

# The Association Between Teenage Motherhood and Poor Offspring Outcomes: A National Cohort Study Across 30 Years

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Teenage motherhood is associated with poor offspring outcomes but these associations may be influenced by offspring birth year because of substantial social changes in recent decades. Existing research also has not examined whether these associations are due to the specific effect of mother’s age at childbirth or factors shared by siblings in a family. We used a population-based cohort study in Sweden comprising all children born from 1960 to 1989 ( $N = 3,162,239$ ), and a subsample of siblings differentially exposed to maternal teenage childbearing ( $N = 485,259$ ) to address these limitations. We examined the effect of teenage childbearing on offspring violent and non-violent criminal convictions, poor academic performance, and substance-related problems. Population-wide teenage childbearing was associated with offspring criminal convictions, poor academic performance, and substance-related problems. The magnitude of these associations increased over time. Comparisons of differentially exposed siblings indicated no within-family association between teenage childbearing and offspring violent and non-violent criminal convictions or poor academic performance, although offspring born to teenage mothers were more likely to experience substance-related problems than their later-born siblings. Being born to a teenage mother in Sweden has become increasingly associated with negative outcomes across time, but the nature of this association may differ by outcome. Teenage childbearing may be associated with offspring violent and non-violent criminal convictions and poor academic performance because of shared familial risk factors, but may be causally associated with offspring substance-related problems. The findings suggest that interventions to improve offspring outcomes should delay teenage childbearing and also target risk factors influencing all offspring of teenage mothers.

■ **Keywords:** teenage childbearing, teenage motherhood, criminal behavior, substance use, academic attainment, academic achievement

The offspring of teenage mothers are likely to experience a wide range of negative developmental outcomes (Coley & Chase-Lansdale, 1998; Coyne & D’Onofrio, 2012), including antisocial behavior, poor academic performance, and substance-related problems (Coyne & D’Onofrio, 2012; Jaffee et al., 2001, 2012). Although teenage birthrates have declined in the past few decades in developed nations, teenage motherhood continues to be a major international public health issue. Additional research is needed that can consider historical changes in teenage childbearing while also rigorously examining the mechanisms through which teenage childbearing affects offspring development.

## Cohort Changes in Teenage Motherhood

Teenage birthrates have declined substantially in developed nations since the late 1980s (Darroch et al., 2001; Singh

& Darroch, 2000). In Sweden, teenage birth rates remained relatively stable at 40–50 births per thousand 15- to 19-year-olds until 1974 (Danielsson et al., 2001), when legislation passed coupling free access to abortions with a national long-term public health initiative to provide education on human relations, sexuality, and birth control. In subsequent decades, teenage pregnancy, abortion, and birth rates all declined dramatically — in 1975, the teenage birth rate dropped to 30 per thousand 15- to 19-year-old women, and by 1996 it had dropped further to 8 per thousand

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(Danielsson et al., 2001; Darroch et al., 2001). Premarital sex and teenage sexual relationships are widely accepted in Sweden, but teenage childbirth is an unusual occurrence (Danielsson et al., 2001; Darroch et al., 2001; Wahn et al., 2005). Swedish teenage mothers come from families with higher rates of poverty and family conflict relative to adult mothers (Wahn & Nissen, 2008), suggesting that teenage motherhood reflects an atypical developmental trajectory for young women. Behavior genetic research suggests that the genetic and environmental influences on age at first childbearing in Sweden also changed considerably for women born from 1945 to 1965 (D’Onofrio et al., 2011). These studies suggest that the risk factors associated with teenage motherhood may vary across generations of Swedish teenage mothers. Researchers must therefore consider changes over time in order to fully explain the association between teenage childbearing and offspring development.

### Developmental Hypotheses About Teenage Childbearing

There are two hypotheses commonly used to explain why teenage motherhood is associated with poor offspring outcomes: social influence and social selection (Coley & Chase-Lansdale, 1998; Coyne & D’Onofrio, 2012; Jaffee et al., 2012). The social influence hypothesis posits that poor offspring outcomes are a consequence of the early timing of teenage childbirth — childbearing disrupts teenage mothers’ development and introduces social and economic stressors that hinder their ability to parent effectively (Jaffee et al., 2001). After childbirth, teenage mothers are at increased risk for low educational attainment and single parenthood, both of which increase the likelihood that their children are raised in family environments marked by limited economic and social resources (Coley & Chase-Lansdale, 1998; Coyne & D’Onofrio, 2012; Kiernan, 1997). The social influence hypothesis, therefore, suggests that teenage childbearing is causally associated with poor offspring outcomes.

Alternatively, the social selection hypothesis proposes that poor offspring outcomes are due to maternal selection factors that influence both the likelihood of teenage childbearing and the likelihood that offspring experience poor outcomes. Teenage mothers come from more disadvantaged backgrounds than mothers who delay childbearing — prior to pregnancy, these young women come from more impoverished homes, have poorer academic achievement, and are more delinquent than their peers who delay childbearing (Kiernan, 1997; Pogarsky et al., 2006; Woodward et al., 2001; Xie et al., 2001). Social selection suggests that poor offspring outcomes are merely correlates of teenage childbearing — in other words, the association between teenage childbearing and offspring outcomes is not causal but is instead confounded by genetic and/or environmental selection factors. Few previous studies have directly tested the

social influence and social selection hypotheses (Coyne & D’Onofrio, 2012; Jaffee et al., 2012).

### Quasi-Experimental Studies of Offspring Outcomes

Quasi-experimental studies which use design features with observational data to approximate true experiments are critical for testing the social influence and social selection hypotheses (Rutter et al., 2001; Shadish et al., 2002). The sibling comparison design, for instance, controls for environmental and genetic confounds shared by siblings that might account for the association between teenage childbearing and poor offspring outcomes (Coyne & D’Onofrio, 2012; Lahey & D’Onofrio, 2010). Capitalizing on this family relatedness, studies can compare siblings discordant for maternal teenage childbearing to test the competing hypotheses (Coyne & D’Onofrio, 2012). For example, if an individual born to a teenage mother was at increased risk for criminal conviction relative to his later-born sibling, then the pattern of results would be consistent with a causal association (i.e., the social influence hypothesis). If there were no difference in the risk of criminal conviction between differentially exposed siblings, then the association between teenage childbearing and offspring criminal convictions must be due to selection effects (i.e., the social selection hypothesis).

Previous quasi-experimental studies have explored the association between teenage childbearing and offspring antisocial behavior, poor academic performance, and substance-use problems, with conflicting results. In cousin-comparison studies (which control for less shared genetic and environmental influences than sibling-comparisons), were conducted using samples of mothers and their offspring (born beginning in 1970) from the US National Longitudinal Survey of Youth (NLSY). In these studies, cousins whose mothers were discordant for teenage childbearing had equally high ratings of externalizing problems and similar scores on achievement tests, suggesting that younger maternal age at childbirth (MAC) was not causally associated with offspring externalizing problems or academic achievement (Geronimus et al., 1994; Turley, 2003). More recently, however, two quasi-experimental studies using twin and cousin comparisons reported that younger MAC was independently associated with offspring teenage externalizing behavior problems and substance-use (Harden et al., 2007), and offspring antisocial behavior (D’Onofrio et al., 2009). In these studies using twins from an Australian twin register (Harden et al., 2007) and cousins from the NLSY (D’Onofrio et al., 2009), the results support causal inference. In sum, the mechanisms that account for the association between teenage childbearing and poor offspring outcomes are not well understood.

### Study Aims

The current study used quasi-experimental methods and population-based longitudinal data spanning three

decades. A unique combination of information about teenage mothers, their partners, and offspring allowed us to explore two related questions. First, we explored whether associations between teenage childbearing and three domains of poor offspring outcomes (violent and non-violent criminal convictions, poor academic performance, and substance-related problems) changed over time. Second, we tested the extent to which the associations between teenage childbearing and these outcomes were due to factors specifically related to teenage childbearing for each child (i.e., social influence) or to factors shared by siblings (i.e., social selection) by comparing poor offspring outcomes among siblings differentially exposed to teenage childbearing.

## Methods

### Sample

Our sample was created by merging six longitudinal population registries, each maintained by Swedish government agencies with updated data through 2010. The Multi-Generation Register (MGR; Statistics Sweden, 2006) contains each individual's unique identifier and date of birth and enabled us to link all children to their biological mothers and fathers (based on maternal reports) and identify all siblings. All siblings in the current study share the same mother (i.e., they are full or maternal half-siblings), as the focus is on maternal age at childbirth and an overwhelming majority of children live with their mother after a divorce in Sweden (Statistics Sweden, 1994). The National Crime Register (Fazel & Grann, 2006) includes information about all criminal convictions of individuals aged 15 (the age of criminal responsibility) and older since 1973. The register provides detailed data about the timing, nature, and number of all offenses leading to court convictions. The Education Register (Kim-Cohen et al., 2004) provides individuals' highest level of completed formal education and the National School Register provides educational achievement data (i.e., scores in multiple subjects and summary grades) for all students at the end of Grade 9. The Migration Register provides information on individuals who immigrated to or emigrated from Sweden and the Cause of Death Register, maintained by the National Board of Health and Welfare, includes data on causes of death for all individuals since 1958. Immigration and death information were used to identify individuals who emigrated or died before age 15. Institutional review boards provided ethical approval for secondary data analysis in the current study.

### Inclusion and Exclusion Criteria

A sample of individuals born between 1960 and 1989 was selected from the MGR (see Figure 1). Individuals who were missing maternal identification information, died, or emigrated before age 15 were dropped. Offspring who were born to mothers who began childbearing before age 13,

were born with congenital malformations, or were non-singletons ( $n = 28,076$ ) were also excluded.

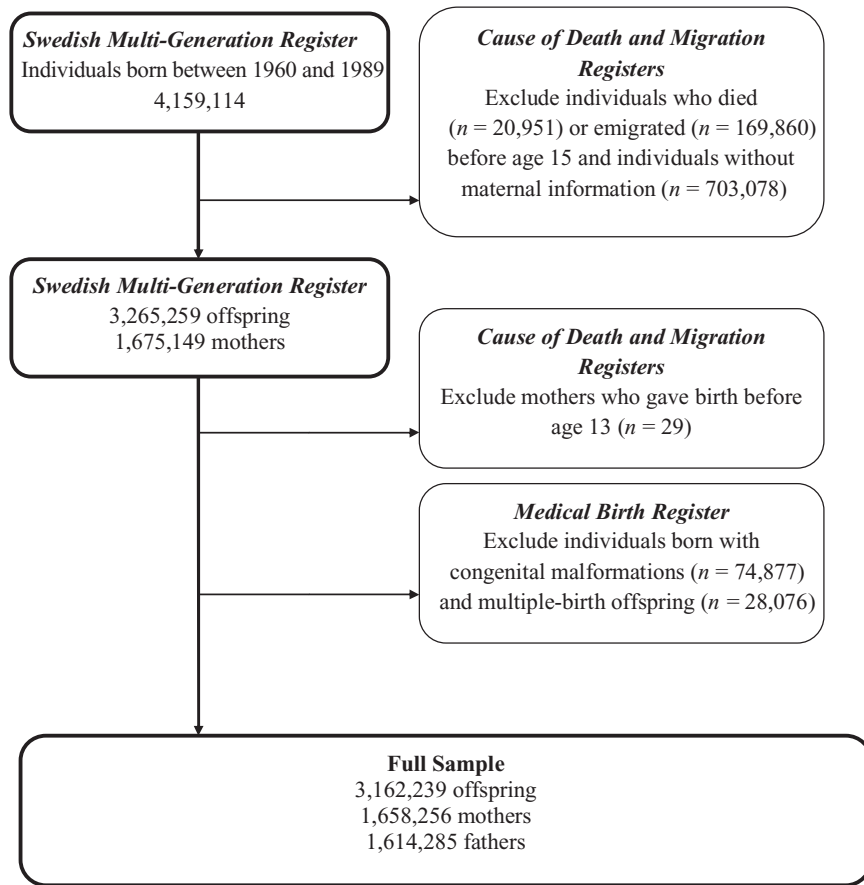
### Measures

**Maternal age at childbirth.** The MGR includes information about MAC and the birth order of each live-born child. We measured MAC as both a binary and continuous variable and ran the same analytic models for both variables. Binary MAC was categorized into two developmental periods: *teenage childbirth* (13–19 years old) and *adult childbirth* (20 years of age and older). Between 1960 and 1989, an average of 5.8% of all live births were to teenage mothers, similar to previously reported teenage birthrates (Danielsson et al., 2001; Darroch et al., 2001). Continuous MAC was grand mean-centered at 25, the mean maternal age at birth in the sample.

**Offspring covariates.** Demographic characteristics of the sample are presented in Table 1. For ease of interpretation, offspring birth year was defined as birth year since 1960. Offspring gender and birth order and paternal age at birth were included in all analytic models. Fathers of offspring born to teenage mothers tended to be younger than fathers of offspring born to adult mothers.

**Parental covariates.** Mothers' and fathers' highest level of education and criminal history prior to childbirth were included as parental covariates. Highest level of education was dichotomized at 9 years of education. In Sweden, primary school (9 years) is compulsory and subsequent secondary school education is voluntary. Dummy codes were used to represent (a) low educational attainment (i.e., completed less than 9 years of formal education) and (b) individuals missing information about their highest level of educational attainment. Maternal and paternal history of criminal behavior was based on any conviction for any reported criminal offense. More mothers who gave birth as teenagers were convicted of a crime prior to childbirth, compared with mothers who first gave birth as adults (16.4% vs. 9.1%). More fathers of offspring born to teenage mothers were convicted of a crime prior to the child's birth, compared with fathers of offspring born to adult mothers (46.3% vs. 29.4%).

**Offspring outcomes.** Offspring history of criminal conviction was separated into two subtypes, including (1) *violent criminal conviction*, defined according to the Swedish Penal Code as murder, manslaughter, or filicide, assault, kidnapping, illegal restraint, illegal coercion or threats, robbery, threats or violence against an officer, arson, gross violation of a person's integrity, or harassment, and sexual offenses, with attempted or aggravated offences were included wherever applicable (Fazel et al., 2009); and (2) *non-violent criminal convictions*, defined as any other crimes that were not violent, driving related, or drug related.



**FIGURE 1**  
Participant exclusion criteria.

For each subtype of crime, analyses were based on first conviction. The time-to-event for these outcomes was based on the date of the first criminal act leading to a criminal conviction. In the current sample, 18% ( $n = 558,602$ ) of the sample had at least one criminal conviction, 3% ( $n = 102,105$ ) had at least one violent criminal conviction, and 7% ( $n = 224,655$ ) had at least one non-violent criminal conviction (not related to drugs or driving violations) by age 25.

The *low educational attainment* and *low academic achievement* outcomes were constructed as binary measures of offspring academic performance. *Low educational attainment* was defined as completing only 9 years of compulsory formal education, with the reference category representing less than 10 years of formal education (i.e., lowest 20th percentile of educational attainment in the offspring sample). *Low academic achievement* was based on a summary grade point score for offspring in Grade 9, calculated across 16 different subject scores and converted to a  $z$  score. Scores in the 20th percentile were categorized as *low academic achievement*.

Outcomes representing substance-related problems included substance-related criminal convictions and hospitalizations. Substance-related criminal convictions included

(1) *narcotic drug-related criminal convictions*, as defined by the Narcotic Drugs Criminal Act, including possession for personal use, supply and manufacture, and consumption; and (2) *driving-related criminal convictions*, defined as crimes committed while driving under the influence of alcohol or other substance. *Substance-related hospitalizations* were derived from inpatient records. We included inpatient hospitalizations that occurred after age 12 with a primary diagnosis involving psychoactive substance use as defined by ICD8-10 diagnostic codes. This captured inpatient hospitalizations that were due to alcohol or any other non-nicotine substance. In the present sample, 3% experienced a substance-related hospitalization by the age of 25. In the current sample, there were  $n = 71,190$  substance-related hospitalizations.

### Statistical Analyses

**Comparing teenage and adult mothers.** All data analyses were performed with SAS<sup>®</sup> software, Version 9.3. First, to determine whether background characteristics of teenage and adult mothers changed over the three-decade period, we conducted preliminary results in which we compared maternal and paternal educational attainment and criminal

**TABLE 1**  
**Sample Characteristics in a National Registry-Linkage Study for Offspring Born to Teenage and Adult Mothers in Sweden 1960–1989**

Variable	All mothers		Teenage mothers		Adult mothers	
	N	M/%	N	M/%	N	M/%
Mean maternal age at first birth		25.6		18.5		26.7
Unique mothers	1,658,256		220,723		1,606,269	
<i>Offspring outcomes</i>						
Violent criminal conviction <sup>a</sup>	139,712	4.4%	21,336	8.6%	118,376	4.1%
Non-violent convictions <sup>a</sup>	270,179	8.5%	31,857	13.0%	238,322	8.2%
Low academic attainment	691,680	22.3%	64,380	27.0%	627,300	21.9%
Low academic achievement	273,424	16.0%	28,271	31.1%	245,153	15.1%
Driving-related conviction <sup>a</sup>	116,306	3.7%	17,207	7.01%	99,099	3.4%
Drug-related conviction <sup>a</sup>	71,271	2.3%	10,435	4.25%	60,836	2.1%
Substance-related hospitalization <sup>a</sup>	71,190	2.3%	9,288	3.79%	61,902	2.1%
<i>Offspring covariates</i>						
Female gender	1,539,461	48.7%	119,136	48.6%	1,420,325	48.7%
<i>Offspring birth order</i>						
1st born	1,635,351	51.7%	220,499	89.9%	1,414,852	48.5%
2nd born	1,056,910	33.4%	23,468	9.6%	1,033,442	35.4%
3rd born	355,142	11.2%	1,249	0.5%	353,893	12.1%
4th born or later	114,836	3.6%	79	<0.1%	114,757	3.9%
<i>Father's age at birth</i>						
Mean age		30.3		25.9		31.2
<20 years old	51,261	1.6%	38,901	15.9%	26,463	1.6%
20–24 years old	559,846	17.6%	141,232	57.6%	288,270	17.9%
25–29 years old (ref)	1,040,695	32.9%	36,911	15.0%	534,952	33.1%
30–35 years old	802,945	25.4%	7,450	3.0%	416,144	25.8%
>35 years old	627,665	19.9%	2,935	1.2%	346,345	21.5%
Missing	79,827	2.5%	17,866	7.3%	2,112	0.1%
<i>Parental covariates</i>						
<i>Maternal educational achievement</i>						
<9 years of education (ref)	305,262	18.4%	34,693	15.72%	439,305	27.4%
≥9 years of education	1,333,816	80.4%	183,013	82.06%	1,150,803	80.2%
Missing	19,178	1.2%	3,017	1.35%	16,161	1.1%
<i>Paternal educational achievement</i>						
<9 years of education (ref)	388,871	24.6%	60,511	26.5%	328,360	24.3%
≥9 years of education	1,190,844	73.8%	167,742	71.8%	1,023,102	74.1%
Missing	34,571	2.1%	5,336	2.3%	11,790	0.9%
Maternal criminal conviction before birth of 1st child	166,676	10.1%	36,484	16.4%	130,192	9.1%
Paternal criminal conviction before birth of 1st child	514,905	31.9%	108,247	46.3%	406,658	29.5%

Note: Total offspring N = 3,162,237 for analyses;<sup>a</sup>offspring outcomes given as Kaplan–Meier estimates and frequency of convictions by age 35 or hospitalization by age 25.

history of offspring born to teenage mothers and those born to adult mothers. Logistic regression models were used to predict low parental educational attainment, and survival models (i.e., Cox regression models) were used to predict parental criminal conviction, as not all parents had lived through the risk period for criminal convictions, with each variable regressed separately on maternal teenage childbearing.

**Predicting poor offspring outcomes.** Because most studies have focused on the distinction between teenage and adult childbearing, the main text presents the results based on the binary MAC variable. All models statistically controlled for father's age at birth, offspring sex, and birth order, which is important when comparing siblings (Lahey & D'Onofrio, 2010). Logistic regression models were used to predict offspring poor academic performance outcomes. Cox regression models were used to predict criminal convictions and substance-related outcomes, as not all offspring had lived through the risk period for these outcomes. We followed procedures for testing for violations of the propor-

tional hazards assumption by partitioning the event-time axis into smaller time periods for the criminal convictions and substance-related outcomes (Therneau & Grambsch, 2000). These analyses indicated there was little evidence of nonproportionality in our sample (results provided upon request).

We fit four models predicting offspring violent criminal conviction. Model 1 examined the population-wide association between teenage childbearing and offspring violent criminal conviction. Model 1 (and all subsequent models) used robust standard errors to account for the nested nature of the data (i.e., siblings were nested in families). Model 2 tested whether offspring birth year moderated the association between teenage childbearing and offspring criminal convictions across the entire sample. Model 3 examined the population-wide association between teenage childbearing and offspring violent criminal conviction after controlling for parental criminal conviction and educational attainment.

In Model 4, we fit a fixed-effects model to examine the association between teenage childbearing and offspring

violent criminal conviction and served as a comparison of differentially exposed siblings (Allison, 2004). This model provided an estimate of the association between teenage childbearing and offspring violent convictions, controlling for genetic and environmental factors shared by all siblings within a family (Lahey & D’Onofrio, 2010). If selection effects confounded the association between teenage child-birth and offspring violent convictions, then differentially exposed siblings would be at similar risk for violent convictions. If teenage childbearing were causally associated with offspring violent convictions, then offspring born when their mother was a teenage would still have a greater risk for violent convictions than all later-born siblings (Lahey et al., 2009).

We then fit Models 1–4 to predict the other criminal (i.e., non-violent convictions) and substance-related outcomes (i.e., substance-related hospitalizations, and drug- and driving-related convictions), using Cox regression. Models 1–4 were also fitted to predict offspring poor academic performance outcomes (i.e., low educational attainment and poor academic achievement), using logistic regression.

**Sensitivity analyses.** Models 1–4 were also rerun for each outcome using the continuous MAC measure in order to maximize statistical power.

## Results

### Comparing Teenage and Adult Mothers

These results are available upon request. First, across this 30-year period, the risk of low educational attainment increased for women who gave birth as teenagers relative to women who gave birth as adults. Specifically, teenage mothers who gave birth from 1960 to 1969 were less likely to have low educational attainment than adult mothers during the same period (OR: 0.61, 95% CI: 0.60–0.62); however, from 1980 to 1989, teenage mothers giving birth were 3.5 times more likely to have low educational attainment than adult mothers. A similar pattern of results was found for the fathers of offspring born to teenage mothers.

Second, across all three decades, teenage mothers and the fathers of their offspring were more likely to be convicted of a crime than adult mothers and the fathers of their offspring. With some fluctuations, lifetime conviction risk increased over time for teenage mothers relative to adult mothers. The pattern of convictions for fathers of offspring born to teenage mothers followed a similar pattern — the odds of criminal conviction for fathers of offspring born to teenage mothers increased between the 1960s and 1970s, and then decreased slightly from 1980 to 1989, but remained high relative to the fathers of offspring born to adult mothers in all decades.

### Survival Analyses Predicting Offspring Criminal Convictions

The parameter estimates for the effects of teenage childbearing, birth year, and the birth year  $\times$  teenage childbearing interaction for all offspring outcomes are presented in Table 2. (Full results are available upon request.) In Model 1, teenage childbearing predicted increased odds of offspring violent criminal convictions population-wide ( $b_{\text{unrelated}} = 0.524$ ; HR = 1.69). In Model 2, the population-wide risk of violent conviction was higher for offspring born to teenage mothers than for offspring born to adult mothers in 1960 ( $b_{\text{unrelated}} = 0.266$ ), and the risk increased across the 30-year timespan ( $b_{\text{interaction}} = 0.025$ ). In other words, offspring born to teenage mothers had greater risk of lifetime violent conviction than offspring born to adult mothers, and the odds of a violent conviction for offspring born to teenage mothers increased in magnitude over time relative to offspring of adult mothers. The pattern of association between teenage childbearing and offspring violent criminal convictions across time is shown in Figure 2(a). In Model 3, teenage childbearing remained a strong, population-wide predictor of offspring violent convictions in 1960 after controlling for parental covariates ( $b_{\text{unrelated}} = 0.321$ ), and offspring birth year still moderated the association ( $b_{\text{interaction}} = 0.017$ ).

In Model 4, however, the within-family comparison of differentially exposed siblings showed that the effect of teenage childbearing in 1960 was greatly attenuated after accounting for genetic and environmental factors shared by siblings within a family ( $b_{\text{maternal age}} = -0.012$ ). Additionally, birth year no longer moderated the association between teenage childbearing and offspring violent convictions ( $b_{\text{interaction}} = -0.003$ ). This sibling comparison suggested that offspring born to teenage mothers were no more likely to be convicted of a violent crime than were their later-born siblings, and their risk of violent criminal convictions did not change over time.

Models 1–4 were run to predict non-violent criminal convictions, and a similar pattern of associations was found (Table 2). Teenage childbearing was associated with increased risk of offspring non-violent criminal conviction population-wide (Model 1,  $b_{\text{unrelated}} = 0.300$ ; HR = 1.35) and that risk increased across the 30-year timespan (Model 2). Figure 2(a) shows the pattern of association between teenage childbearing and offspring non-violent criminal convictions across time. Teenage childbearing remained a strong predictor of offspring non-violent convictions after controlling for parental covariates, and birth year continued to moderate the association between teenage childbearing and non-violent criminal convictions (Model 3). Again, the sibling comparisons suggested that offspring born to teenage mothers were no more likely to be convicted of a non-violent crime than their later-born siblings (Model 4), and that risk did not change over time (Figure 2b).

**TABLE 2**  
Survival Models With Teenage Childbirth Predicting Poor Offspring Outcomes

	Model 1 <sup>a</sup>		Model 2 <sup>a</sup>		Model 3 <sup>a</sup>		Model 4 <sup>b</sup>	
	<i>b</i>	SE	<i>b</i>	SE	<i>b</i>	SE	<i>b</i>	SE
<b>Offspring criminal convictions</b>								
<i>Violent criminal convictions</i>								
Teenage childbirth (vs. adult childbirth)	0.524*	0.009	0.266*	0.014	0.321*	0.014	-0.012	0.025
Birth year (since 1960)			0.013*	<0.001	0.013*	<0.001	-0.025*	0.002
Teenage childbirth × year of birth			0.025*	0.001	0.017*	0.001	-0.003	0.002
<i>Other non-violent convictions</i>								
Teenage childbirth (vs. adult childbirth)	0.300*	0.007	0.127*	0.011	0.144*	0.011	-0.042	0.018
Birth year (since 1960)			-0.023*	<0.001	-0.026*	<0.001	-0.043*	0.002
Teenage childbirth × year of birth			0.016*	0.001	0.012*	0.001	0.005	0.002
<b>Offspring poor academic performance</b>								
<i>Low academic attainment</i>								
Teenage childbirth (vs. adult childbirth)	0.785*	0.009	0.393*	0.030	0.425*	0.031	0.103	0.063
Birth year (since 1960)			0.005*	<0.001	0.011*	<0.001	-0.050*	0.002
Teenage childbirth × year of birth			0.021*	0.002	0.011*	0.002	0.002	0.003
<i>Low academic achievement</i>								
Teenage childbirth (vs. adult childbirth)	0.257*	0.006	0.135*	0.010	0.089*	0.010	0.010	0.015
Birth year (since 1960)			0.036*	<0.001	0.047*	<0.001	0.020*	0.001
Teenage childbirth × year of birth			0.015*	0.001	0.013*	0.006	<0.001	0.001
<b>Offspring substance-related outcomes</b>								
<i>Substance-related hospitalizations</i>								
Teenage childbirth (vs. adult childbirth)	0.346*	0.013	0.374*	0.021	0.315*	0.021	0.210*	0.034
Birth year (since 1960)			0.065*	0.001	0.058*	0.001	0.039*	0.003
Teenage childbirth × year of birth			0.003*	0.001	-0.002*	0.001	-0.014*	0.003
<i>Drug-related convictions</i>								
Teenage childbirth (vs. adult childbirth)	0.461*	0.013	0.447*	0.021	0.508*	0.021	0.368*	0.036
Birth year (since 1960)			0.053*	0.001	0.044*	0.001	0.014*	0.003
Teenage childbirth × year of birth			0.007*	0.001	-0.002	0.001	-0.033*	0.003
<i>Driving-related convictions</i>								
Teenage childbirth (vs. adult childbirth)	0.429*	0.010	0.251*	0.015	0.288*	0.014	0.099*	0.028
Birth year (since 1960)			-0.027*	0.000	-0.031*	0.001	-0.063*	0.003
Teenage childbirth × year of birth			0.018*	0.001	0.010*	0.001	-0.014*	0.003

Note: <sup>a</sup>based on *N* = 3,162,239; <sup>b</sup>based on a fixed-effects model examining differentially exposed siblings (*N* = 485,259). \**p* < .05. Parameters are distributed as logits.

**Logistic Analyses Predicting Offspring Poor Academic Performance**

For unrelated offspring, teenage childbearing was associated with increased risk of low educational attainment (Model 1: *b*<sub>unrelated</sub> = 0.785; HR = 2.19) and low educational achievement (Model 1: *b*<sub>unrelated</sub> = 0.257; HR = 1.29), and the risk of both low educational attainment and low educational achievement increased over time (Model 2). When controlling for all measured parental covariates, teenage childbearing remained a robust predictor of both measures of poor academic performance (Model 3). The results of the sibling-comparison models indicated that birth to a teenage mother was not associated with either measure of poor academic performance, and the risk of both measures of poor academic performance for teenage-born siblings did not change across the timespan (Model 4).

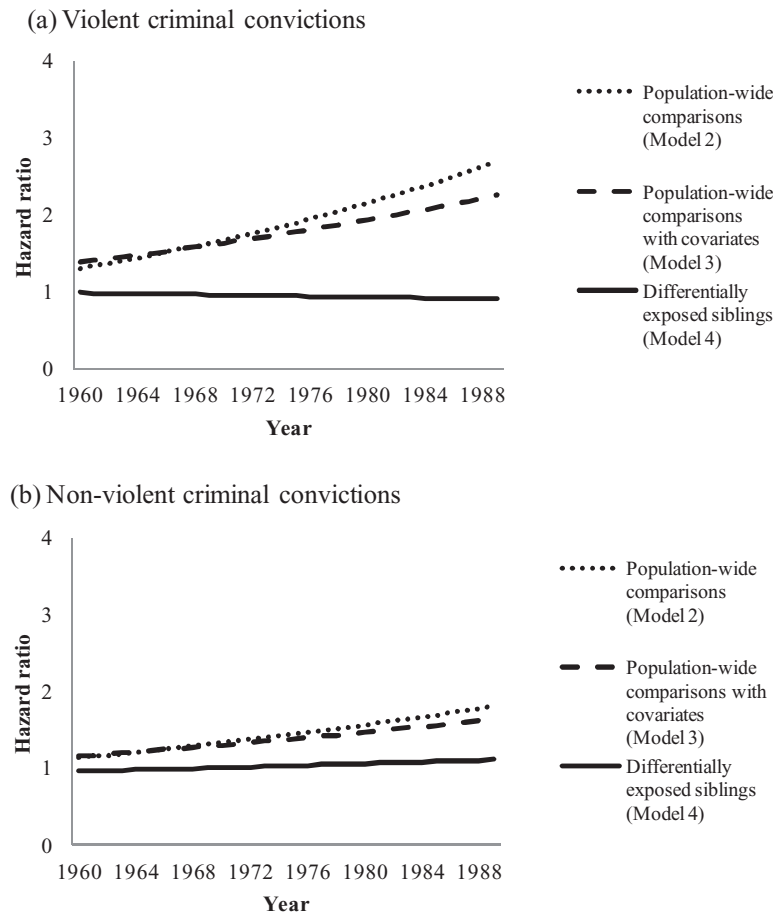
**Survival Analyses Predicting Offspring Substance-Related Problems**

In Model 1, teenage childbearing was associated with increased risk of offspring substance-related hospitalizations population-wide (*b*<sub>unrelated</sub> = 0.346; HR = 1.41). The risk of substance-related hospitalizations increased across the 30-year timespan when year of birth was included as a mod-

erator (Model 2). Teenage childbearing remained a robust predictor of substance-related hospitalizations population-wide after controlling for parental covariates (Model 3). The sibling comparison (Model 4) suggested that offspring born to teenage mothers were more likely to be hospitalized for substance problems than their later-born siblings, even after controlling for genetic and environmental factors shared by siblings within a family (Model 4), and that the risk associated with teenage childbearing decreased across the 30-year timespan. These results are consistent with a causal interpretation of the association between teenage childbearing and offspring substance-related hospitalizations. The same pattern of results was found across all four models predicting offspring drug- or driving-related criminal convictions (Table 2). Overall, offspring born to teenage mothers were more likely to experience substance-related problems than their later-born siblings, and the risk of these substance-related problems for the sibling exposed to their mother’s teenage childbearing decreased over the 30-year timespan.

**Sensitivity Analyses**

Cox regressions and logistic regressions using the continuous measure of MAC as a predictor for the same offspring



**FIGURE 2**

Hazard ratios predicting the risk of violent (a) and non-violent (b) criminal convictions for offspring born to teenage mothers relative to offspring born to adult mothers between for offspring born from 1960 to 1989.

outcomes produced a similar pattern of association between teenage childbearing and each outcome (results available upon request).

### Discussion

The current study used multiple decades of genetically informative, population-based data to explore the association between teenage childbearing and multiple indices of poor offspring development. We used a quasi-experimental design to explore changes in patterns of association over time and test causal hypotheses. To our knowledge, this is the first study to test whether year of birth moderates the association between teenage childbearing and poor offspring outcomes.

Our first aim was to identify changes in the association between teenage childbearing and offspring criminal convictions, poor academic performance, and substance-related problems across a 30-year timespan. In population-wide comparisons of offspring, we found that the risk of criminal conviction, poor academic performance, and

substance-related problems increased between 1960 and 1989 for offspring born to teenage mothers versus adult mothers. These results are consistent with previous studies suggesting that the problematic consequences of teenage motherhood may have intensified over time, despite broad declines in teenage birthrates in developed nations (Kiernan, 1997; Maughan & Lindelow, 1997). Our preliminary analyses, which compared the educational attainment and criminal history of teenage mothers and adult mothers, suggested that sociodemographic risk for teenage mothers also increased across the timespan. In general, teenage mothers and the fathers of their offspring were more likely to have low educational attainment and a criminal history than were adult mothers and the fathers of their offspring. Though limited to educational and criminal sociodemographic characteristics, these results provide evidence of a cohort effect. Specifically, across the 30-year timespan, young women who became teenage mothers became increasingly likely to have low educational attainment and a criminal history relative to women who first gave birth as adults. Future studies will need to carefully explore



historical changes in the sociodemographic characteristics and consequences of teenage motherhood.

Our second aim was to explore the mechanisms driving the association between teenage childbearing and offspring outcomes by comparing differentially exposed siblings, a quasi-experimental approach. These analyses focused on the specific effect of mother's age at each offspring's birth measured both as binary and continuous predictor of subsequent poor outcomes. The patterns of results differed for offspring criminal convictions (violent and non-violent), poor academic performance, and substance-related problems. Consistent with the social selection hypothesis, the associations between teenage childbearing and criminal convictions and poor academic performance found in population-wide comparisons disappeared when comparing differentially exposed siblings. In other words, we found no within-family association between maternal age at each child's birth and offspring criminality or poor academic performance, and there was no change in these associations across the 30 years included in our study. In the sensitivity analyses, the same pattern of association was found using a continuous measure of MAC. These results suggest that the mother's age at each child's birth is not causally associated with the child's later risk of criminal conviction or poor academic performance. Rather, familial risk factors (genetic and/or environmental) shared by all offspring of a mother who first gave birth as a teenager appear to account for the association between teenage childbearing and offspring criminality or poor academic performance.

Consistent with the social influence hypothesis, the associations between teenage childbearing and offspring substance-related problems found in the sibling comparisons were consistent with a causal association, and the magnitude of this association decreased over the timespan. These results suggest that child-specific environmental factors (e.g., parental monitoring and peer influence) that differ between siblings may account for the increased risk of offspring substance-related problems for offspring born to teen mothers. Thus, the current findings indicate that the causal mechanisms linking teenage childbearing and offspring outcomes differ depending on the outcome.

### Limitations

It is important to note that there are assumptions and limitations to the current study design that should be considered. First, the sibling-comparison design assumes that one sibling's exposure to environmental risk does not influence the unexposed sibling (Lahey & D'Onofrio, 2010), which does not consider the way in which mother's teenage childbearing may influence all subsequent children. Alternatively, some other environmental risk factor shared by all siblings in the family may be causally associated with offspring criminality and poor academic performance, namely, mother's age at first birth. The absence of a within-

family effect for criminality and poor academic performance appears consistent with the social selection hypothesis, but there may be other explanations for these results. Teenage childbearing could be a marker of genetic risk for antisocial behavior and poor academic performance, which means that interventions to delay childbearing would not reduce offspring criminal convictions or improve academic performance. Instead, effective interventions would need to directly address offspring academic difficulties and antisocial behavior. The cumulative effect of teenage mothers' diminished financial and social resources due to early childbirth could increase the risk of criminality and poor academic performance for firstborn as well as later-born offspring (Nagin et al., 1997). There may be carry-over effects associated with first giving birth as a teenager that influence both the firstborn and later-born offspring of teenage mothers; potentially, the association between teenage childbearing and poor offspring outcomes may be due to maternal age at first childbirth, rather than maternal age at each child's birth. In this case, delaying mother's first birth could be an effective intervention for reducing offspring criminal behavior or improving academic performance. Future quasi-experimental studies can test these alternative explanations by comparing differentially exposed cousins or offspring of twins in order to test the effects of maternal age at first birth and other putative risk factors shared by all siblings in a family (Coyne & D'Onofrio, 2012).

Second, sibling comparisons cannot account for differences in sibling outcomes that may be due to birth order. We included birth order as a covariate, but there are other ways to more explicitly test birth-order effects (D'Onofrio et al., 2009). Although our results are consistent with a causal association between teenage childbearing and offspring substance-related problems, it is possible that changes in the family environment associated with birth order (e.g., changes in family hardship) differentially influence siblings' risk of substance-related problems. Including more refined measures of education, socio-economic position, and parental psychopathology could also help identify possible mediators that explain the causal association between teenage childbearing and offspring substance-related problems.

Third, the study used data from Swedish population registries. Given the relatively limited ethnic diversity and low teenage birth rates in Sweden, further studies of samples from different countries are needed to test whether our results generalize to other racial and ethnic groups.

### Conclusion

Our findings demonstrate the need to account for historical context, such as periods of considerable social change, and suggest that the mechanisms linking teenage childbearing and poor offspring outcomes vary by outcome. Our results suggest that to effectively address the negative outcomes of teenage childbearing, preventive interventions

must be comprehensive, targeting the prevention of teenage motherhood, as well as family background factors that increase the risk of negative outcomes for all siblings within a family (Kohler et al., 2002).

## Authors' Contributions

Each of the authors made substantial intellectual contributions to the content of the manuscript. Claire A. Coyne, BA, graduate student, contributor, and guarantor, conceived and designed the study, drafted the manuscript, conducted all statistical analyses, and provided final approval of the submitted manuscript. Brian M. D'Onofrio, PhD, associate professor, contributor, and guarantor, provided substantial contributions to the conception and design of the study, provided supervision, critical revisions of the manuscript, statistical expertise, and final approval of the submitted manuscript. Paul Lichtenstein, PhD, professor, contributor, and guarantor, provided substantial contributions to the conception and design of the study, provided supervision, critical revisions of the manuscript, acquired data, and provided the final approval of the submitted manuscript. Niklas Långström, MD, PhD, professor, contributor, provided substantial contributions to the conception and design of the study, performed critical revisions of the manuscript, and provided the final approval of the submitted manuscript.

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