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Parental belief and adolescent smoking and drinking behaviors: A propensity score matching study

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ABSTRACT

This research examines the effects of parental belief on adolescent later smoking and drinking behaviors. Previous studies show that parental belief may have detrimental or beneficial influences on adolescents' behaviors. Analysis is based on Wave 1 and 2 data from the National Longitudinal Study of Adolescent Health (Add Health), $N = 3232$, and is conducted using an OLS regression estimation and propensity score matching (PSM; nearest-neighbor and kernel matching). Results show that, of adolescents who used cigarettes and alcohol at Wave 1, they are more likely to continue the activity if their parents were aware of it. Adolescents are also more likely to use cigarettes if their parents believed they smoked when in fact they did not. Of adolescents who did not use alcohol, no significant association is found between parental belief and their later alcohol use. Self-fulfilling prophecy is proposed to explain the effects of parental belief. Results obtained from PSM show weaker effects of parental belief, suggesting that part of the effects is explained by shared factors which are responsible for the belief and adolescent substance use. Adolescent concealment is proposed as an important unobserved confounder that influences the association between parental belief and adolescent substance use. The study suggests that research on parent-adolescent communication affected by the self-fulfilling prophecy needs to consider adolescents' intentional concealment, which may help avoid conflicts elicited by discussing topics that adolescents feel uncomfortable confiding in.

1. Introduction

Substance use has always been a concern to adolescent development and public health community. Currently in the US, around one in three students in grade 9–12 have tried cigarette smoking. More than 60% of them have used alcohol and 17% of them used alcohol before the age of 13 (Frieden, Jaffe, Cono, Richards, & Iademarco, 2016). Adolescent substance use is associated with a range of negative consequences, including poor academic grades, physical and mental health problems, substance abuse in adulthood, and premature death (Dawson, Goldstein, Chou, Ruan, & Grant, 2008; DeWit, Adlaf, Offord, & Ogborne, 2000; Grant & Dawson, 1998; Hingson, Heeren, & Winter, 2006; King & Chassin, 2007; Marshall, 2014; McGue, Iacono, Legrand, Malone, & Elkins, 2001; Merline, O'Malley, Schulenberg, Bachman, & Johnston, 2004; Mikkonen et al., 2008; Tucker, Martínez, Ellickson, & Edelen, 2008; Welch, Carson, & Lawrie, 2013). Understanding substance use in early adolescence can, therefore, offer some insight into early precursors and related factors of adolescent substance use, and provide further knowledge for prevention and intervention.

Previous literature has evidently shown that parents across countries are often unaware of their adolescents' involvement in substances

(Ahern, Kempainen, & Thacker, 2016; Bogenschneider, Wu, Raffaelli, & Tsay, 1998; Bylund, Imes, & Baxter, 2005; a Taiwanese study, see Chang, Lee, Miao, et al., 2013; a cross-national study, see Fernandez-Hermida, Becoña, Secades-Villa, Juan, & Sumnall, 2013; Fisher, Bucholz, Reich, et al., 2006; Green et al., 2011; Jones et al., 2017; Langhinrichsen, Lichtenstein, Seeley, et al., 1990; McGillicuddy, Rychtarik, Morsheimer, & Burke-Storer, 2007; a Canadian study, see Williams, McDermitt, Bertrand, & Davis, 2003; Yang, Stanton, Cottrel, et al., 2006). One may assume that parents who are aware of their deviant behaviors may take appropriate and preventive actions to avoid further misbehaving (Beck & Lockhart, 1992; Kerr, Stattin, & Burk, 2010). Yet, empirical evidence suggests otherwise. Parents' accurate belief has been found to be associated with an increase in adolescent's later risky behaviors, whereas their non-belief or unawareness is related to a decrease in these activities (Lamb & Crano, 2014; Madon, Guyll, Spoth, Cross, & Hilbert, 2003; Madon, Guyll, Spoth, & Willard, 2004; Madon, Willard, Guyll, Trudeau, & Spoth, 2006; Mollborn & Everett, 2010; Yang et al., 2006). The self-fulfilling prophecy (SFP) has often been used to explain this observation. It suggests that adolescent behavior, and the consequences of that behavior, are determined by parental belief, including *false* belief (Merton, 1948). Adolescents tend to start or

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continue using substances when their parents believe they have initiated when they have not, and discontinue when the parents believe they have not initiated when they have. When parents think their adolescents are using substances, adolescents may begin to believe that that is what they are expected to do. Existing studies provide evidence in support of the prophecy. For instance, [Lamb and Crano \(2014\)](#) use data from the National Survey of Parents and Youth and find that parental underestimation of adolescent marijuana use at Time 1 is associated with a lower frequency of usage at Time 2. Parents who are correctly aware of their adolescents' marijuana use at Time 1 predict a higher frequency of usage at Time 2. Similar effects of belief are also found in other areas. For example, [Mollborn and Everett \(2010\)](#) find that parental underestimation of adolescent sexual activity at Wave 1 predicts a lower frequency of sexual activity and STI diagnosis at Wave 2, compared with adolescents whose parents are aware of the behavior.

However, most research has failed to acknowledge a potential confounding bias existed in the relationship between adolescent substance use, parental belief, and shared factors. An overview of the past literature implies that factors responsible for parents' belief about their adolescents' involvement in risky behaviors may also be factors that motivate adolescents to engage in those very behaviors (see [Diagram 1](#)). This may partly explain why parental underestimation is more protective than accurate awareness, given that underestimation is often associated with healthy parent-adolescent relationships, good academic performance, and high levels of adolescent religiosity ([Berge, Sundell, Ojehagen, Hoglund, & Hakansson, 2015](#); [Green et al., 2011](#); [Yang et al., 2006](#)). Studies of [Madon et al. \(2003, 2004, 2006\)](#) are particularly relevant to this subject, being based on the assumption that parental belief about adolescents' alcohol use and adolescents' later alcohol consumption share nearly identical risk and protective factors (e.g. household income and past alcohol use). While the authors suggest that the SFP is responsible for the association between parental belief and adolescents' later drinking behavior, they fail to acknowledge potential confounders that may influence the effect of parental belief.

In light of this, this study is designed to contribute to the previous literature by using propensity score matching (PSM) on a representative sample. PSM is a technique that is designed to reduce the bias caused by confounding variables in observational studies ([Rosenbaum & Rubin, 1983](#)). A major advantage of PSM is that it accounts for the probability of receiving a treatment when random assignment of the treatment is not available. The treatment effects of parental belief on adolescent later tobacco use and alcohol consumption are examined. To my best knowledge, this is the first study using PSM to examine the effects of parental belief on adolescents' risky behaviors.

2. The current study

This study extends prior research in two important ways. First, the data analyzed in this study is from the National Longitudinal Study of Adolescent to Adult Health (Add Health). The use of a longitudinal dataset and PSM may tell us more about the actual causation. This could give us important information regarding the possible short-term effects of parental belief on adolescent smoking and drinking behaviors. Second, a large-scale survey enables researchers to explore potential

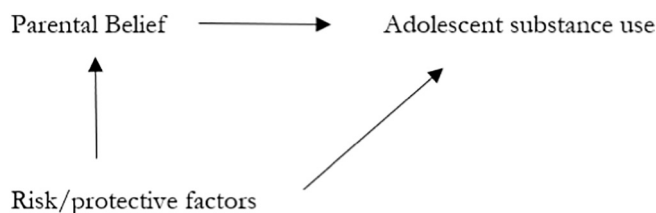


Diagram 1. A model showing a potential confounding bias of the effect of parental belief on adolescent substance use.

determinants of parental belief, enriching our knowledge in the formation of the belief.

The present study first explores the agreement between parental and adolescent reports of adolescent smoking and drinking behaviors. It is hypothesized that the agreement between the two reporters is low (H1). Adolescent-respondents are then partitioned into two groups on the basis of their previous substance use at Wave 1. OLS and PSM are applied to assess the effects of parental belief on adolescents' later substance use. A set of theoretically and empirically tested explanatory variables used to measure both parental belief and adolescent outcomes is included in the models. It is hypothesized that adolescents are likely to use cigarettes and alcohol if their parents believe (rightly or wrongly) that they engage in these activities (H2). It is also hypothesized that the effects of parental belief may reduce, but not disappear completely, when using PSM which accounts for the covariates that predict the probability of parental belief (H3).

3. Data and methods

3.1. Data

The analysis is based on the Add Health dataset from the United States.¹ The survey follows a nationally representative sample of adolescents who were in school grades 7–12 in the 1994/95 school year. Over 90,000 students from 132 schools completed an initial questionnaire in school; a subsample was selected for an in-home interview in the same year, which parents were also interviewed. Sample members were re-interviewed for a second time in the following year, a third time in 2001/02, and a fourth time in 2008 when sample members reached young adulthood (aged 24–32).

The survey covers multiple aspects of respondents' lives, including parent-adolescent relationships, family structure, peer groups, and families' economic situation, with rich data on respondents' usage of tobacco and alcohol. Data have been collected from adolescents, their classmates and friends, teachers, parents, and partners, using computer-assisted self-interview (CAPI) instrument.

The current study uses the first two waves from the public use in-home dataset, which consists of a random selection of the original data ($N = 6504$ and 4834 at Wave 1 and Wave 2, respectively). The response rate of adolescent-sample for Wave 1 is 79% and 88.6%² at Wave 2, and approximately 85% have a parent participated in the interview at Wave 1. Given that more than 90% of observations in the parent questionnaire were completed by mothers, who have more knowledge about their adolescents' risky involvement ([DiIorio, Kelley, & Hockenberry-Eaton, 1999](#); [Mollborn & Everett, 2010](#)) and whose belief are shown to have greater effects than fathers' belief ([Madon et al., 2004](#)), this study focuses on maternal belief.

The sample size is restricted to respondents who were aged between 13 and 18 at the time of the first interview. This gives a core sample size of 3232. [Table 1](#) provides descriptive statistics of outcome variables, variables of interest, and control variables. A list of measurement items used to derive scales is provided in the [Appendix A](#).

3.2. Measurements

3.2.1. Outcome variables: substance use behaviors at Wave 2

Outcome variables assessed are the average number of cigarettes and drinks each day in the past 30 days at Wave 2. The smoking indicator is derived from two measurements: the number of days respondents smoked over the past month, and the average number of

¹ Harris, K.M., C.T. Halpern, E. Whitsel, J. Hussey, J. Tabor, P. Entzel, and J.R. Udry. 2009. The National Longitudinal Study of Adolescent to Adult Health: Research Design [WWW document]. URL: <http://www.cpc.unc.edu/projects/addhealth/design>.

² The response rate at Wave 2 is the original sample at Wave 1 who were eligible for Wave 2 interview.

Table 1

Descriptive statistics of outcome variables, variables of interest, and control variables: National Longitudinal Study of Adolescent Health Wave 1 (1994–1995), and Wave 2 (1995–1996) (N = 3232).

Variable	Range of values		Mean (SD) or %
	Min	Max	
Outcome variables, W2			
Average number of cigarettes per day in the past 30 days	0	24	1.50 (4.35)
Average number of drinks per day in the past 30 days	0	7	0.59 (0.98)
Variables of interest, W1			
Average number of cigarettes per day in the past 30 days	0	20	1.02 (3.47)
Average number of drinks per day in the past 30 days	0	6.5	0.52 (0.84)
Any cigarette use [binary]	0	1	0.22 (0.42)
Any alcohol use [binary]	0	1	0.42 (0.49)
Maternal belief about adolescent regular cigarette use (i.e. once a week or more)	0	1	0.09 (0.29)
Maternal belief about adolescent regular alcohol use (i.e. at least once a month)	0	1	0.06 (0.24)
Control variables, W1			
<i>Demographic factors</i>			
Age	13	18	15.1 (1.45)
Female	0	1	53.5
White (ref)	0	1	67.8
African American	0	1	19.1
American-Indian/Asian/mixed/others	0	1	13.1
Intact family (ref)	0	1	60.2
Step-family	0	1	12.2
Single-parent family	0	1	27.6
[Parental] less than high school levels (ref)	0	1	13.2
[Parental] high school graduate	0	1	26.8
[Parental] some post-school training/college	0	1	32.6
[Parental] bachelor's degree/postgraduate training	0	1	27.4
Grade point average (GPA)	1	4	2.86 (0.76)
Religiosity	-1.74	1.30	0.05 (0.99)
Mental health problems ^a	-1.45	5.18	-0.06 (0.97)
<i>Family relations</i>			
Maternal trust ^b	1	5	4.37 (0.82)
Mother-adolescent closeness ^c	-4.97	6.59	0.01 (0.98)
Parental control ^d	-1.93	4.01	-0.00 (0.99)
Frequency of lying to parents/guardians about whereabouts and peer hang out with	0	3	0.87 (1.03)
<i>Maternal and peer substance use</i>			
Whether mother smokes	0	1	0.49
Mother's high alcohol consumption (i.e. more than three days per week)	0	1	0.23
Number of best friends who smoke	-1.06	2.41	-0.01 (0.96)
Number of best friends who drink alcohol	-1.49	2.26	0.03 (0.98)
<i>Neighborhood environment associated with substance use</i>			
Drug dealers and users is a big problem in the neighborhood	0	1	0.39

^a A higher score indicates worse mental health problems.

^b The variable indicates how much mothers felt they could really trust their adolescent.

^c The variable indicates adolescents' perception of their emotional intimacy with mothers.

^d The variable indicates parental autonomy-granting (reverse coded).

cigarettes smoked on each of these days. The range of the number of cigarettes is 0–24 or more (M = 1.50, SD = 4.35). The drinking indicator is a combined measurement of the quantity-frequency scale (Poikolainen, Podkletnova, & Alho, 2002). The quantity measures the

number of drinks adolescents had each time in the past 12 months. The frequency of alcohol use in the past 12 months was coded in the questionnaire as follows: 0 = never/has not had a drink in a lifetime; 1 = 1 or 2 days; 2 = once a month or less (3–12 times in the past 12 months); 3 = 2 or 3 days a month; 3 = 1 or 2 days a week; 4 = 3 to 5 days a week; and 6 = every day or almost every day. The two measures are multiplied into a single scale by converting the frequency levels into equivalent occasions per month (i.e. 0 = 0, 1 = 0.125 days per month, 2 = 0.625 days, 3 = 2.5 days, 4 = 6 days, 5 = 16 days, 6 = 28 days). Because less than 1% of the respondents consumed more than 7 drinks per day, I replaced the top 1% to be equal to the 99th percentile rank of 7. The average number of drinks per day in the past months is therefore top-coded at 7 (M = 0.59, SD = 0.98).

3.2.2. Maternal belief and adolescent substance use behavior at Wave 1

At Wave 1, mothers were asked whether their adolescents used tobacco and alcohol regularly, namely once a week or more and at least once a month, respectively. In the analysis, the response “unsure” is included in the “yes” category as it implicitly reflects parents' suspicion that the adolescents were engaging in risky behaviors (Bogenschneider et al., 1998).³ Adolescents were asked whether they smoked and consumed alcohol in the past 30 days. Two binary indicators are generated. For adolescents who used tobacco or alcohol at Wave 1, they were asked about the number of cigarettes and drinks they consumed per day in the past month. These variables are measured in the same way as Wave 1. The range of cigarette use is 0 to 20 (M = 1.02, SD = 3.47) and alcohol consumption 0 to 6.5 (M = 0.52, SD = 0.84).

3.2.3. Demographic factors, family relations, maternal and peer substance use, and neighborhood environment

3.2.3.1. Demographic factors. The following variables measured at Wave 1 are controlled: adolescents' age, gender, race, household composition, parental education levels (paternal education levels if maternal education was missing), grade point average (GPA), religiosity (a standardized scale based on 4 items, $\alpha = 0.86$), and mental health problem (a standardized scale based on 19 items, $\alpha = 0.86$). All variables were reported by adolescents.

3.2.3.2. Family relations. Maternal trust, parent-adolescent closeness, parental control, and the frequency of lying to parents in Wave 1 are controlled in the analysis. Maternal trust is an ordinal variable reported by mothers, measuring how much they felt they could really trust their adolescent. The variable ranges from 1 to 5 (never, seldom, sometimes, often, and always; M = 4.37, SD = 0.82). Both closeness and control scales were reported by adolescents. The closeness scale measures adolescents' perception of their emotional intimacy with mothers. It is based on 5 items ($\alpha = 0.84$), including “how much do you think [your mother] cares about you?”. The control scale is a reverse-coded variable that measures parental autonomy-granting. The scale is derived from 7 items ($\alpha = 0.62$); items include “Do your parents let you make your own decisions about the time you must be home on weekend nights?” (reverse coded). Existing literature has shown that parenting styles vary across adolescent age and gender (Belsky, 1984; Parent, Forehand, et al., 2014). The relevant scales are therefore regressed on age and sex, and are standardized. Adolescents were also asked how often in the past year they lied to their parents about where they had been or whom they were with. The item scale ranges from 0 “never” to 3 “5 or more times” (M = 0.87, SD = 1.03).

3.2.3.3. Maternal and peer substance use. In Wave 1, maternal smoking is defined based on the reports from either the mothers or the adolescents. Maternal alcohol consumption is defined on the basis of

³ The percentage of parents reporting “unsure” about their adolescents' substance use is 2% for smoking and 5% for alcohol use.

either the mothers or the fathers reporting that the mothers drank alcohol on more than three days per week (adolescents were not asked about parental drinking; $M = 0.49$, $SD = 0.50$ for maternal smoking; $M = 0.23$, $SD = 0.42$ for maternal drinking). Maternal smoking is only included in the model estimating adolescent later cigarette use, and maternal alcohol use in the regression estimating adolescent alcohol consumption. Adolescents were asked how many of their three best friends smoked and drank alcohol. Responses range from 0 to 3 and are adjusted for adolescent age and sex. Both scales are then standardized. The peer-smoking variable is included in the model of adolescent cigarette use, whereas the peer-drinking variable in the model of alcohol use. Since it is possible that adolescents with friends who smoked or used alcohol were likely to lie to their parents about their activities and whom they were with, two interaction terms between peer substance use and the frequency of lying are generated. The interaction term of peer smoking and adolescent lying is included in the regression on cigarette use, and peer drinking and adolescent lying in the regression on alcohol use.

3.2.3.4. Neighborhood environment associated with substance use. Substance use in a neighborhood context is a binary indicator reported by mothers at Wave 1, measuring whether drug dealers and drug users were a big problem in the neighborhood ($M = 0.39$, $SD = 0.49$).

3.3. Methods

In this study, I first calculate the kappa statistic to test the agreement between maternal and adolescent reports of adolescent smoking and drinking behaviors. The kappa statistic is widely used as a measure of reliability between two reporters. It is believed to be less biased than other agreement measurements (e.g. Yule's Y statistics) as it takes into account the amount of observed agreement occurring by chance (Fleiss, Levin, & Paik, 2003). To interpret kappa statistic results, Fleiss et al.'s (2003) guidelines are used for evaluating the agreement between maternal and adolescent reports: coefficients less than 0.00–0.39 (poor); 0.40–0.75 (fair); and 0.76–1.00 (excellent). To explore the effects of maternal belief, adolescents are then divided into two groups, those who used substances at Wave 1 and those who did not. Once separated, an OLS regression method is employed for each group.

Although OLS and logistic regression models were applied in most of the previous work, they may produce biased estimations. Firstly, they do not control for the effects of other observed variables on maternal belief when estimating the relationship between the belief and the outcome. This potentially increases the bias caused by confounders in the estimations (Zanutto, 2006). Secondly, the average treatment effect for the treated (ATT; the effect of a treatment for individuals with a high propensity to experience the event) may be on average different from the treatment effect for the untreated (i.e. the effect of a treatment for individuals with a low propensity to experience the event). As a result, simply calculating the average treatment effect for the sample may be inadequate in reflecting the average treatment effect for the total population, especially when the propensity scores vary greatly between individuals (Morgan & Harding, 2006). To address these issues, PSM is thus used as part of the data analysis.

PSM is a technique that attempts to mimic an experimental research setting on an observational data set by creating two groups from the sample, a treatment and a control group, based on whether or not participants had actually received the treatment (i.e., the beliefs) (Becker & Ichino, 2002; Rosenbaum & Rubin, 1983, 1984, 1985). Participants from the treatment unit are matched with those from the control unit who have similar propensity scores obtained from a logistic regression model; the regression model estimates the likelihood of maternal beliefs conditional on a set of pre-treatment variables/covariates. After matching, the sample distribution of the observed covariates in the treated and control groups should be very similar, and the difference between these groups should therefore be more attributed to

the treatment itself. This technique may have the potential to estimate the causal effect of the treatment (Rosenbaum & Rubin, 1983). After matching, the sample distribution of the observed covariates in the treated and control groups would be similar; the covariates and treatment itself become unrelated in both groups. In this study, adolescents are divided into two groups: (a) those whose mother believed their use of cigarette or alcohol regularly (i.e., the “treatment” group); and (b) those whose mother did not believe their use of cigarette or alcohol regularly (i.e., the “control” group).

The PSM estimates presented in this study use nearest neighbor matching with replacement. This approach pairs each adolescent in the “treatment” group with one or more than one adolescents in the “control” group which has the closest propensity score calculated prior. Control cases that are unable to match with treatment cases are dropped from the analysis to reduce the likelihood of bias. This matching method is commonly used by researchers from various fields and is relatively less biased (Dehejia & Wahba, 2002; Frisco, Muller, & Frank, 2007). Most importantly, it suits the dataset where there are many potential matches in the control group (i.e. mothers who *did not* believe their children smoked/used alcohol) for each treatment unit (i.e. mothers who *believed* their children smoked/used alcohol) (Bai, 2011).

For the purpose of reliability check, the analysis is replicated using a kernel matching estimation, which uses all available cases and matches treatment units to a weighted mean of all control units. The analysis is performed with common support imposition to help improve the quality of the matches that would be used for estimating the ATT (Caliendo & Kopeinig, 2008).

Sensitivity analyses are performed, which involve testing different observed variables, number of neighbors, and bandwidths, to determine the final models that have the least mean bias percentage.^{4,5} Blinder-Oaxaca decomposition analysis is also used to help determine variables that would be included in the final PSM models. Missing values are handled with listwise deletion, and bootstrapping techniques with 1000 replicates are used to obtain standard errors and 95% confidence intervals (Frisco et al., 2007). Results presented are from unweighted models since the statistical software Stata used in this study does not allow PSM estimations with any weight commands. It has also been reviewed that the procedure of weighting involves arbitrary decisions on weight factors and interactions (Gelman, 2007), which may possibly affect PSM estimations.

4. Results

4.1. Parent-adolescent agreement indices

Tables 2a and 2b report the agreement indices of adolescent and maternal reports of adolescent cigarette and alcohol use at Wave 1. In line with prior work (e.g. Bogenschneider et al., 1998; Williams et al., 2003; Yang et al., 2006), mothers tend to underestimate adolescent substance

⁴ While some scholars suggest that PSM estimations should include all relevant variables even if they are only modestly related to the treatment (Rubin & Thomas, 1996), others are concerned about the degrees of freedom and advise that variable selection should be guided by theories and previous research, and that sensitivity analyses are necessary to estimate the level of bias (Caliendo & Kopeinig, 2008; Dehejia & Wahba, 2002; Frisco et al., 2007; Guo & Fraser, 2010). I, therefore, perform sensitivity analyses to explore how including and excluding different variables would affect the prediction of the likelihood of parental belief (i.e. the propensity scores) and adolescents' later substance use. Variables that are considered include Baumrind's fourfold parenting styles (an interaction between parent-adolescent closeness and control scales; Baumrind, 1991), household income, adolescent conduct disorders (e.g. getting into a serious physical fight), maternal age, and parental employment status. Their exclusion does not substantially affect the results, and also saves degrees of freedom and the number of missing values.

⁵ Given that the nearest-neighbor matching estimation relies on the distance with the nearest propensity scores, different calipers (ranging from 0.001 to 0.9) and numbers of neighbors (ranging from 3 to 7) are tested. For the kernel matching estimation which depends on the density of adjacent propensity scores, various bandwidths (ranging from 0.001–0.9) are tested.

Table 2a
Agreement indices of adolescent and maternal reports of adolescent cigarette use at Wave 1 (N = 3232).

Adolescent cigarette use (%)	Maternal belief of adolescent cigarette use (%)		Total
	No	Yes	
No	2456 (97.97)	51 (2.03)	2504
Yes	478 (65.93)	247 (34.07)	725
Total	2934 (90.78)	298 (9.22)	3232
Percentage of agreement	0.836		
Kappa	0.405***		

Note: Statistical significance is denoted by asterisks: *** sig at 0.1%.

Table 2b
Agreement indices of adolescent and maternal reports of adolescent alcohol use at Wave 1 (N = 3232).

Adolescent alcohol use (%)	Maternal belief of adolescent alcohol use (%)		Total
	No	Yes	
No	1835 (98.66)	25 (1.34)	1860
Yes	1204 (87.76)	168 (12.24)	1372
Total	3039 (94.03)	193 (5.97)	3232
Percentage of agreement	0.620		
Kappa	0.123***		

Note: Statistical significance is denoted by asterisks: *** sig at 0.1%.

use, in particular alcohol consumption. For smoking, Table 2a shows that 65.9% of mothers underestimated their children's cigarette use, 2% overestimated, and 34.1% made correct assessments. For drinking, 87.8% of mothers were unaware of their children's alcohol consumption, 1.3% of them overestimated, and 12.2% of them correctly estimated their drinking behavior. Percentages of agreement show the proportion of mothers and adolescents who provided the same response. Around 98% of mothers made correct assessments about their children's abstinence from substance use; this contributes to the high percentage agreement statistics. Agreement on drinking behavior is lower than cigarette use.

The Kappa statistics confirm the results of cross-tabulation, showing poor-to-fair agreement on cigarette use (41%) and alcohol use (12%). Sensitivity (i.e. the proportion of adolescents and mothers both reporting the adolescents' substance use) and specificity (i.e. the proportion of adolescents and mothers both reporting no substance use) tests are performed. The sensitivity and specificity proportions reporting adolescents' cigarette use are 0.34 and 0.98, and adolescents' alcohol use 0.12 and 0.99 (results not shown). The results are consistent with the kappa statistics and percentages of agreement.

Table 3 presents a preliminary analysis using a logistic regression estimation to compare the effects of observed variables on maternal belief about adolescent alcohol use, and on adolescents' alcohol use at Wave 1. Results demonstrate that maternal belief and adolescent alcohol use can be predicted by adolescent age, ethnicity, religiosity, mother's trust, and maternal and peer alcohol consumption. This suggests that these shared factors are responsible for both maternal belief and adolescent alcohol consumption at Wave 1. Consequently, simply using conventional regression models to estimate the effects of the belief on children's later substance use is likely to produce a biased estimation. The shared factors are similar between models estimating maternal belief of cigarette use and adolescents' actual cigarette use at Wave 1, except adolescent GPA is also a shared factor while mother's cigarette use is not.

The sample is then split into two groups (i.e. adolescents who used the substances at Wave 1 and those who did not) to predict the propensity for maternal belief. Propensity scores output obtained from propensity models is used to match cases using nearest neighbor and kernel matching methods.

4.2. Parental belief and adolescent substance use: results from PSM and OLS methods

Table 4 shows the estimated number of cigarettes and drinks per day at Wave 2, and the results from covariate unbalancing tests. The table reports three estimates - the ATT using nearest neighbor matching, the ATT using kernel matching, and coefficients from an OLS regression estimation. Results obtained from the covariate unbalancing tests demonstrate the balance of observed variables between treatment and control groups. They show sufficient density distribution overlaps and common support areas for calculating efficient estimations of ATT between the groups across models, except for the model of adolescents who did not consume alcohol at Wave 1. The covariate unbalancing percentage in this model exceeds the threshold 5% (Caliendo & Kopeinig, 2008; 6.7% with nearest-neighbor matching and 6.2% with kernel matching). Failure in matching suggests that, of alcohol-inexperienced adolescents at Wave 1, the density distributions of the propensity scores in the treatment and control groups vary greatly. The region of common support is thus very small to produce efficient ATT. Relevant variables that contribute to the unsuccessful matching estimations include the interaction term of peer alcohol use and frequency of lying, adolescent religiosity, and peer alcohol use. The estimated values should therefore be interpreted with caution.

Overall, the results in Table 4 show that adolescents are more likely to continue their cigarette use and alcohol consumption if their mothers were aware of these activities. The probability of adolescent cigarette initiation is also higher if their mother overestimated their smoking behavior at Wave 1. Adolescents whose mothers made correct assessments smoke 2.4–2.6 cigarettes more than those whose mothers did not make correct assessments. Of adolescents who did not smoke at Wave 1, maternal overestimation is positively associated with 1.4–1.6 cigarettes each day in the following year. Adolescents whose mothers made correct assessments consume around 0.3 to 0.4 drinks per day in the following year (i.e. around 2 to 3 drinks per week), compared with those whose mothers did not make correct assessments. Of adolescents who did not use alcohol at Wave 1, maternal belief of their drinking behavior shows no effects on their later alcohol use. The effects of maternal belief reduce when using PSM where the covariates predicting the belief are accounted for. A fuller discussion of this finding will be presented in the Discussion session.

4.2.1. Robustness checks

Several alternative specifications are estimated as robustness checks. As an initial check, a parallel analysis is conducted using binary indicators of the outcome variables at Wave 2 to examine the changing status between Wave 1 and 2. Results demonstrate a very similar pattern: OLS estimations show that there is a positive association between maternal belief and adolescents' later cigarette and alcohol use, regardless whether they had initiated these activities at Wave 1 (the effect of maternal belief on adolescents' alcohol use is only significant at the 10% level among adolescents who did not use alcohol at Wave 1). Results obtained from the PSM models indicate a reduction in the effects of maternal belief.

A second check is to explore alternative specifications for the indicator of maternal belief. The original indicator records the belief which mothers reported either “yes” or “unsure” (due to the possibility of suspiciousness). I then further examine how the “unsure” category relates to the outcome variables. Two complementary sets of analyses are performed; (a) the “unsure” category is excluded from the model, and (b) the “unsure” category is included in the “no” category. In the former model, maternal belief is significantly related to a higher number of cigarettes among adolescents who had already initiated smoking at Wave 1. Of adolescents who had not used cigarettes or had used alcohol at Wave 1, the effect of maternal belief is significant in the OLS regression model but insignificant in the PSM estimations. In the latter model where the “unsure” category is included in the “no” category, the effects of maternal are positively related to adolescents' later

Table 3

Logistic regression models comparing the predictors of maternal belief about adolescent alcohol use and adolescent alcohol use at Wave 1 (N = 3232).

	Estimating maternal belief about adolescent alcohol use		Estimating adolescent alcohol use	
	OR	95% CI	OR	95% CI
Demographic factors				
Age	2.058***	(1.798–2.355)	1.466***	(1.377–1.560)
Female ¹	0.728‡	(0.518–1.024)	0.991	(0.828–1.187)
African-American	0.399**	(0.225–0.708)	0.452***	(0.351–0.583)
American Indian/Asian/Mixed/others ²	0.905	(0.546–1.500)	0.986	(0.759–1.282)
Step-parent family	1.048	(0.633–1.735)	1.239	(0.944–1.627)
Single-parent family ³	1.390‡	(0.950–2.033)	1.195	(0.964–1.482)
[Parental] High school graduate	0.909	(0.513–1.611)	1.112	(0.826–1.497)
[Parental] Some post-school training/College	1.022	(0.587–1.778)	1.204	(0.903–1.604)
[Parental] Bachelor's degree or beyond ⁴	1.382	(0.781–2.443)	1.109	(0.818–1.504)
Grade point average (GPA)	0.926	(0.736–1.166)	0.942	(0.829–1.070)
Religiosity	0.674***	(0.569–0.797)	0.857**	(0.781–0.940)
Mental health problems	0.992	(0.835–1.179)	1.077	(0.973–1.192)
Family relations				
Maternal trust	0.495***	(0.414–0.593)	0.878*	(0.784–0.984)
Mother-adolescent closeness	0.970	(0.827–1.138)	0.885*	(0.804–0.975)
Parental control	0.959	(0.803–1.144)	0.842***	(0.769–0.922)
Frequency of lying to parents/guardians about whereabouts and people hang out with	0.970	(0.798–1.178)	1.549***	(1.413–1.698)
Maternal and peer substance use				
Mother's high levels of alcohol consumption	1.488*	(1.044–2.120)	1.500***	(1.218–1.847)
Peers' alcohol use	1.726***	(1.370–2.174)	2.909***	(2.553–3.314)
Neighborhood environment				
Neighborhood drug problems	1.589**	(1.143–2.210)	0.970	(0.808–1.165)
Interaction terms				
Peers' alcohol use * frequency of lying	1.087	(0.936–1.261)	0.994	(0.905–1.092)
Constant	0.000***	(0.000–0.000)	0.003***	(0.001–0.009)
Pseudo R ²	0.269		0.293	

Notes: 95% CI in parentheses.

Statistical significance is denoted by asterisks: ‡ sig at 10%, * sig at 5%, ** sig at 1%, *** sig at 0.1%. Reference category: ¹Male; ²White; ³Intact family; ⁴Less than high school levels.

cigarette use, regardless whether they had initiated at Wave 1, and later alcohol use when they had drinking experiences previously. Results are all significant at least at the 10% level with OLS estimations. The effects of maternal belief reduce when using PSM.

A third robustness check is to compare the magnitude of maternal belief effects between experienced and inexperienced adolescents at Wave 1, as well as across smoking and drinking models. Post hoc tests are carried out using Hausman test and seemingly unrelated estimation.⁶ The tests indicate that the effects of maternal belief differ in magnitude across smoking and drinking models, and across models of alcohol-experienced and -inexperienced adolescents. A final robustness check is to test if outliers affect the results. All analyses are replicated by trimming at the top and bottom 1st, 5th, and 10th percentile. Results show no significant differences.

5. Discussion

By using various statistical methods, this paper builds up on previous studies to investigate the relationship between maternal belief and adolescents' substance use. In line with existing literature (e.g. Bogenschneider et al., 1998; Williams et al., 2003; Yang et al., 2006), parents generally are not aware of their adolescents' cigarette and alcohol use. This study shows that more than two-third of mothers were unaware of adolescent substance use at Wave 1. One interesting finding from the agreement indices is that although there were more

adolescents reporting their alcohol use than those reporting their cigarette use, mothers were much less likely to make correct assessments on the former. Low agreement on adolescent drinking may be due to the use of alcohol is less noticeable than the use of cigarettes (e.g. residual odors) if one does not drink to excess (McGillicuddy et al., 2007).

Investigations into the correlates of maternal belief and adolescent substance use using PSM are lacking. This study shows that, of adolescents who used or did not use cigarettes and those who consumed alcohol at Wave 1, maternal belief is related to an increased probability of adolescents' later engagement in these activities. The observed correlations could be explained by the SFP. According to the prophecy, it is possible that maternal knowledge about their adolescents' smoking or drinking behavior may be perceived as an approval when she is aware of the behavior but does not take any preventive actions. Further, in the alternative, parents may adopt a more coercive and disciplinary parenting practice in response to their adolescents' substance use. Such parenting may ruin the parent-adolescent relationship and increase the probability of adolescent substance use (Yang et al., 2006). Moreover, parents who believe their adolescents are involved in risky behaviors may express their belief that is possibly interpreted as an expectation by adolescents. To conform to the expectation, adolescents are encouraged to act what they are expected to. In addition, parents may actively look for signs about adolescent substance use if they believe their adolescents are engaging in the activity. Such parental actions may make adolescents feel their secrecy, autonomy, and freedom are breached; the lack of trust could lead them to initiate or continue using substances.

One of the most important findings in this study is that results obtained from the PSM estimations (nearest-neighbor matching and kernel matching) appear to be weaker than those from the OLS regression estimations. This provides evidence for the argument that part of the maternal belief effects can be explained by the shared factors that are

⁶ Seemingly unrelated estimation test is only performed followed by OLS regression models. This is because Stata does not allow prior estimates of standard errors to be adjusted with a bootstrapping technique. This post hoc test is thus unable to compare the effect sizes of maternal belief between the PSM models that use bootstrapping to compute standard errors and 95% confidence intervals.

Table 4
Comparison of OLS regression estimates and average treatment effects of maternal belief on adolescent smoking and drinking behaviors.

	OLS regression	Propensity score matching methods	
		ATT of experiencing maternal belief about adolescent substance use	
		Nearest neighbor matching	Kernel matching
Smoke, W1			
Number of cigarettes, W2	2.616*** (1.529, 3.702)	2.580* (0.606, 4.554)	2.425* (0.490, 4.361)
Average covariate unbalance	–	4.6	3.9
Treatment observations	247	190	190
Control observations	478	181	395
Total N	725	371	585
No smoke, W1			
Number of cigarettes, W2	1.401*** (0.825, 1.976)	1.570* (0.090, 3.051)	1.376‡ (–0.077, 2.829)
Average covariate unbalance	–	3.8	3.6
Treatment observations	51	51	50
Control observations	2456	220	2454
Total N	2507	271	2504
Alcohol, W1			
Number of drinks, W2	0.418*** (0.217, 0.619)	0.258 (–0.096, 0.611)	0.310‡ (–0.012, 0.631)
Average covariate unbalance	–	4.3	4.7
Treatment observations	168	166	166
Control observations	1204	402	1204
Total N	1372	568	1370
No alcohol, W1			
Number of drinks, W2	0.101 (–0.131, 0.334)	0.102 (–0.248, 0.451)	0.116 (–0.148, 0.379)
Average covariate unbalance	–	6.7	6.2
Treatment observations	25	20	20
Control observations	1835	97	1793
Total N	1860	117	1813

Note: OLS regression models include control variables measured at Wave 1. PSM 95% confidence intervals in parentheses computed by bootstrapping with 1000 repetitions. Statistical significance is denoted by asterisks: ‡ sig at 10%, * sig at 5%, ** sig at 1%, *** sig at 0.1%.

responsible for adolescent substance use. While PSM can control for the observed variables, the effects of other unobserved variables related to maternal belief may not be completely removed. A potential and relevant unobserved variable that influences the association between maternal belief and adolescent substance use could be adolescent concealment. Adolescent concealment is commonly found in a parent-adolescent relationship and can determine parental awareness about adolescents' substance use. For various reasons, adolescents withhold information from their parents deliberately. Those reasons may help explain the negative relationship between parental underestimation and adolescent substance use. Firstly, adolescents may conceal the behaviors to avoid disappointment and punishment (Darling, Cumsille, Caldwell, & Dowdy, 2006; Smetana & Metzger, 2008; Smetana, Metzger, Gettman, & Campione-Barr, 2006). The amount of effort they put to hide their cigarette and alcohol use (e.g. brushing teeth to get rid of the smell of smoke or alcohol on the breath or applying fragrance to cover the residual scent of cigarettes) may discourage them from continuing with the substances. Second, a sense of guilt or a fear of being rejected by parents for engaging in undesirable behaviors may reduce their use; a study from Dearing, Stuewig, and Tangney (2005) shows a negative correlation between guilt-proneness (the tendency to feel bad about a specific behavior) and substance use problems. Lastly, it is possible that adolescents feel entitled to conceal their substance use information to protect and maintain the relationship

with their parents (Finkenauer, Engels, & Kubacka, 2008). This suggests that their substance use is mainly for experimental purposes and that it is unlikely for them to develop long-term substance use which is often found in high-conflict families (e.g. White, Johnson, & Buyske, 2000). As a result, it becomes logical to assume that adolescent concealment plays a role in explaining the positive effects of parental underestimation or unawareness found in previous work and the current study.

Despite the use of PSM, it is important to note that one cannot be certain regarding “causal relationships” between maternal belief at Wave 1 and adolescent substance use at Wave 2. Maternal belief and adolescent substance use might change simultaneously during the one-year window between two waves. It is also plausible that adolescents whose mothers know about their smoking or drinking activities are more likely to be regular smokers or alcohol users than those who do not know. Regular users are likely to continue their substance use in later waves. Nonetheless, findings with respect to the changing behaviors, especially adolescents changing from non-smokers to smokers, provide evidence that maternal belief to some extent leads to an increased probability of adolescent substance use.

In contrast to earlier findings, however, no evidence of maternal belief effects is found in a sample of adolescents who did not use alcohol at Wave 1. There are two possible reasons for the inconsistent and insignificant results. First, the sample of adolescents who did not use alcohol fails to achieve balanced matching. The ATT estimations based on the unbalanced matching sample is likely to be biased, and may contribute to the insignificant results, caused by the lack of common support area. This may also explain the different effect sizes of maternal belief between alcohol-experienced and -inexperienced models found in the post hoc tests. Second, alcohol is the most widely used substance in the United States (Schulenberg, Johnston, O'Malley, Miech, & Patrick, 2016); the drinking consumption among inexperienced adolescents could be driven by various reasons. The effects of parental belief may thus be minimized by the drinking norms in society. The different social acceptance of alcohol and cigarette use may also help explain the various effect sizes of maternal belief between smoking and drinking models found in the post-estimations.

6. Limitations

A number of important limitations need to be considered. First, this study is based on the assumption that adolescents and mothers would provide honest answers. However, social desirability bias and the legal minimum smoking and drinking age may discourage respondents from reporting truthfully. Second, race/ethnicity, gender, or age groups are not separately estimated in the present study because there are too few cases of mothers reporting adolescent substance use. It would be interesting for future studies to estimate effects of parental belief separately for these groups. Third, this research only investigates maternal belief, the effects of paternal belief may vary. Crouter and Head (2002) suggest that mothers tend to know more about their daughters and fathers about their sons. Fourth, it is noteworthy that the survey used in this study asked parents whether their adolescents used tobacco and alcohol regularly (i.e. use tobacco once a week or more; use alcohol once a month at least). It would be more informative to know if parents were truly aware of adolescent substance use or whether they made a guess about it. It is also important to note that questions on adolescent substance use were phrased differently in adolescent and parental questionnaires. However, these questions should sufficiently reflect adolescents' monthly cigarette and alcohol use. Fifth, although PSM helps reduce unobserved bias, ‘hidden bias’ created by the omission of important variables in PSM analyses may produce non-randomized unobserved heterogeneity and hence inaccurate estimations (Guo & Fraser, 2010; Rosenbaum & Rubin, 1983). However, earlier research has indicated that PSM is applicable in any conditions as long as the data violates the assumption of random assignment (Caliendo & Kopeinig, 2008; Dehejia & Wahba, 2002). Further, providing that adolescents' previous substance use frequency is controlled in the current

study, the likelihood of omitted variables bias should be reduced significantly since it absorbs much variance in Wave 2 substance use. Finally, the sample size of adolescents whose mothers overestimated their substance use is relatively small. Future research may wish to consider using a larger and a more balanced sample size between the treatment and control groups, which may help increase statistical power.

7. Conclusions

Despite the limitations, the findings from this study make several contributions to the current literature. Using both an OLS estimation and PSM, this study shows that adolescents are more likely to smoke and drink if their mothers believe (rightly or wrongly) that they are engaging in these activities. This observation is not new, but one of the implications of this study is that by using PSM, a confounding bias is found in the relationship between maternal belief and adolescent substance use. This finding suggests that part of the parental belief effects is explained by shared factors that are responsible for the belief and adolescent behaviors. No known empirical research has used PSM to explore this association.

By proposing the SFP and adolescent concealment to explain the association between maternal belief and adolescent substance use, this study provides a deeper insight into parent-adolescent relationships. In

recognition of the power of SFP, family-based programs and scholars have suggested that parents should have open and informative discussions about substance use and the associated problems with their adolescents. While communication is central in all kinds of relationships, it is also important to consider that adolescence is a critical period characterized by increased conflicts. This could put pressure on communication between adolescents and parents. The concept of adolescent concealment, therefore, suggests that parents should also understand their adolescents' unwillingness in sharing information regarding risk behaviors. This may help avoid conflicts elicited by discussing topics that adolescents feel uncomfortable confiding in.

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Conflict of interest statement

None declared.

Appendix A. Items in measurement scales

Mental health problems in the past week (all measured on 4-point scales)

- You were bothered by things that usually don't bother you.
- You didn't feel like eating, your appetite was poor.
- You felt that you could not shake off the blues, even with help from your family and your friends.
- You felt that you were just as good as other people.
- You had trouble keeping your mind on what you were doing.
- You felt depressed.
- You felt that you were too tired to do things.
- You felt hopeful about the future.
- You thought your life had been a failure.
- You felt fearful.
- You were happy.
- You talked less than usual.
- You felt lonely.
- People were unfriendly to you.
- You enjoyed life.
- You felt sad.

Religiosity (all measured on 4-point scales)

- In the past 12 months, how often did you attend religious services?
- How important is religion to you?
- How often do you pray?
- Many churches, synagogues, and other places of worship have special activities for teenagers—such as youth groups, Bible classes, or choir. In the past 12 months, how often did you attend such youth activities?

Mother-adolescent closeness (all measured on 5-point scales)

- How much do you think she [your maternal figure] cares about you?
- How close do you feel to your [maternal figure]?
- Most of the time, your mother is warm and loving toward you.
- You are satisfied with the way your mother and you communicate with each other.
- Overall, you are satisfied with your relationship with your mother.

Parental control (all measured as yes/no)

- Do your parents let you make your own decisions about:
 - The time you must be home on weekend nights
 - The people you hang around with
 - What you wear
 - How much television you watch
 - What time you go to bed on week nights
 - Which television programs you watch
 - What you eat

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