twins. Mean represents the sample average of the corresponding measure for the corresponding sex, which is also reported in Table 3. Controls include region dummies, race dummies, age and age squared variables, residential mothers' age, residential mother's college degree (dummy), missing maternal educational attainment (dummy), residential father's college degree (dummy), and missing paternal educational attainment (dummy). Estimates are weighted by the reciprocal of the observation count for each respondent. Standard errors clustered at the school level are indicated within parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5. Robustness to Alternative Specifications

	Male					
	(1)	(2)	(3)	(4)	(5)	(6)
Cigarette						
Ever tried smoking						
SS	0.119**	0.084*	0.084*	0.086*	0.101**	0.082*
	(0.046)	(0.046)	(0.050)	(0.047)	(0.049)	(0.044)
N	687	644	644	644	463	642
Smoked during the last 30 days						
SS	0.122***	0.099**	0.099**	0.102**	0.133***	0.094**
	(0.041)	(0.041)	(0.045)	(0.041)	(0.046)	(0.039)
N	679	636	636	636	460	634
Marijuana						
Ever tried marijuana						
SS	0.149***	0.160***	0.160***	0.163***	0.181***	0.164***
	(0.050)	(0.047)	(0.047)	(0.046)	(0.053)	(0.045)
N	664	625	625	625	456	623
Used marijuana during the last 30 days						
SS	0.060	0.055	0.055	0.054	0.055	0.054
	(0.038)	(0.037)	(0.035)	(0.036)	(0.039)	(0.037)
N	673	634	634	634	457	611
Alcohol						
Ever tried alcohol						
SS	0.138**	0.123**	0.123**	0.117**	0.131*	0.110***
	(0.054)	(0.050)	(0.057)	(0.049)	(0.070)	(0.043)
N	688	644	644	644	462	642
Drunk during the last 12 months						
SS	0.189***	0.155***	0.155***	0.154***	0.162***	0.152***
	(0.044)	(0.043)	(0.044)	(0.043)	(0.050)	(0.040)
N	683	641	641	641	459	641
Any binge drinking during the last 12 months						
SS	0.096**	0.076*	0.076*	0.077*	0.087**	0.075*
	(0.040)	(0.040)	(0.045)	(0.040)	(0.042)	(0.038)
N	681	639	639	639	458	639
Controls	**No**	Yes	Yes	Yes	Yes	Yes
Cluster	School	School	**Family**	School	School	School
SS Sample	All / H	All / H	All / H	**1/2 Wt**	**1 Obs / H**	All / H
Specification	Linear	Linear	Linear	Linear	Linear	**Probit**

	Female					
	(1)	(2)	(3)	(4)	(5)	(6)
Cigarette						
Ever tried smoking						
SS	0.042	0.048	0.048	0.053	0.047	0.039
	(0.055)	(0.052)	(0.056)	(0.053)	(0.059)	(0.053)
N	656	625	625	625	454	610
Smoked during the last 30 days						
SS	0.021	0.028	0.028	0.034	0.019	0.034
	(0.047)	(0.045)	(0.042)	(0.044)	(0.046)	(0.044)
N	654	623	623	623	453	618
Marijuana						
Ever tried marijuana						
SS	0.060	0.062	0.062	0.063	0.077	0.059
	(0.044)	(0.044)	(0.047)	(0.044)	(0.052)	(0.042)
N	636	607	607	607	443	602
Used marijuana during the last 30 days						
SS	0.039	0.048*	0.048	0.050*	0.032	0.042
	(0.027)	(0.027)	(0.031)	(0.028)	(0.030)	(0.027)
N	644	616	616	616	448	611
Alcohol						
Ever tried alcohol						
SS	0.022	0.052	0.052	0.063	0.041	0.014
	(0.070)	(0.066)	(0.072)	(0.068)	(0.083)	(0.049)
N	659	628	628	628	456	623
Drunk during the last 12 months						
SS	-0.046	-0.016	-0.016	-0.008	-0.034	-0.016
	(0.052)	(0.050)	(0.047)	(0.050)	(0.053)	(0.049)
N	655	624	624	624	453	619
Any binge drinking during the last 12 months						
SS	-0.020	-0.011	-0.011	-0.008	-0.012	-0.007
	(0.043)	(0.040)	(0.036)	(0.040)	(0.043)	(0.040)
N	654	623	623	623	453	618
Controls	**No**	Yes	Yes	Yes	Yes	Yes
Cluster	School	School	**Family**	School	School	School
SS Sample	All / H	All / H	All / H	**1/2 Wt**	**1 Obs / H**	All / H
Specification	Linear	Linear	Linear	Linear	Linear	**Probit**

Notes: Each cell represents a separate regression of the corresponding measure of substance use among dizygotic twins. Controls include region dummies, race dummies, age and age squared variables, residential mothers' age, residential mother's college degree (dummy), missing maternal educational attainment (dummy), residential father's college degree (dummy), and missing paternal educational attainment (dummy). Estimates are weighted by the reciprocal of the observation count for each respondent.(In column (4), the model additionally weights those with a same-sex twin sibling by multiplying the weight by 1/2.) Clustered standard errors are in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6. Exploring the Channel of Parental Investment

	Time		Allowance	Preventive Care	
	Activities With Father	Activities With Mother	Weekly Amount	Physical Check-up	Dental Check-up
Panel 1: Male					
SS	0.227	-0.111	0.831	0.017	-0.013
	(0.211)	(0.180)	(0.862)	(0.051)	(0.052)
Mean	2.804	3.457	5.755	0.683	0.617
N	468	637	644	642	646
Panel 2: Female					
SS	0.220	0.161	1.552	-0.019	-0.019
	(0.198)	(0.192)	(1.243)	(0.053)	(0.052)
Mean	2.426	4.010	6.005	0.695	0.652
N	417	618	627	620	619

Notes: Each cell represents a separate regression among dizygotic twins. Mean represents the sample average of the corresponding measure for the corresponding sex. Controls include region dummies, race dummies, age and age squared variables, residential mothers' age, residential mother's college degree (dummy), missing maternal educational attainment (dummy), residential father's college degree (dummy), and missing paternal educational attainment (dummy). Estimates are weighted by the reciprocal of the observation count for each respondent. Standard errors clustered at the school level are indicated within parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7. Exploring the Channel of Family Structure

	Number of Siblings	Living With Both Biological Parents at Age 5	Respondent Parent's Number of Marriages
Panel 1: Male			
SS	-0.048	-0.003	0.104
	(0.131)	(0.043)	(0.077)
Mean	2.130	0.770	1.184
N	283	283	253
Panel 2: Female			
SS	-0.122	-0.022	0.012
	(0.135)	(0.044)	(0.087)
Mean	2.138	0.767	1.154
N	271	271	237

Notes: Each cell represents a separate regression among dizygotic twins. The analysis is performed at the household level, using only one observation per household. Mean represents the sample average of the corresponding measure for the corresponding sex. Controls include region dummies, race dummies, age and age squared variables, residential mothers' age, residential mother's college degree (dummy), missing maternal educational attainment (dummy), residential father's college degree (dummy), and missing paternal educational attainment (dummy). Estimates are weighted by the reciprocal of the observation count for each respondent. Standard errors clustered at the school level are indicated within parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ Clustered standard errors are in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8. Exploring the Channel of the Peer Network: Substance-Using Friends by Sex

	Among the Three Best Friends, Number of Those Who			Having at Least One	
	Smoke	Use Marijuana	Drink Alcohol	Male Friend	Female Friend
Female	-0.268***	-0.179***	-0.229***	-0.119***	0.127***
	(0.071)	(0.068)	(0.078)	(0.017)	(0.018)
Mean	0.838	0.706	1.108	0.918	0.916
N	1251	1252	1250	1273	1273

Notes: Each cell represents a separate regression among dizygotic twins. Mean represents the sample average of the corresponding measure among all respondents. Controls include region dummies, race dummies, age and age squared variables, residential mothers' age, residential mother's college degree (dummy), missing maternal educational attainment (dummy), residential father's college degree (dummy), and missing paternal educational attainment (dummy). Estimates are weighted by the reciprocal of the observation count for each respondent. Standard errors clustered at the school level are indicated within parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9. Exploring the Channel of the Peer Network: Common Friends and Time Spent Together by Co-Twin's Sex

	Whether Having at Least One	Whether Spending a Lot of Time with	
	Common Friend Outside of the Family	Co-Twin	Co-Twin and Common Friends
Panel 1: Male			
SS	0.219**	0.220***	0.257***
	(0.092)	(0.043)	(0.041)
Mean	0.515	0.465	0.323
N	221	601	600
Panel 2: Female			
SS	0.455***	0.241***	0.268***
	(0.087)	(0.042)	(0.048)
Mean	0.556	0.585	0.376
N	203	583	583

Notes: Each cell represents a separate regression among dizygotic twins. Mean represents the sample average of the corresponding measure for the corresponding sex. Controls include region dummies, race dummies, age and age squared variables, residential mothers' age, residential mother's college degree (dummy), missing maternal educational attainment (dummy), residential father's college degree (dummy), and missing paternal educational attainment (dummy). Estimates are weighted by the reciprocal of the observation count for each respondent. Standard errors clustered at the school level are indicated within parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10. Exploring the Channel of the Peer Network: Substance-Using Friends by Co-twin's Sex

	Among the Three Best Friends, Number of Those Who			Having at Least One	
	Smoke	Use Marijuana	Drink Alcohol	Male Friend	Female Friend
Panel 1: Male					
SS	0.169*	0.144	0.179*	0.012	0.025
	(0.093)	(0.094)	(0.108)	(0.012)	(0.032)
Mean	0.959	0.780	1.224	0.972	0.857
N	633	634	635	646	646
Panel 2: Female					
SS	0.101	0.046	0.102	-0.060**	-0.010
	(0.105)	(0.093)	(0.105)	(0.027)	(0.012)
Mean	0.706	0.625	0.979	0.860	0.980
N	618	618	615	627	627

Notes: Each cell represents a separate regression among dizygotic twins. Mean represents the sample average of the corresponding measure for the corresponding sex. Controls include region dummies, race dummies, age and age squared variables, residential mothers' age, residential mother's college degree (dummy), missing maternal educational attainment (dummy), residential father's college degree (dummy), and missing paternal educational attainment (dummy). Estimates are weighted by the reciprocal of the observation count for each respondent. Standard errors clustered at the school level are indicated within parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11. Effects of Younger Sibling's Gender on Older Sibling's Substance Use

	Cigarette		Marijuana	
	Ever Tried Smoking	Smoked During the Last 30 Days	Ever Tried Marijuana	Used Marijuana During the Last 30 Days
Panel 1: Male				
SS	-0.007	-0.075	0.069	0.002
	(0.079)	(0.054)	(0.055)	(0.037)
Mean	0.616	0.319	0.359	0.192
N	383	383	376	382
Panel 2: Female				
SS	0.052	-0.067	-0.124**	-0.036
	(0.066)	(0.056)	(0.053)	(0.036)
Mean	0.568	0.291	0.258	0.122
N	390	391	382	390

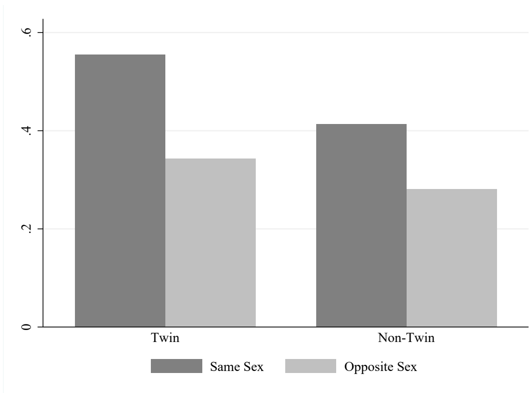
	Alcohol		
	Ever Tried Alcohol	Drunk During the Last 12 Months	Any Binge Drinking Days
Panel 1: Male			
SS	0.088	0.038	0.005
	(0.080)	(0.052)	(0.062)
Mean	0.681	0.529	0.373
N	388	386	384
Panel 2: Female			
SS	-0.018	-0.083	-0.072
	(0.075)	(0.070)	(0.047)
Mean	0.675	0.549	0.285
N	391	391	390

Notes: Each cell represents a separate regression among non-twin full siblings. Mean represents the sample average of the corresponding measure for the corresponding sex. Controls include region dummies, race dummies, age and age squared variables, residential mothers' age, residential mother's college degree (dummy), missing maternal educational attainment (dummy), residential father's college degree (dummy), and missing paternal educational attainment (dummy). Estimates are weighted by the reciprocal of the observation count for each respondent. Standard errors clustered at the school level are indicated within parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

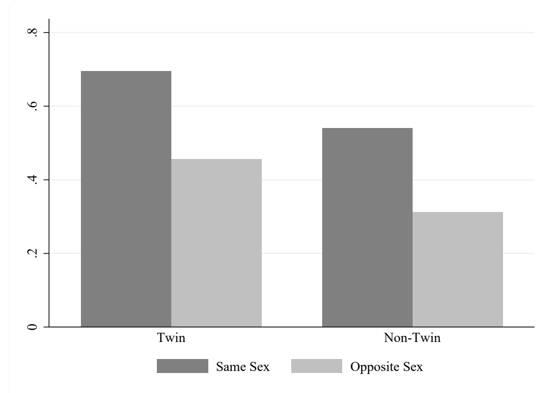
Figure A1. Time Spent with Sibling by Sibling Type

Panel 1: Whether you spend a lot of time with your sibling

(a) Males

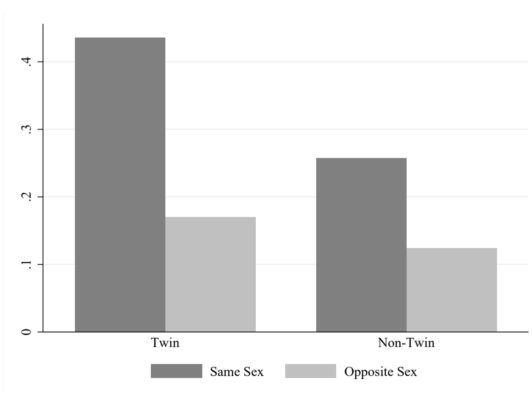


(b) Females



Panel 2: Whether you spend a lot of time with your sibling and common friends

(a) Males



(b) Females

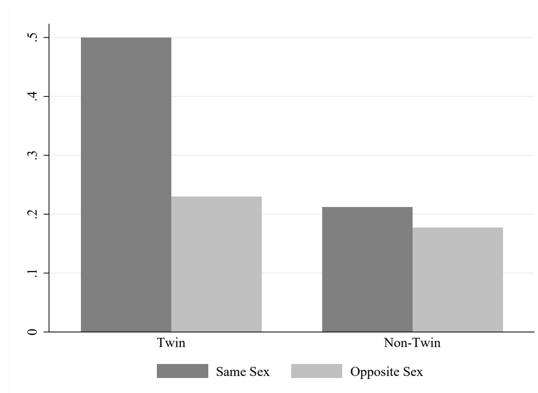


Table A1. Correlation in Substance Use Among Same-Sex Twins

	Males		Females	
	MZ	DZ	MZ	DZ
Cigarette				
Ever tried smoking				
Correlation	0.518***	0.324***	0.600***	0.452***
	(0.077)	(0.105)	(0.080)	(0.084)
N	211	193	217	181
Smoked during the last 30 days				
Correlation	0.585***	0.290***	0.525***	0.372***
	(0.062)	(0.080)	(0.090)	(0.090)
N	209	185	213	180
Marijuana				
Ever tried marijuana during your life				
Correlation	0.523***	0.275***	0.591***	0.380***
	(0.090)	(0.080)	(0.080)	(0.092)
N	202	177	209	169
Used marijuana during the last 30 days				
Correlation	0.614***	0.288***	0.287**	0.253***
	(0.095)	(0.090)	(0.133)	(0.094)
N	208	182	213	174
Alcohol				
Ever tried drinking alcohol				
Correlation	0.373***	0.065	0.480***	0.729***
	(0.084)	(0.150)	(0.066)	(0.143)
N	211	192	218	182
Drunk during the last 12 months				
Correlation	0.422***	0.215***	0.532***	0.278***
	(0.079)	(0.074)	(0.065)	(0.080)
N	208	191	218	181
Any binge drinking during the last 12 months				
Correlation	0.538***	0.366***	0.521***	0.219**
	(0.087)	(0.070)	(0.089)	(0.100)
N	208	190	216	180

Notes: Each model is estimated among twins with a same-sex twin sibling. MZ and DZ represent monozygotic and dizygotic twins. Coefficients are unadjusted correlation coefficients for the corresponding measure of substance use. Estimates are weighted by the reciprocal of the observation count for each respondent. Standard errors clustered at the school level are indicated within parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A2. Monozygotic Twins vs Dizygotic Twins with a Same-Sex Sibling

	Cigarette		Marijuana	
	Ever Tried Smoking	Smoked During the Last 30 Days	Ever Tried Marijuana	Used Marijuana During the Last 30 Days
Panel 1: Male				
MZ	-0.061	-0.090**	-0.108**	-0.044
	(0.050)	(0.037)	(0.050)	(0.036)
Mean	0.638	0.318	0.345	0.172
N	792	782	770	782
Panel 2: Female				
MZ	0.102*	0.054	-0.005	-0.012
	(0.058)	(0.044)	(0.044)	(0.032)
Mean	0.554	0.249	0.250	0.127
N	801	797	778	789

	Alcohol		
	Ever Tried Alcohol	Drunk During the Last 12 Months	Any Binge Drinking During the Last 12 Months
Panel 1: Male			
MZ	-0.171***	-0.167***	-0.104***
	(0.049)	(0.040)	(0.038)
Mean	0.656	0.471	0.304
N	791	790	788
Panel 2: Female			
MZ	-0.019	0.037	0.022
	(0.063)	(0.048)	(0.041)
Mean	0.586	0.411	0.206
N	804	802	799

Notes: Each model is estimated among all twins with a same-sex twin sibling. MZ is a dummy variable for respondent i being a monozygotic twin. Controls include region dummies, race dummies, age and age squared variables, residential mothers' age, residential mother's college degree (dummy), missing maternal educational attainment (dummy), residential father's college degree (dummy), and missing paternal educational attainment (dummy). Estimates are weighted by the reciprocal of the observation count for each respondent. Standard errors clustered at the school level are indicated within parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A3. Comparing the Effects of Having a Same-Sex Sibling between Males and Females

	Smoking		Using Drug	
	Ever Tried Smoking	Smoked During the Last 30 Days	Ever Tried Marijuana	Used Marijuana During the Last 30 Days
Coefficients				
SS	0.046	0.031	0.059	0.040
	(0.052)	(0.046)	(0.044)	(0.026)
Male	0.109**	0.060*	0.055	0.033
	(0.049)	(0.034)	(0.038)	(0.026)
SS × Male	0.052	0.071	0.098*	0.013
	(0.067)	(0.062)	(0.059)	(0.039)
Total Effects				
$D_{Male}(=\beta_{SS}+\beta_{SS\times Male})$	0.098**	0.102**	0.157***	0.053
	(0.048)	(0.041)	(0.047)	(0.036)
$D_{Female}(=\beta_{SS})$	0.046	0.031	0.059	0.040
	(0.052)	(0.046)	(0.044)	(0.026)
$DD(=\beta_{SS\times Male})$	0.052	0.071	0.098*	0.013
	(0.067)	(0.062)	(0.059)	(0.039)
	1269	1259	1232	1250

	Drinking Alcohol		
	Ever Tried Alcohol	Drunk During the Last 12 Months	Any Binge Drinking Days
Coefficients			
SS	0.056	-0.012	-0.008
	(0.070)	(0.051)	(0.041)
Male	0.026	-0.040	0.082**
	(0.056)	(0.036)	(0.041)
SS × Male	0.072	0.178***	0.093
	(0.080)	(0.061)	(0.057)
Total Effects			
$D_{Male}(= \beta_{SS} + \beta_{SS \times Male})$	0.128**	0.166***	0.085**
	(0.053)	(0.044)	(0.038)
$D_{Female}(= \beta_{SS})$	0.056	-0.012	-0.008
	(0.070)	(0.051)	(0.041)
$DD(= \beta_{SS \times Male})$	0.072	0.178***	0.093
	(0.080)	(0.061)	(0.057)
	1272	1265	1262

Notes: Each model is estimated among all dizygotic twins. SS is a dummy variable for respondent i having a same-sex twin, $Male$ is a dummy variable for respondent i being male, and $SS \times Male$ is their interaction. Controls include region dummies, race dummies, age and age squared variables, residential mothers' age, residential mother's college degree (dummy), missing maternal educational attainment (dummy), residential father's college degree (dummy), and missing paternal educational attainment (dummy). Estimates are weighted by the reciprocal of the observation count for each respondent. Standard errors clustered at the school level are indicated within parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A4. Effects of Having a Same-Sex Co-Twin Using Summary Indices

	All	By Substance		
	All	Cigarette	Marijuana	Alcohol
Panel 1: Male				
SS	0.273***	0.230**	0.285***	0.234***
	(0.076)	(0.091)	(0.105)	(0.085)
N	646	644	635	646
Panel 2: Female				
SS	0.157	0.090	0.149*	0.045
	(0.117)	(0.101)	(0.086)	(0.110)
N	628	625	616	628

Notes: Each cell represents a separate regression among dizygotic twins. Summary indices are derived by averaging the standardized z-scores for each outcome and then re-standardizing the average. These summary indices encompass the all substances summary index (comprising all outcome variables in Table Table 4), the cigarette summary index, the marijuana summary index, and the alcohol summary index. Controls include region dummies, race dummies, age and age squared variables, residential mothers' age, residential mother's college degree (dummy), missing maternal educational attainment (dummy), residential father's college degree (dummy), and missing paternal educational attainment (dummy). Estimates are weighted by the reciprocal of the observation count for each respondent. Standard errors clustered at the school level are indicated within parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A5. Description of Mechanism Variables

Variable	Data and Definition
Table 6	
Activities with father	Number of activities that a respondent had with his/her father in the past 4 weeks, ranging from 0 to 10 (going shopping; playing a sport; going to a religious service or church-related event; talking about someone the respondent is dating or a party the respondent went to; going to a movie, play, museum, or concert, or sports event; talking about a personal problem the respondent was having; having a serious argument about the behavior of the respondent; talking about the respondent's school work or grades; working on a project for school; talking about other things the respondent is doing in school)
Activities with mother	Number of activities that a respondent had with his/her mother in the past 4 weeks, ranging from 0 to 10, as the variable of activities with father does
Weekly allowance	The amount of weekly allownace the respondent receives from parents
Physical examination	Dummy variable for whether the respondent had a physical examination by a doctor or nurse within a year
Dental examination	Dummy variable for whether the respondent had a dental examination by a dentist or hygienist within a year
Table 7	
Number of siblings	Number of siblings of the respondent in the household
Living with both biological parents until age 5	Dummy variable for whether the respondent lives with both biological parents in the same household until age 5
Respondent parent's number of marriages	Number of marriages or marriage-like relationships that the respondent parent has ever had
Table 8	
Number of best friends who smoke	Of the three best friends of the respondent, the number of friends who smoke at least 1 cigarette a day

Variable	Data and Definition
Number of best friends who drink alcohol	Of the three best friends of the respondent, the number of friends who drink alcohol at least once a month
Number of best friends who use marijuana	Of the three best friends of the respondent, the number of friends who use marijuana at least once a month
Having at least one male friend	Dummy variable indicating if the respondent reports at least one male friend in the list of friends
Having at least one female friend	Dummy variable indicating if the respondent reports at least one female friend in the list of friends
Table 9	
Having a common friend	Dummy variable indicating if the list of the friends reported by the respondent overlaps with the one by the respondent's co-twin
Spending a lot of time with sibling	Dummy variable for whether the respondent chose the answer 'a lot' to the question "How much time do you and {Sibling} spend together?" among the choices 'a lot', 'some', 'little', and 'none'
Spending a lot of time with sibling and common friends	Dummy variable for whether the respondent chose the answer 'a lot' to the question "How much time do you and {Sibling} spend with the same friend or group of friends?" among the choices 'a lot', 'some', 'little', and 'none'
Table A6	
Paternal warmth	Standardized sum of the answers from the following five questions which use 5-point Likert scale: "How close do you feel to your father?", "How much do you think he cares about you?", "Do you agree or disagree with the following statement? You are satisfied with the way your father and you communicate with each other.", "Do you agree or disagree with the following statement? Overall, you are satisfied with your relationship with your father.", and "Do you agree or disagree with the following statement? Most of

Variable	Data and Definition
	the time, your father is warm and loving toward you." Larger value implies that the father is reported to be warmer.
Maternal warmth	Standardized sum of the answers from the same five questions as the maternal warmth which use 5-point Likert scale and correspond to mother. Larger value implies that the mother is reported to be warmer.
Table A7	
Legally living without a father	Dummy variable indicating if the twin children legally live without a father at the time of the survey (i.e., the marital status of the mother is divorced, widowed, or never married)
Practically living without a father	Dummy variable indicating if the twin children practically live without a father at the time of the survey (i.e., the mother reports spouse absent, separated, divorced, widowed, or never married)
Mother never married	Dummy variable indicating if the mother has never married at the time of the survey
Current divorce or separation	Dummy variable indicating if the current marital status of the mother is divorced or separated at the time of the survey

Table A6. Exploring the Channel of Differential Parenting Style

	Warmth	
	Paternal Warmth	Maternal Warmth
Panel 1: Male		
SS	-0.039	0.027
	(0.063)	(0.059)
Mean	-0.035	0.055
N	646	646
Panel 2: Female		
SS	0.061	-0.051
	(0.063)	(0.068)
Mean	-0.221	-0.025
N	628	628

Notes: Each cell represents a separate regression among dizygotic twins. Mean represents the sample average of the corresponding measure for the corresponding sex. Controls include region dummies, race dummies, age and age squared variables, residential mothers' age, residential mother's college degree (dummy), missing maternal educational attainment (dummy), residential father's college degree (dummy), and missing paternal educational attainment (dummy). Estimates are weighted by the reciprocal of the observation count for each respondent. Standard errors clustered at the school level are indicated within parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A7. Exploring the Channel of Family Structure in the 1990 Census

	Legally Living Without Father	Practically Living Without Father	Mother Never Married	Mother Currently Divorced or Separated
Panel 1: Male				
SS	-0.003	-0.008	-0.000	-0.005
	(0.006)	(0.006)	(0.004)	(0.006)
Mean	0.162	0.208	0.078	0.128
N	13,133	13,133	13,133	12,107
Panel 2: Female				
SS	-0.005	-0.005	0.004	-0.009
	(0.006)	(0.006)	(0.004)	(0.006)
Mean	0.163	0.213	0.082	0.126
N	13,016	13,016	13,016	11,954

Notes: Each cell represents a separate regression among women in the 1990 Census data, aged 18 to 40, with at least one child (the oldest being younger than 18 years old), living with all the children they ever reported having delivered, and having two children with the same birth year, birthplace, and age in years. Outcome variables are defined as described in Table A5. All models in this table include controls for region dummies, race dummies, child's age and age squared variables, maternal age, mother's college degree (dummy), missing maternal educational attainment (dummy), and family income. Standard errors are in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A8. Number of Non-Twin Full Siblings

	Male	Female	**Total**
Having a different-sex sibling	213	213	426
Having a same-sex sibling	308	310	618
Total	521	523	1,044

Notes: The sample of non-twin full siblings consists of all respondents identified by Add Health to have a non-twin full sibling who was also in grades 7-12 during the 1994-95 school year and agreed to be a respondent of the Add Health survey. Then, as I did for the sample of twins, I require that each individual should report his/her sibling in the household roster at Wave I, that the sibling is his/her closest sibling in terms of age, and that the age difference with the sibling is larger than one year.

Table A9. Effects of Younger Sibling's Gender on Parental Investment in Older Siblings

	Time		Allowance	Preventive Care	
	Activities With Father	Activities With Mother	Weekly Amount	Physical Check-up	Dental Check-up
Panel 1: Male					
SS	-0.161	0.146	-1.321	0.019	0.020
	(0.266)	(0.222)	(0.984)	(0.060)	(0.059)
Mean	3.060	3.663	5.262	0.678	0.698
N	323	384	387	386	388
Panel 2: Female					
SS	0.230	-0.078	-1.335	-0.039	-0.088
	(0.264)	(0.241)	(0.989)	(0.063)	(0.063)
Mean	3.208	4.624	5.313	0.717	0.709
N	285	380	388	393	393

Notes: Each cell represents a separate regression among non-twin full siblings. Mean represents the sample average of the corresponding measure for the corresponding sex. Controls include region dummies, race dummies, age and age squared variables, residential mothers' age, residential mother's college degree (dummy), missing maternal educational attainment (dummy), residential father's college degree (dummy), missing paternal educational attainment (dummy), and the age difference between the siblings. Estimates are weighted by the reciprocal of the observation count for each respondent. Standard errors clustered at the school level are indicated within parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A10. Effects of Younger Sibling's Gender on Family Structure

	Number of Siblings	Living With Both Biological Parents at Age 5	Respondent Parent's Number of Marriages
Panel 1: Male			
SS	0.155	-0.004	0.053
	(0.193)	(0.048)	(0.155)
Mean	1.731	0.883	1.241
N	137	137	125
Panel 2: Female			
SS	0.398**	0.019	-0.158
	(0.176)	(0.039)	(0.134)
Mean	1.790	0.891	1.294
N	134	134	117

Notes: Each cell represents a separate regression among non-twin full siblings. The analysis is performed at the household level, using only one observation per household. Mean represents the sample average of the corresponding measure for the corresponding sex. Controls include region dummies, race dummies, age and age squared variables, residential mothers' age, residential mother's college degree (dummy), missing maternal educational attainment (dummy), residential father's college degree (dummy), missing paternal educational attainment (dummy), and the age difference between the siblings. Estimates are weighted by the reciprocal of the observation count for each respondent. Standard errors clustered at the school level are indicated within parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ Clustered standard errors are in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A11. Substance-Using Friends by Sex Among Older Siblings

	Among the Three Best Friends, Number of Those Who			Having at Least One	
	Smoke	Use Marijuana	Drink Alcohol	Male Friend	Female Friend
Female	-0.124	-0.282***	-0.132	-0.050***	0.084***
	(0.088)	(0.083)	(0.096)	(0.016)	(0.020)
Mean	0.913	0.687	1.329	0.954	0.917
N	771	771	772	779	780

Notes: Each cell represents a separate regression among non-twin older siblings. Mean represents the sample average of the corresponding measure for the corresponding sex. Controls include region dummies, race dummies, age and age squared variables, residential mothers' age, residential mother's college degree (dummy), missing maternal educational attainment (dummy), residential father's college degree (dummy), missing paternal educational attainment (dummy), and the age difference between the siblings. Estimates are weighted by the reciprocal of the observation count for each respondent. Standard errors clustered at the school level are indicated within parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A12. Effects of Younger Sibling's Gender on Older Sibling: Common Friends and Time Spent Together

	Whether Having at Least One	Whether Spending a Lot of Time with	
	Common Friend Outside of the Family	The Sibling	The Sibling and Common Friends
Panel 1: Male			
SS	0.106	0.220***	0.085*
	(0.129)	(0.061)	(0.043)
Mean	0.272	0.327	0.166
N	141	348	348
Panel 2: Female			
SS	0.090	0.145**	0.076
	(0.118)	(0.061)	(0.047)
Mean	0.244	0.464	0.180
N	131	334	334

Notes: Each cell represents a separate regression among non-twin full siblings. Mean represents the sample average of the corresponding measure for the corresponding sex. Controls include region dummies, race dummies, age and age squared variables, residential mothers' age, residential mother's college degree (dummy), missing maternal educational attainment (dummy), residential father's college degree (dummy), missing paternal educational attainment (dummy), and the age difference between the siblings. Estimates are weighted by the reciprocal of the observation count for each respondent. Standard errors clustered at the school level are indicated within parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A13. Effects of Younger Sibling's Gender on Older Sibling: Substance-Using Friends

	Among the Three Best Friends, Number of Those Who			Having at Least One	
	Smoke	Use Marijuana	Drink Alcohol	Male Friend	Female Friend
Panel 1: Male					
SS	-0.143	-0.054	-0.123	0.000	0.071*
	(0.131)	(0.115)	(0.133)	(0.015)	(0.037)
Mean	0.930	0.798	1.368	0.976	0.873
N	382	383	382	388	388
Panel 2: Female					
SS	-0.301***	-0.171	-0.231**	-0.086***	0.025
	(0.114)	(0.105)	(0.104)	(0.031)	(0.018)
Mean	0.896	0.575	1.289	0.931	0.961
N	389	388	390	391	392

Notes: Each cell represents a separate regression among non-twin full siblings. Mean represents the sample average of the corresponding measure for the corresponding sex. Controls include region dummies, race dummies, age and age squared variables, residential mothers' age, residential mother's college degree (dummy), missing maternal educational attainment (dummy), residential father's college degree (dummy), missing paternal educational attainment (dummy), and the age difference between the siblings. Estimates are weighted by the reciprocal of the observation count for each respondent. Standard errors clustered at the school level are indicated within parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A14. Effects of Older Sibling's Gender on Younger Sibling's Substance Use

	Cigarette		Marijuana	
	Ever Tried Smoking	Smoked During the Last 30 Days	Ever Tried Marijuana	Used Marijuana During the Last 30 Days
Panel 1: Male				
SS	-0.032	0.071	0.015	0.034
	(0.070)	(0.054)	(0.054)	(0.037)
Mean	0.621	0.311	0.241	0.125
N	373	373	361	368
Panel 2: Female				
SS	-0.043	-0.045	-0.006	0.013
	(0.057)	(0.056)	(0.039)	(0.027)
Mean	0.612	0.317	0.251	0.118
N	406	405	406	406

	Alcohol		
	Ever Tried Alcohol	Drunk During the Last 12 Months	Any Binge Drinking Days
Panel 1: Male			
SS	-0.064	-0.055	-0.025
	(0.084)	(0.049)	(0.043)
Mean	0.587	0.393	0.274
N	373	369	369
Panel 2: Female			
SS	0.079	0.065	-0.032
	(0.063)	(0.050)	(0.052)
Mean	0.583	0.415	0.214
N	408	408	406

Notes: Each cell represents a separate regression among non-twin full siblings. Mean represents the sample average of the corresponding measure for the corresponding sex. Controls include region dummies, race dummies, age and age squared variables, residential mothers' age, residential mother's college degree (dummy), missing maternal educational attainment (dummy), residential father's college degree (dummy), missing paternal educational attainment (dummy), and the age difference between the siblings. Estimates are weighted by the reciprocal of the observation count for each respondent. Standard errors clustered at the school level are indicated within parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$