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ABSTRACT

The role of friends in the US opioid epidemic is examined. Using data from the National Longitudinal Survey of Adolescent Health (Add Health), adults aged 25-34 and their high school best friends are focused on. An instrumental variable technique is employed to estimate peer effects in opioid misuse. Severe injuries in the previous year are used as an instrument for opioid misuse in order to estimate the causal impact of someone misusing opioids on the probability that their best friends also misuse. The estimated peer effects are significant: Having a best friend with a reported serious injury in the previous year increases the probability of own opioid misuse by around 7 percentage points in a population where 17 percent ever misuses opioids. The effect is driven by individuals without a college degree and those who live in the same county as their best friends.

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1 Introduction

Opioids have led to the worst drug overdose epidemic in US history –see Cutler and Glaeser (2021) and Maclean et al. (2022) for recent reviews. What has been the role of peers in the spread of the opioid crisis? For those who misuse prescription opioids, friends are among the most common sources to obtain them. Table 1, panel A, shows the fraction of individuals between ages 26 and 34 who misuse opioids and get them from friends and relatives. Between 2010 and 2019, more than 50 percent of opioid misusers obtained opioids from friends or relatives.[1] At the peak of the epidemic, in 2010, the role of friends and relatives was even stronger, possibly due to the wider availability of prescribed opioids. Hence, it is not surprising that peers have been highlighted as a potentially important factor in the fight against opioids (Compton et al., 2019; Blanco et al., 2020). Yet, the empirical estimation of peer effects is challenging due to the unavailability of data and the difficulties in achieving identification.

Table 1: Individuals aged 26-34 who misuse prescription opioids
main method of acquiring and main reason for misuse

Year	All	Non-College	College
Panel A: Fraction that obtained opioids from friends			
2010	56.35%	56.16%	56.91%
2015	46.32%	46.15%	46.91%
2019	34.83%	33.26%	38.95%
Panel B: Physical pain as main reason for last misuse of opioids			
2015	59.14%	61.52%	58.42%

Note: Calculations based on NSDUH data.

This gap is filled here by exploiting rich information on opioid misuse by individuals between ages 25-34 and their high school best friends' opioid misuse, utilizing a comprehensive set of controls that include information on demographics, health, and parental characteristics. To estimate the causal impact of peer influence, an instrumental variable technique is employed while accounting for state and/or school-specific factors. The identification strategy is that individuals can develop misuse and addiction as a result of an opioid prescribed for a severe injury, an exogenous factor, which can then affect their peers. Previous research has shown that a one-time exposure to opioids, e.g., in an emergency room or during a c-section, increases

[1]The numbers in Table 1 come from the National Survey on Drug Use and Health (NSDUH), an annual nationwide survey that provides national and state-level data on the use of tobacco, alcohol, illicit drugs (including the non-medical use of prescription drugs), and mental health in the United States. The misuse of prescription drugs is defined as use in any way that is not directed by a doctor during the last 12 months–i.e., without a prescription, use in greater amounts than prescribed, more often than prescribed, longer than prescribed, or in any other non-directed way.

the likelihood of opioid misuse six months and one month after, respectively (Barnett et al., 2017; Carrico et al., 2020). As Table 1, panel B, shows 59% of opioid misusers aged 26-34 report physical pain as the main reason for their behavior. When using best friends' severe injuries as an instrument, there is a significant positive peer effect on opioid misuse. Having a best friend with a reported serious injury in the previous year increases the probability of own opioid misuse by around 7 percentage points (pp) in a population where 17 percent have misused opioids. The effect is driven by less educated individuals, without a college degree.

Related Literature. This study contributes to the recent literature on the determinants of the opioid epidemic in the United States (see, among others, Ruhm 2019; Alpert et al. 2018; Alpert et al. 2022; Eichmeyer and Zhang 2022; Eichmeyer and Zhang 2023; Janssen and Zhang 2023). This appears to be the first paper that causally identifies at the micro level the role of friends in the opioid epidemic spread in the United States. Mäckle and Ruenzi (2022) exploit the OxyContin reformulation and friendship links (facebook friends) between counties to study network effects on overdose deaths at the county level. The current investigation analyzes instead opioid misuse at the individual level and focuses on friendships formed many years before (during adolescence) without considering newly formed friendships, that are more likely to suffer from endogeneity concerns.

Seamans et al. (2018) study opioid initiation among household members using a similar instrument (injury of a family member), distinguishing by injury type (ankle sprain or fracture, with the latter being treated more frequently with opioids). The estimated positive effect on other household members highlights the relevance of drug availability at home but is difficult to interpret as a peer effect due to homophily and correlated effects among family members. The strategy here is to estimate peer effects among high school best friends including state and/or school fixed effects to account for correlated effects. Finally, Thingholm (2023) documents spillovers in opioid prescriptions among practitioners in Denmark and the negative consequences on the labor market outcomes of their patients.

The findings also relate to the literature that studies peer effects on the consumption of other substances such as tobacco or alcohol (Cutler and Glaeser, 2005; Clark and Lohéac, 2007; Kremer and Levy, 2008; Lundborg, 2006; Fletcher, 2012). Some of these studies also adopt an instrumental variable technique (substance availability at friends' parental homes, average characteristics of friends). The current analysis

contributes by focusing on opioid misuse 14 years after friendship formation (not contemporaneous) and by proposing an instrument whose exclusion restriction is more likely to hold.

2 Data

To analyze peer effects on opioid misuse, unique information is garnered from Add Health on best friends at high school and opioid misuse in adulthood (14 years after). Add Health is a longitudinal survey–see Figure A1. Information is harnessed from three waves and longitudinal survey weights are used to account for any possible attrition. More specifically, Wave I of the survey took place in 1994/1995 and entailed in-home interviews of a representative sample of high school students in the United States. Respondents were asked to nominate up to five male and five female friends. Nominations were made starting from the closest friend to the most distant friend. The focus is on the first male and female nominations; i.e., the best friends. This choice is motivated by the higher likelihood of the respondents staying in contact with best friends in adulthood and the low fraction of respondents, less than 1/3 of them, nominating more than two friends. Given that, in most cases, individuals and their best friends were attending the same school, they were all part of the Add Health in-home interview, which allows the retrieval of a rich set of information both for the individuals and their best friends.[2]

Besides providing information on friendship formation, Wave I of Add Health also contains information on several socioeconomic, educational, and behavioral outcomes for teenagers and their families. In particular, it contains information on the availability of cigarettes and alcohol in respondents' homes. There is also information on the availability of drugs at home and on whether the respondent has consumed any illegal drug by Wave I. Last, for a subset of respondents whose parents participated in the parents' interview, there is information on whether the respondent lived with both parents and questions about maternal education and household gross income.

After Wave I, respondents (individuals and their friends) were followed up to adulthood. Wave III took place in 2001 and Wave IV took place in 2008. A question that allows the direct measurement of opioid

[2]Nominated friends in Add Health can be used to construct friendship networks and to study peer effects based on different socio-economic outcomes, such as education, living arrangements, and teenage pregnancies (see, among others, Bifulco et al. 2011; Fernández-Villaverde et al. 2014; Patacchini et al. 2017; Adamopoulou and Kaya 2018; Agostinelli et al. 2022).

misuse was asked for the first time in Wave IV. At that time, the respondents were between 25 and 34 years old. The question was:

"Which of the following types of prescription drugs have you ever taken that were not prescribed for you, taken in larger amounts than prescribed, more often than prescribed, for longer periods than prescribed, or that you took only for the feeling or experience they caused? Pain killers or opioids, such as Vicodin, OxyContin, Percocet, Demerol, Percodan, or Tylenol with codeine."[3]

Additionally, respondents in Wave IV were asked whether they suffered a serious injury in the previous year. The question was:

"In the past 12 months, have you suffered any serious injuries? For example, broken bones, cuts or lacerations, burns, torn muscles, tendons or ligaments, or other injuries that interfered with your ability to perform daily tasks."

As Table A1, column 2, shows, almost 17% of individuals reported misusing opioids and 14% reported a serious injury during the last year.[4] The reference period for this question is 2008. This is a period when the opioid dispensing rate per 100 persons in the United States was high (above 75) and increasing–see Centers for Disease Control and Prevention.[5]

Moreover, around 19% of the individuals have at least one best friend who reported misusing opioids and 16% have at least one best friend who suffered a serious injury in the previous year. Wave IV also contains information on additional socio-demographic characteristics for the respondents, such as race, occupation, and whether they completed college. There is also information on whether the respondents were ever diagnosed with depression, post-traumatic stress disorder, anxiety or panic disorder, and on whether they were ever at risk under the influence of a drug. The survey in Wave IV also elicited information on Big 5 personality traits (extraversion, agreeableness, openness, conscientiousness, and neuroticism) and a measure of risk aversion.[6]

[3]The definition of misuse of prescription drugs is very similar in the NSDUH and Add Health. A slightly different age bracket is used in Table 1 since age is reported in particular brackets in the NSDUH.

[4]Between 2005 and 2019, among individuals between 26 and 34, about 7% report misusing opioids during the last 12 months in the NSDUH. This percentage is lower than in Add Health as the reference period is "the last 12 months" in the NSDUH questionaire as opposed to "ever taken" in the Add Health questionaire.

[5]The opioid dispensing rate per 100 persons is defined as the ratio of the total number of prescriptions dispensed annually at the national level over the annual resident population. In the United States, it peaked in 2012 (reaching 81) and subsequently dropped (down to 43 in 2020)–see https://www.cdc.gov/drugoverdose/rxrate-maps/index.html and https://www.cdc.gov/mmwr/volumes/66/wr/mm6626a4.htm.

[6]The question on risk aversion was "How much do you agree with the statement about you as you generally are now, not as you wish to be in the future? 'I like to take risks' ", and the respondents could answer on a five-point scale ranging from

3 Empirical strategy

Estimating peer effects entails several empirical challenges (Manski, 1993, 2000; Angrist, 2014). The first challenge is endogenous friendship formation and termination, so-called "homophily". Individuals tend to choose friends that are similar to themseves, so any association in behavior can be driven from this endogenous choice of friends rather than direct peer influences. Homophily is mitigated by focusing on friendships formed during high school, in particular best friends, who are likely to maintain contacts after high school graduation and by estimating an intention to treat without conditioning on current friendships.[7]

The second challenge is the simultaneity of outcomes within a group, the so-called "reflection problem," which makes it difficult to differentiate between the effect of best friends on an individual and the impact of operating the other way. The reflection problem is tackled by studying opioid use at least 14 years after friendship formation and using a valid instrument: best friends' serious injuries.[8] The idea is that best friends who got seriously injured were prescribed opioids, which in turn led to opioid misuse. The identification is based on the presumption that friends' injuries affect own opioid misuse only through an increase in best friends' opioid misuses (and not directly). This exclusion restriction could be violated if the individual got injured together with their best friend (e.g., joint accident) or if the individual started misusing opioids due to the stress caused by the best friends' injury. Therefore, the benchmark specification controls for whether individuals suffered a serious injury themselves and for whether the individual has ever been diagnosed with depression, post-traumatic stress or anxiety.

The third challenge is correlated effects, i.e., that both individuals and their friends are often subject to common factors/environment. Correlated effects are addressed by including different sets of fixed effects as described below.

The benchmark estimated empirical model consists of a second-stage equation, a first-stage regression,

strongly agree to strongly disagree.

[7] In a robustness check, any possible peer influence in opioid misuse already during high school is excluded by restricting the sample to individuals who report that they have never used drugs by Wave I.

[8] The use of instruments is widespread in the literature that causally estimates peer effects–see, for example, Dahl et al. (2014) and Kim et al. (2023)

and an exclusion restriction:

$$\text{Opioid misuse}_{is} = \beta_1(\text{any best } \widehat{\text{friend opioid misuse}})_{is} + \beta_2(\text{serious injury})_{is} + \beta_3 X_{is} + \eta_s + u_{is}, \tag{1}$$

$$\text{Any best friend opioid misuse}_{is} = \gamma_1(\text{any best friend serious injury})_{is} + \gamma_2(\text{serious injury})_{is} + \gamma_3 X_{is} + \mu_s + e_{is}, \tag{2}$$

and

$$Cov(\text{any best friend serious injury}_{is}, u_{is} \mid X_{is}, \eta_s) = 0, \tag{3}$$

where i stands for the individual and s for the state of residence or school. The empirical specification instruments whether any best friend reports opioid misuse with whether any best friend suffered a severe injury in the previous year. The vector X_{is} includes socio-demographic characteristics, such as age, gender, education (with or without a college degree), and race, an indicator for having ever been diagnosed with depression, post-traumatic stress or anxiety, and an indicator for the availability of cigarettes or alcohol in the parental home while at high school. Standard errors are clustered at the school level. The benchmark specification includes Wave III State fixed effects to control for policies that may affect the availability of opioids at the state level.[9] In a robustness exercise, school fixed effects or a combination of school and state fixed effects are used and all results hold.

The robustness of the benchmark estimates is checked by including an extensive list of additional individual controls; i.e., the Big 5 personality traits (extraversion, neuroticism, agreeableness, openness, conscientiousness), risk aversion, occupational dummies, the availability of drugs in the parental home while at high school and additional family of origin controls (maternal education, household gross parental income during high school, and living with both parents during high school). One robustness exercise includes (exogenous) peer characteristics, namely, the fraction of best friends who are college graduates, Hispanic, African Americans, and the fraction who had cigarettes/alcohol/drugs available in the parental home while at high school.

[9] Wave III instead of Wave IV state fixed effects are used as the latter are endogenous (individuals in Wave IV may choose the state of residence based on the availability of opioids).

4 Results

Table 2 reports the estimates of the second-stage regression equation (1). The first-stage results are reported in Appendix Table A2. Column 1 shows the estimated peer effect in opioid misuse without any controls. There is a positive and statistically significant effect. The estimated effect does not change much when own severe injury (column 2) is added and reduces in size as soon as state fixed effects (column 3) are included. The estimated peer effect decreases slightly when controlling for demographic characteristics (column 4), and for having ever been diagnosed with depression, post-traumatic stress or anxiety (column 5). The availability of cigarettes or alcohol in the parental home while at high school does not seem to play any role (column 6).

Table 2: Peer effects in opioid misuse-2SLS

	Dep. var.: Prob(Opioid misuse)					
	(1)	(2)	(3)	(4)	(5)	(6)
Any best friend opioid misuse	0.576**	0.613***	0.519**	0.495**	0.471**	0.472**
	(0.227)	(0.225)	(0.203)	(0.196)	(0.198)	(0.196)
Severely injured		0.132***	0.124***	0.115***	0.106***	0.106***
		(0.029)	(0.029)	(0.029)	(0.029)	(0.029)
College				-0.038*	-0.033	-0.032
				(0.023)	(0.022)	(0.023)
Female				-0.024	-0.040**	-0.040**
				(0.020)	(0.020)	(0.020)
Age				-0.009	-0.008	-0.009
				(0.007)	(0.007)	(0.007)
Hispanic				0.000	-0.002	-0.000
				(0.042)	(0.040)	(0.039)
African American				-0.002	0.002	0.005
				(0.037)	(0.036)	(0.036)
Ever diagn. depressed					0.071*	0.070*
					(0.042)	(0.042)
Ever diagn. post-traumatic stress					0.100	0.099
					(0.064)	(0.063)
Ever diagn. anxiety					0.041	0.042
					(0.044)	(0.045)
Cigarette avail. in parental home in WI						0.021
						(0.031)
Alcohol avail. in parental home in WI						0.023
						(0.028)
Observations	2,846	2,846	2,843	2,830	2,830	2,826
State FE	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap Wald rk F statistic	17.43	17.21	16.90	18.58	18.27	18.44

Note: The estimated coefficients of equation 1 and the F-statistic of equation 2 with different sets of control variables and fixed effects (columns 1-6). The estimates in column 6 correspond to the benchmark specification. Robust standard errors clustered at the school level in parentheses. Survey weights used. *p<0.10; **p<0.05; ***p<0.01.

In all specifications, the F-statistic of the first stage is above 10 (last row in Table 2), indicating that the instrument is not weak. To understand the economic significance of the results, consider both the first stage and second stage coefficients. As Table A2 shows, the coefficient of the first stage is 0.156, implying that

if any best friend has a serious injury, the probability of them misusing opioids increases by 15.6pp. The coefficient of the second stage is 0.472 (Table 2, column 6). Therefore, if any best friend has a serious injury, the probability of the respondent misusing opioids increases by 0.156×0.472=7.36pp. This is substantial given that the average incidence of ever misusing opioids is 17% (Table A1).

To place the magnitude of the estimated peer effect in perspective, consider the "reduced-form" regression:

$$\text{Opioid misuse}_{is} = \beta_1(\text{any best friend serious injury})_{is} + \beta_2(\text{serious injury})_{is} + \beta_3 X_{is} + \eta_s + u_{is}. \quad (4)$$

As Table 3, column 1, shows, if any best friend has a serious injury, the probability of the respondent misusing opioids increases by 7.3pp. The reduced-form equation can also be used to exclude the possibility that the benchmark specification captures some general risky behavior among friends rather than a pure peer effect. To this end, equation 4 is estimated with the probability of smoking rather than the probability of opioid misuse as an outcome variable. As Table 3, column 2, shows, the estimated coefficient in the placebo regression is essentially null, further supporting the interpretation of the peer effect in the benchmark specification.

5 Robustness checks

A battery of additional exercises are run to check the robustness of our benchmark estimates. Table 4 reports the results. Column 1 introduces school instead of state fixed effects and the estimates continue to be statistically significant but of slightly smaller size. Column 2 includes both state and school fixed effects. Although this specification is demanding (it includes 174 fixed effects), the coefficient continues to be statistically significant and of slightly smaller size than the benchmark estimate. Columns 3 and 4 control for whether drugs were available in the parental home in Wave I and for exogenous/pre-determined friend characteristics and the results are very similar to the benchmark estimate.

The findings are also robust to the inclusion of the Big 5 personality traits and a risk aversion measure (column 5) and to the inclusion of occupational dummies (column 6).[10] Column 7 further investigates the

[10]Previous research has shown that personality traits are an important determinant of other health related outcomes like bulimia-see Ham et al. (2021). The current analysis shows that risk aversion and conscientiousness decrease the probability of opioid misuse while openness increases it.

Table 3: Peer effects in opioid misuse-reduced form estimates and placebo regression

Dep. var.:	Prob(Opioid misuse)	Prob(Smoking)
	(1)	(2)
Any best friend severely injured	0.073**	0.004
	(0.029)	(0.031)
Severely injured	0.091***	0.029
	(0.030)	(0.039)
College	-0.018	-0.134***
	(0.023)	(0.031)
Female	-0.052***	-0.069***
	(0.019)	(0.026)
Age	-0.018***	-0.004
	(0.006)	(0.008)
Hispanic	-0.025	-0.069
	(0.034)	(0.052)
African American	-0.048*	-0.174***
	(0.025)	(0.044)
Ever diagn. depressed	0.097**	0.058*
	(0.039)	(0.029)
Ever diagn. post-traumatic stress	0.073	-0.002
	(0.069)	(0.059)
Ever diagn. anxiety	0.042	0.108***
	(0.043)	(0.033)
Cigarettes avail. at parental home in WI	0.021	0.059**
	(0.029)	(0.025)
Alcohol avail. at parental home in WI	0.040	0.016
	(0.024)	(0.023)
Observations	2,826	2,817
State FE	Yes	Yes
Mean	0.169	0.697

Note: The estimated coefficients of equation 4 for the benchmark specification and for the placebo regression. The outcome variable in the placebo regression is the probability of smoking instead of the probability of opioid misuse. Robust standard errors clustered at the school level in parentheses. Survey weights used. *p<0.10; **p<0.05; ***p<0.01.

role of previous drug experience during high school. More specifically, the sample excludes individuals who reported in Wave I that they have ever tried drugs. Again, the results are robust albeit of slightly smaller size. In column 8 only individuals and best friends are kept who either do not use drugs in Wave IV or they use drugs but report that they have never put themselves or others at risk under the influence of a drug.[11] In this way, serious injuries that may have occurred due to drug use are excluded. Likewise, column 9 excludes individuals and best friends who are risk lovers (answered strongly agree to the statement 'I like to take risks'). The results of both exercises are extremely similar to the benchmark estimates. Last, column 10 controls for maternal education, household income, and household structure in Wave I. These variables are available for a smaller sample, but the peer effects remain significant.

[11] More specifically, those that answered "never" to the following question in Wave IV are kept: "How often have you been under the influence of your favorite drug when you could have gotten yourself or others hurt, or put yourself or others at risk, including unprotected sex?". Within the context of the AddHealth questions, drugs here exclude misuse of prescription opioids.

Table 4: Peer effects in opioid misuse-2SLS robustness

	Dep. var.: Prob(Opioid misuse)									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Any best friend opioid misuse	0.416**	0.380*	0.466**	0.490**	0.459**	0.533**	0.408**	0.468**	0.449**	0.441*
	(0.206)	(0.203)	(0.195)	(0.211)	(0.189)	(0.222)	(0.201)	(0.201)	(0.208)	(0.238)
Severely injured	0.122***	0.121***	0.105***	0.109***	0.097***	0.115***	0.116***	0.108***	0.086***	0.103***
	(0.032)	(0.032)	(0.029)	(0.030)	(0.030)	(0.030)	(0.035)	(0.029)	(0.030)	(0.032)
College	-0.059**	-0.053**	-0.030	-0.044*	-0.033	-0.033	-0.043*	-0.019	-0.022	-0.028
	(0.023)	(0.024)	(0.023)	(0.025)	(0.026)	(0.026)	(0.024)	(0.023)	(0.025)	(0.031)
Female	-0.029	-0.036*	-0.039*	-0.038*	-0.014	-0.029	-0.035*	-0.039**	-0.037*	-0.041*
	(0.019)	(0.018)	(0.020)	(0.019)	(0.023)	(0.027)	(0.020)	(0.019)	(0.021)	(0.022)
Age	-0.012	-0.016*	-0.009	-0.010	-0.006	-0.007	-0.016**	-0.007	-0.010	-0.013
	(0.009)	(0.009)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)
Hispanic	0.017	0.017	0.003	0.003	0.002	0.010	-0.018	0.016	0.010	-0.030
	(0.047)	(0.048)	(0.040)	(0.049)	(0.040)	(0.040)	(0.037)	(0.047)	(0.040)	(0.055)
African American	-0.030	-0.025	0.004	0.009	0.006	0.015	-0.006	0.000	-0.021	0.025
	(0.046)	(0.046)	(0.036)	(0.080)	(0.035)	(0.039)	(0.035)	(0.032)	(0.035)	(0.050)
Ever diagn. depressed	0.090*	0.082*	0.070*	0.067	0.056	0.072*	0.067	-0.001	0.043	0.054
	(0.046)	(0.043)	(0.041)	(0.042)	(0.041)	(0.042)	(0.041)	(0.041)	(0.042)	(0.048)
Ever diagn. post-traumatic stress	0.060	0.074	0.103	0.108*	0.089	0.129*	0.131*	0.112	0.068	0.039
	(0.065)	(0.066)	(0.064)	(0.064)	(0.063)	(0.069)	(0.069)	(0.071)	(0.064)	(0.073)
Ever diagn. anxiety	0.021	0.035	0.036	0.041	0.031	0.037	0.020	0.088*	0.041	0.053
	(0.047)	(0.043)	(0.043)	(0.044)	(0.043)	(0.046)	(0.038)	(0.045)	(0.045)	(0.047)
Cigarettes avail. in parental home in WI	0.020	0.023	0.013	0.016	0.018	0.011	0.026	0.020	0.024	0.049
	(0.030)	(0.031)	(0.031)	(0.033)	(0.032)	(0.029)	(0.030)	(0.032)	(0.030)	(0.035)
Alcohol avail. in parental home in WI	0.030	0.028	0.019	0.017	0.018	0.021	0.033	0.003	0.009	0.008
	(0.029)	(0.027)	(0.028)	(0.028)	(0.028)	(0.032)	(0.030)	(0.031)	(0.029)	(0.040)
Drugs avail. in parental home in WI			0.142*	0.145*						
			(0.076)	(0.077)						
% college educated best friends				0.036						
				(0.031)						
% Hispanic best friends				0.020						
				(0.051)						
% African American best friends				0.008						
				(0.077)						
% best friends with cigarettes avail. in parental home				-0.014						
				(0.029)						
% best friends with alcohol avail. in parental home				0.023						
				(0.029)						
% best friends with drugs avail. in parental home				-0.031						
				(0.070)						
Extraversion					-0.001					
					(0.004)					
Neuroticism					0.005					
					(0.004)					
Agreeableness					0.003					
					(0.005)					
Conscientiousness					-0.019***					
					(0.005)					
Openness					0.014***					
					(0.005)					
Risk aversion					-0.023**					
					(0.011)					
Maternal education in WI										0.008
										(0.021)
Gross Hhd income in thousand $ in WI										0.001**
										(0.000)
Live with both parents in WI										-0.053*
										(0.028)
Observations	2,826	2,823	2,824	2,804	2,807	2,767	2,631	2,633	2,598	2,151
FE	School	School and State	State	State	State	State	State	State	State	State
Description	Different FE	Different FE	Drug avail. control	Peer char. controls	Big5 & risk aversion controls	Occupational dummies	No illegal drugs in WI	Not at risk under drugs by WIV	No risk lovers	Family of origin controls
Kleibergen-Paap Wald rk F statistic	16.37	17.39	18.47	16.47	18.97	16.72	16.67	17.18	16.60	15.12

Note: The estimated coefficients of equation 1 and the F-statistic of equation 2 with different sets of fixed effects, control variables, and sample restrictions (columns 1-10). Robust standard errors clustered at the school level in parentheses. Survey weights used. *p<0.10; **p<0.05; ***p<0.01.

6 Heterogeneous effects and mechanisms

There is substantial heterogeneity in opioid misuse by socioeconomic characteristics. In particular, opioid misuse is more common among less educated individuals and among non-hispanic whites. As Table A3 shows, in Wave IV of Add Health, less than 15% of college graduates report ever using opioids, whereas the number for non-college graduates is 18.2%.[12] Moreover, 19.3% of non-hispanic whites report ever using opioids in Wave IV, whereas the number is just 6.3% for other races.

Some individuals are more prone to the influence of peers than others. This is examined by focusing on education and race and distinguishing between college and non-college graduates and between non-hispanic whites and others. Table 5 presents the results. Peer effects in the second stage are significant and large for those without a college degree (column 2) but not among those with a college degree (column 1). There is no significant difference in the peer effect by race (columns 3 and 4).[13] The F-statistic of the first stage is close to or above 10 for all groups (last row of Table 5).

Peer effects could arise due to information sharing regarding the efficacy of opioids or through the direct provision of opioids. To shed light on the underlying mechanism the geographical proximity between the respondents and their best friends is considered. For around half of the cases, the county of residence of the respondents and of their best friends in Wave III coincides. Therefore equation 1 is re-estimated considering best friends residing in the same county as the respondents and in a different county (Table 5, columns 5 and 6). Peer effects stem exclusively from best friends in the same county, indicating the key role of geographical proximity.[14] This can be interpreted as supportive evidence of the direct provision channel. Column 7 restricts the set of best friends to those of the same gender as the respondents. The estimated peer effect becomes larger, indicating that information sharing may also be at work.

[12] The educational gap in opioid misuse is higher in the NSDUH. Between 2005 and 2019, among individuals between ages 26 and 34, 4.7% of individuals with a college degree and 7.8% of those without a college degree reported misusing opioids during the last 12 months.

[13] Due to the small sample size, only two race categories, Non-Hispanic Whites and Others, are considered.

[14] The peer effects are stronger for non-college graduates, who are less likely to move. The fraction of college graduates is 37% in the overall sample and only 32% in the restricted sample with same county best friends. However, if we re-run the same county best friends regression for college and non-college separately, the peer effect is more substantial for both education groups.

Table 5: Peer effects in opioid misuse-2SLS heterogeneous effects

	Dep. var.: Prob(Opioid misuse)						
	By education		By race		By friends' geographical proximity		By friend-respondent gender
	College	Non College	Non hispanic white	Others	Same county friends	Different county friends	Same gender friends
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Any best friend opioid misuse	0.206	0.597**	0.395*	0.691	0.916**	-0.209	0.746**
	(0.300)	(0.238)	(0.223)	(0.485)	(0.378)	(0.390)	(0.349)
Severely injured	0.178**	0.066*	0.136***	-0.012	0.080	0.127**	0.150***
	(0.071)	(0.037)	(0.037)	(0.060)	(0.059)	(0.059)	(0.040)
College			-0.052*	0.019	-0.019	-0.008	-0.050**
			(0.029)	(0.043)	(0.042)	(0.035)	(0.024)
Female	-0.047	-0.047**	-0.031	-0.060	0.000	-0.090**	0.021
	(0.036)	(0.023)	(0.023)	(0.041)	(0.041)	(0.037)	(0.037)
Age	0.000	-0.017*	-0.017**	0.016	-0.008	-0.036**	-0.009
	(0.013)	(0.009)	(0.008)	(0.014)	(0.010)	(0.016)	(0.007)
Hispanic	-0.005	0.039			-0.005	0.009	0.023
	(0.082)	(0.061)			(0.085)	(0.070)	(0.071)
African American	0.028	-0.014			0.056	-0.102	0.059
	(0.067)	(0.045)			(0.050)	(0.074)	(0.046)
Ever diagn. depressed	0.042	0.089	0.068	0.059	0.079	0.128*	0.053
	(0.045)	(0.058)	(0.046)	(0.085)	(0.087)	(0.066)	(0.054)
Ever diagn. post-traumatic stress	0.071	0.112	0.094	0.078	0.151	0.119	0.095
	(0.077)	(0.091)	(0.076)	(0.131)	(0.128)	(0.114)	(0.075)
Ever diagn. anxiety	-0.002	0.047	0.030	0.118	0.032	-0.012	0.016
	(0.054)	(0.063)	(0.049)	(0.096)	(0.069)	(0.064)	(0.053)
Cigarettes avail. in parental home in WI	-0.039	0.049	0.012	0.066	0.026	0.022	-0.028
	(0.038)	(0.048)	(0.037)	(0.052)	(0.057)	(0.034)	(0.049)
Alcohol avail. in parental home in WI	0.014	0.037	0.030	-0.031	0.023	0.040	0.052
	(0.034)	(0.042)	(0.032)	(0.043)	(0.044)	(0.039)	(0.034)
Observations	1,072	1,747	1,726	1,095	1,330	1,304	2,127
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean	0.147	0.182	0.193	0.063	0.160	0.169	0.164
Kleibergen-Paap Wald rk F statistic	9.829	12.42	12.31	9.177	8.407	10.13	10.97

Note: The estimated coefficients of equation 1 and the F-statistic of equation 2 for different educational groups (columns 1 and 2), for different racial groups (columns 3 and 4), for best friends residing in the same or different county as the respondent (columns 5 and 6), and for best friends of the same gender as the respondent (column 7). Robust standard errors clustered at the school level in parentheses. Survey weights used. *p<0.10; **p<0.05; ***p<0.01.

7 Conclusions

Using data from Add Health, peer effects on opioid misuse between friends are causally identified. Concerns related to endogenous friendship formation and termination are mitigated by focusing on friendships formed during high school and subsequent drug use as an adult. The spotlight is on best friends, who are likely to maintain contacts after high school graduation and the estimation of an intention to treat without conditioning on current friendships. By studying opioid use at least 14 years after friendship formation and using a credible instrument (best friends' serious injuries) the challenge of simultaneity (reflection problem) in the estimation of peer effects is addressed. The analysis finds significant positive peer effects on opioid misuse, especially among individuals without a college degree.

The findings have implications for the design of policies that are meant to reduce opioid dependence (Currie and Schwandt, 2021). The reformulation of OxyContin and the implementation of must-access prescription drug monitoring programs had unintended consequences, with opioid-dependent users resorting to illegal drugs including heroin (Alpert et al., 2018) and a subsequent increase in child abuse (Evans et al., 2022). The large social multiplier that is identified suggests that policies targeted on selected individuals (e.g., with a large social network) may be particularly effective. For example, educating juveniles about the perils of drug use might be effective.

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Online Appendix

Figures and Tables

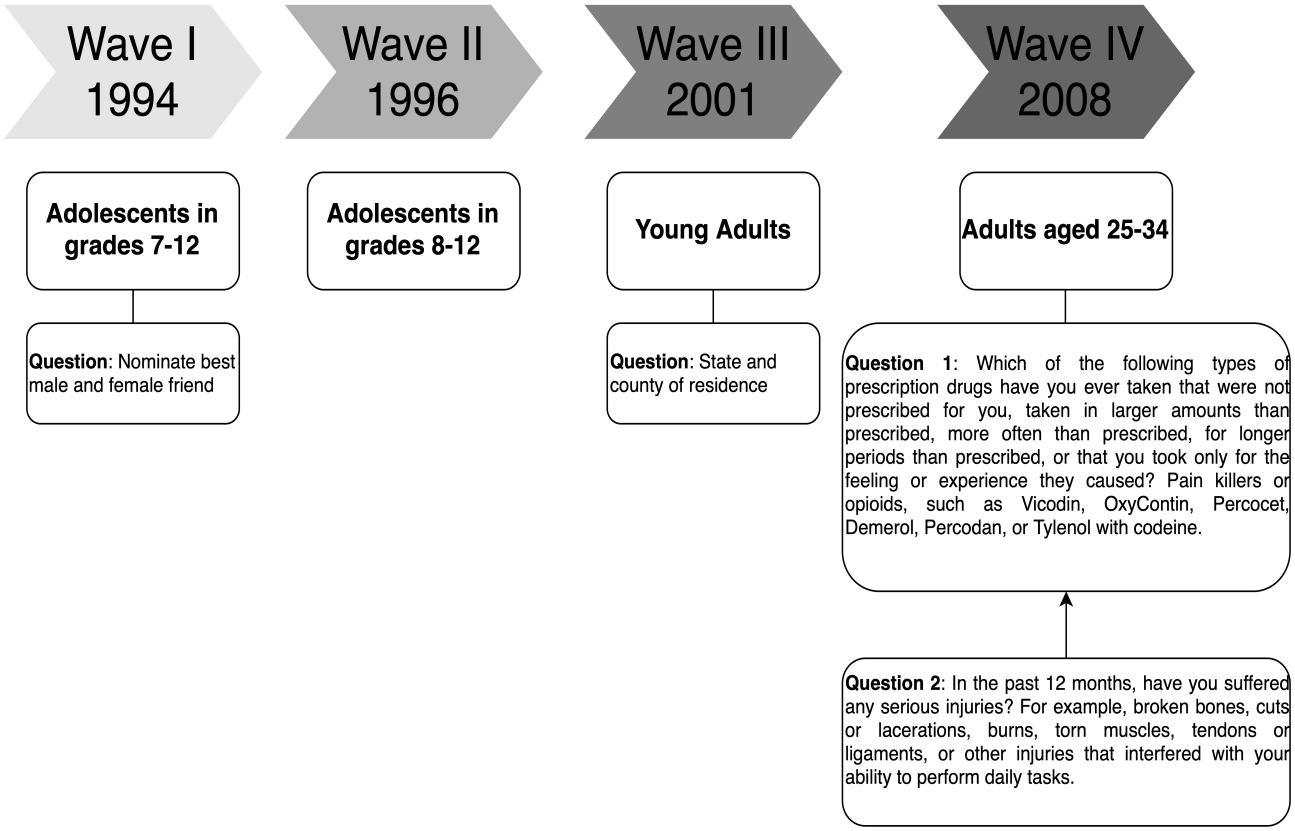

Figure A1: Waves and main questions of Add Health Survey used in the analysis

Table A1: Final sample statistics

	N	mean	sd	min	max
	(1)	(2)	(3)	(4)	(5)
Opioid misuse	2,826	0.169	0.375	0	1
Any best friend opioid misuse	2,826	0.192	0.394	0	1
Severely injured	2,826	0.138	0.345	0	1
Any best friend severely injured	2,826	0.161	0.368	0	1
Female	2,826	0.523	0.500	0	1
College	2,826	0.370	0.483	0	1
African American	2,826	0.123	0.329	0	1
Hispanic	2,826	0.0809	0.273	0	1
Age	2,826	28.63	1.771	25	34
Ever diagn. depressed	2,826	0.150	0.357	0	1
Ever diagn. post-traumatic stress	2,826	0.0295	0.169	0	1
Ever diagn. anxiety	2,826	0.126	0.332	0	1
Cigarette avail. in parental home in Wave I (WI)	2,826	0.312	0.463	0	1
Alcohol avail. in parental home in Wave I (WI)	2,826	0.312	0.463	0	1

Note: Characteristics of individuals in the Add Health regression sample. Survey weights used.

Table A2: First-stage regression

	Dep. var.: Prob(Any best friend opioid misuse)
Any best friend severely injured	0.156***
	(0.036)
Severely injured	-0.033
	(0.026)
College	0.029
	(0.029)
Female	-0.025
	(0.024)
Age	-0.018***
	(0.007)
Hispanic	-0.052
	(0.036)
African American	-0.113***
	(0.028)
Ever diagn. depressed	0.057*
	(0.034)
Ever diagn. post-traumatic stress	-0.056
	(0.055)
Ever diagn. anxiety	0.002
	(0.031)
Cigarette avail. in parental home in WI	0.001
	(0.022)
Alcohol avail. in parental home in WI	0.036
	(0.027)
Observations	2,826
State FE	Yes

Note: The estimated coefficients of equation 2 for the benchmark specification. Robust standard errors clustered at the school level in parentheses. Survey weights used. *p<0.10; **p<0.05; ***p<0.01.

Table A3: Share of opioid misusers by education and race

By education		By race	
College	Non College	Non-hispanic white	Others
(1)	(2)	(3)	(4)
0.147	0.182	0.193	0.063

Note: Characteristics of individuals in the Add Health regression sample. Survey weights used.