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ORIGINAL PAPER

Intergenerational Replication of Teenage Pregnancy and Educational Attainment in Mexico

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Abstract

Mexico ranks among the OECD countries with the highest prevalence of teenage pregnancies, exhibiting a fertility rate of 70.6 births for every 1000 adolescents. Mexican adolescents with a history of pregnancy are twice as likely to lag behind in their studies as those who have not been pregnant. Research on adolescent maternity and its explanatory mechanisms is required as a basis for implementing policies and programs that effectively curb teenage pregnancy-related behaviors, prevent educational gaps, and reduce the intergenerational transmission of poverty. Based on quasi-experimental methodology and a non-recursive structural equation model with instrumental variables, this paper analyzed the intergenerational transmission of teenage pregnancy from mothers to daughters, as well as the relationship between teenage pregnancy and educational attainment. Using data from the 2009 National Survey of Demographic Dynamics in Mexico, our estimated model indicated a unidirectional relationship from teenage pregnancy to educational attainment. An association was observed between teenage pregnancy and an increased probability of a moderate or severe educational gap (≥ 1 year) by $21\% \pm 5$ and a severe educational gap (≥ 2 years) by $33\% \pm 8$. Adolescents whose mothers reported teenage pregnancy at < 15 years of age were approximately 84% more likely to experience teenage pregnancy themselves than other adolescents. Relevant explanatory mechanisms included low socioeconomic status and a low level of education in the household. Mexico needs to formulate, implement, and expand comprehensive and early prevention strategies as well as teenage pregnancy care throughout its most vulnerable regions. Efforts should be made at the individual, family, and community levels; incorporate alliances with teenage networks; actively engage parents, teachers, and health care providers; and reinforce educational initiatives on sexual and reproductive health for adolescents. It would be convenient for the Government to implement public policies that emphasize the results obtained. There is no better instrument than to show the evidence of the gradual deterioration of human capital in Mexico associated with adolescent pregnancy.

Keywords Teenage pregnancy · Educational attainment · Poverty traps · Intergenerational transmission · Social Policy · Endogeneity bias

Introduction

National public policy agendas have prioritized teenage maternity as an urgent public health problem. Unlike women who delay maternity, teenage mothers face daunting socioeconomic disadvantages in the short, medium and long terms, owing partly

Memorial dedication: We dedicate this paper to our colleague Dr. Sandra Sosa-Rubi who passed away in March 2021. Dr. Sosa will be remembered as a remarkable health economist, friend, and human being.

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to their lower educational levels and diminished employment perspectives (Wildsmith et al., 2012).

The most important short-term consequences of teenage pregnancy relate to human capital accumulation (Chaaban & Cunningham, 2011). For instance, girls who have experienced a teenage pregnancy are 37 percent less likely to attend and complete middle school (Kruger et al., 2009). They face restrained development opportunities (Panday et al., 2009), substandard life projects, (Zeck et al., 2007) and unfavorable living conditions for themselves, their children and their immediate environments (Harper et al., 2003; Raneri & Wiemann, 2007; Zeck et al., 2007). The medium-term consequences of teenage pregnancy include limited labor opportunities and reduced access to resources required for proper child development (Castro & Juarez, 1995; Chaaban & Cunningham, 2011; Cunningham et al., 2008).

In Mexico, endeavors to improve the reproductive health of adolescents continue to encounter major challenges. An estimated 31.2% of adolescents aged 15–19 years engage in sexual activities, and of these, more than half (56%) become pregnant (Gutiérrez et al., 2012). Mexico ranks among the OECD countries with the highest prevalence of teenage pregnancies, exhibiting a fertility rate of 70.6 births for every 1000 adolescents. Furthermore, only 59.9% of sexually active adolescents use birth control (INEGI, 2018a). Teenage pregnancy occurs most frequently in population groups marked by low socioeconomic status (SES) (García Hernández, 2012). Mexican adolescents with a history of pregnancy are twice as likely to lag behind in their studies as those who have not been pregnant. The risk of educational delay is even greater among adolescents who have experienced more than one pregnancy. This suggests that teenage pregnancy may be directly affecting their possibilities for increasing their social capital (Villalobos-Hernández et al., 2015).

Teenage pregnancy poses a complex challenge caused by a large variety of factors that converge at the individual, family, community and other social levels. At the family level, numerous studies have documented the intergenerational transmission of teenage pregnancy, revealing that the daughters of adolescent mothers are more likely to become adolescent mothers themselves than the daughters of women who experience pregnancy at an older age (Kahn & Anderson, 1992; Liu et al., 2018; Sipsma et al., 2010). The literature suggests that transmission from the first birth can be directly attributable to a biological predisposition toward or heritability of the attitudes and norms related to early maternity. Intergenerational transmission of teenage pregnancy can also result indirectly from the socioeconomic environment surrounding the first precocious birth. Authors have recognized that a number of intrinsic and extrinsic factors either promote or mitigate the risk of having children in adolescence and its transmission across generations. Salient among these factors are the characteristics associated with adolescent maternity (age, marital status, educational level and ethnicity). In addition, the following also play a role: the family environment of the adolescents (household socioeconomic level, family structure and quality of child rearing; as well as adolescent attitudes and behaviors, that is, their educational expectations and life projects, level of self-esteem, social behavior and religious beliefs) (Wildsmith et al., 2012).

Although studies have investigated the educational consequences of teenage pregnancy, the directionality and extent of their relationship have remained unclear (Kane et al., 2013). There is a dearth of evidence from developing countries, not only on the mechanisms operating between teenage pregnancy and educational attainment, but also on the role of the former in the intergenerational transmission of poverty. Most authors have approached this issue using exclusively qualitative methods or exploring only the statistical associations between these processes (Stern, 2012). Assessing the ways in which teenage pregnancy translates into lower educational attainment poses an empirical challenge, given the endogenous nature of the systematic differences in educational attainment between girls who have/not experienced teenage pregnancy (Chevalier & Viitanen, 2003; Levine & Painter, 2003). Few studies have analyzed the connection between teenage pregnancy and education isolating observable (Ferre et al., 2013; Ranchhod et al., 2011) and non-observable (Kruger et al., 2009) differences. The one study using matching methods in Mexico (Arceo-Gomez & Campos-Vazquez, 2014) found that teenage pregnancy led to educational lags ranging from 0.6 to 0.8 years of schooling; other Mexican studies on the subject suffer from limitations concerning their selected comparison groups (Echarri Cánovas & Pérez Amador, 2007; Menkes & Suárez, 2003; Villalobos-Hernández et al., 2015).

Educational attainment has been linked to capital investment, social mobility and the ability to overcome poverty (OXFAM, 2019). In particular, human capital accumulation has been found to be strongly associated with breaking the poverty trap (Deaton, 2013; Fogel, 2004; Piketty, 2015). Poverty impedes human capital accumulation; when the effects of low human capital become irreversible, a poverty trap emerges and is persists into future generations.

Based on the conceptual framework of human capital and the poverty trap developed by Mayer-Foulkes (2008), this paper aims to examine the intergenerational mother-daughter transmission of teenage pregnancy and its role in the relationship between teenage pregnancy and educational attainment. Mayer-Foulkes explains the dynamics of the intergenerational human capital trap, analyzing its long-term presence in Mexico rooted in low human capital accumulation. The results of his research indicate that poverty traps are characterized by a functional relationship between parental wealth and the future income of their children. The theorical causal path that explains the poverty trap lies in the fact that the absence of capital investment in areas such as health and education can restrict the returns

from education and, hence, the accumulation of social capital and future income generation.

To put this research in context, a poverty trap is "any self-reinforcing mechanism which causes poverty to persist" (Azariadis & Stachurski, 2005). Following this rationale, and from a micro-level perspective, teenage pregnancy constitutes a potential poverty trap mechanism. Pregnancy and childbirth compromise the health, education and earning potential of teenage girls, locking them into a lifetime of poverty, exclusion and powerlessness (UNFPA, 2013). Teenage pregnancy jeopardizes the health of mothers and their offspring, increasing the risk, not only of maternal mortality, illness, and disability, but also of health problems among children in their first years of life. Young mothers tend to interrupt their formal education and are thus deprived of the opportunity to realize their full potential; they are excluded from paid employment and a satisfactory livelihood. Teenage pregnancy, along with its financial consequences, is passed down from teenage mothers to their offspring. Children from adolescent mothers begin their lives with disadvantages relative to other children. Ensuing adversities extends to the households and communities of these young mothers, culminating in a poverty trap.

In order to achieve our aims, we used a non-recursive structural equation model with instrumental variables, in combination with propensity score matching methods. Our methodological strategy incorporated a reciprocal directionality between teenage pregnancy and educational gaps, separating the direct/indirect paths of teenage pregnancy, maternal teenage pregnancy and socio-demographic factors associated with educational gaps in the study population. We hypothesized that the risk of teenage pregnancy was higher among girls whose mothers had experienced teenage pregnancy and that the likelihood of an educational gap increased with the occurrence of teenage pregnancy. The rationale behind these mechanisms is founded on the framework concerning the intergenerational transmission of disadvantages.

Method

Participants

We conducted a retrospective analysis of data from the population-based National Survey of Demographic Dynamics (ENADID by its Spanish initials), 2009, in Mexico. ENADID is a periodic, cross-sectional, probabilistic and retrospective survey representative at the national and state levels (Mexico has 32 states) as well as by rural/urban strata. Implemented by the National Institute of Statistics and Geography of Mexico, ENADID features a complex multistage sampling design and provides the main source of high-quality statistical information on the socioeconomic and demographic characteristics of the Mexican population. Details on its methodology have been published elsewhere (INEGI, 2018b). Following the recommendations of the world's leading agencies on demographics, ENADID 2009 was carried out in accordance with the Demographic and Health Surveys (DHS) (INEGI, 2018b). It administered a reproductive health module to all women 12–54 years old ($n = 112{,}159$). Our study did not require approval from the ethics committees of our institutions since analysis was based on publicly available secondary data.

Our analytical sample included 19,539 Mexican girls between the ages of 12 and19 years, daughters of household heads, for whom teenage pregnancy data were recorded. Adolescents with incomplete basic socio-demographic information were excluded from analysis, leaving a final sample of 18,601 individuals aged 12–19 years (with a non-response rate = 4.8%), of whom 11,258 were aged 15–19 years. We limited our structural equation modeling (SEM) analysis to the latter, as the information on contraceptive use required by model specifications was available exclusively for this age group. We also excluded inconsistent cases as regards teenage pregnancy status and the age at which the adolescents had given birth or lost a child ($n = 252$, 2.2%). After eliminating individuals with missing variable values, the analysis sample for SEM models comprised 10,622 adolescents (with a non-response rate = 5.7%).

Measures

We used educational attainment, our main endogenous variable, as a proxy for the stock of human capital (Patrinos, 2018), and measured this variable through the educational gaps of the adolescent mothers analyzed. We defined educational attainment as the difference between the number of expected years of schooling, according to age, and the number of school years self-reported by respondents (Darney et al., 2016). Educational gaps were operationalized into two binary variables classified as moderate or severe (≥ 1 year) and severe (≥ 2 years) educational gaps. The first definition offered higher sensitivity but lower specificity for detecting the actual educational gaps, while the second offered higher specificity but lower sensitivity. We could have determined even higher degrees of educational gap by selecting a higher cutoff; however, this would have resulted in more limited sample sizes for the event category.

We defined teenage pregnancy as our main exposure variable for educational gaps based on a recent debate regarding the international convention on the measurement of teenage pregnancy (Blum et al., 2014) and the revised definition of adolescence by the World Health Organization (WHO) as the period between the ages of 10 and19 years (WHO, 2018). We measured teenage pregnancy as a binary variable equal to one for women who self-reported at least one pregnancy (multiple or not, and whether or not the child was born alive) between the ages of 12 and 19 years, and equal to zero otherwise. We

also took into account the following endogenous variables: the maximum number of years of schooling in the household, access to social programs such as the Prospera conditional cash-transfer program and the PROAGRO Program, a scheme of direct support to agriculture; and a household SES index based on assets and constructed housing. The index was developed through principal component analysis using a polychoric correlation matrix (Kolenikov & Angeles, 2004), with higher scores indicating higher SES.

The exogenous variables included the type of family (nuclear or extended); ethnicity (indigenous or non-indigenous) according to the official definition in Mexico (CDI, 2017); the characteristics of the head of household such as age, gender and employment status; the number of equivalent adults in the household; health insurance status (Social Security, *Seguro Popular de Salud* or none); an indicator variable for having a birth place different from the place of residence; the size of the place of residence: rural (< 2,500 inhabitants), urban (2,500–99,999 inhabitants) and metropolitan (> 100,000 inhabitants); an indicator variable for non-use of contraception at first sexual intercourse; and two indicator variables for the age at which the mother of the teenager became pregnant during adolescence: < 15 or 15–19 years. We assumed that the wives of the male heads of households (77% of the sample) and the female heads of households were the biological mothers of the adolescents in our sample. The characteristics concerning SES, household and place of residence of the adolescents in our sample were selected given their potential role as explanatory variables for both teenage pregnancy and educational gap. We adjusted for such variables with a view to reducing the residual variance of the outcomes and enhancing the information from our estimated models. Figure 1 shows the a-priori hypothesized direction of the main path coefficients. We expected teenage pregnancy and educational gap to exhibit a positive relationship with variables such as indigenous status, rurality, a larger household size, a non-nuclear family type and having no medical insurance, and an either positive or negative relationship with other exogenous covariates. These variables have been used previously by other studies as predictors of sexual and reproductive health as well as educational outcomes (Arceo-Gomez & Campos-Vazquez, 2014; García Hernández, 2012; Hardy et al., 1998; Villalobos-Hernández et al., 2015). Section A of the Supplementary Material details the analyzed variables and the specified mathematical structure of the models used for this analysis.

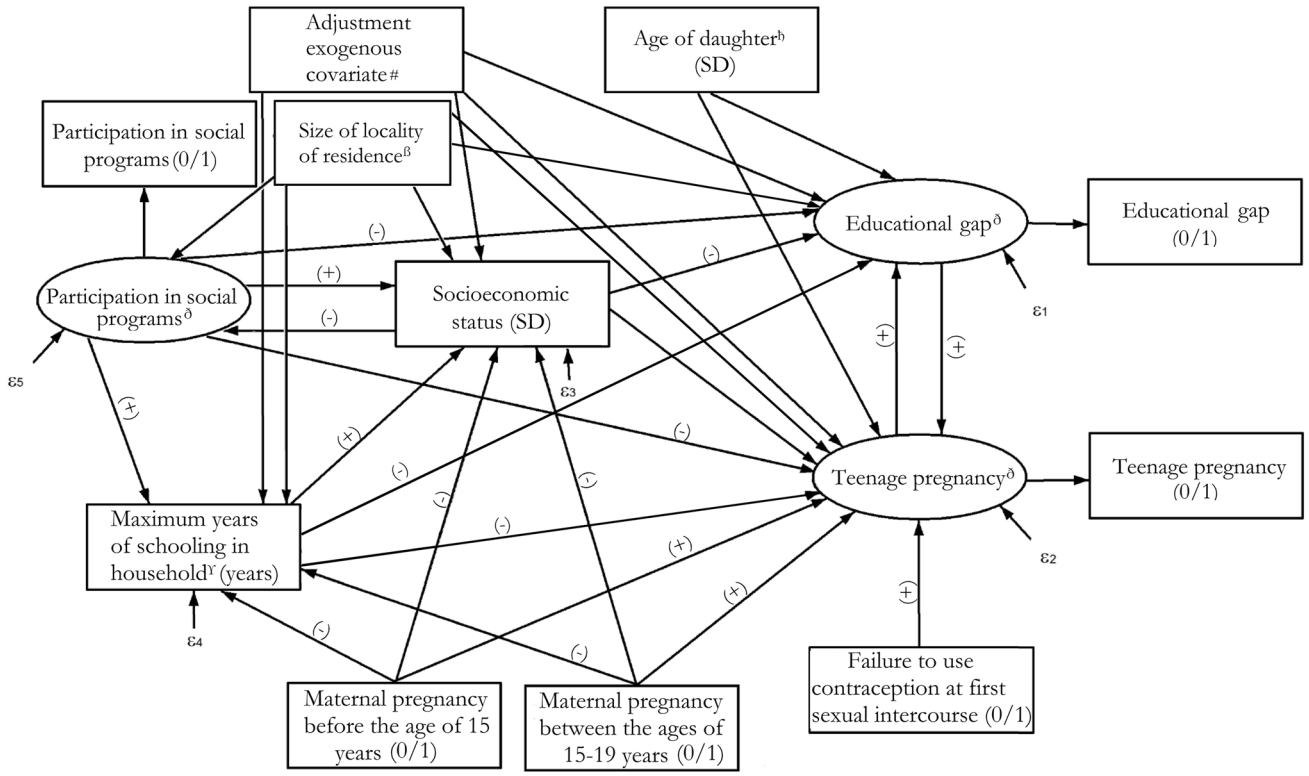

Fig. 1 Theorical framework and path diagram of structural equations for modeling intergenerational replication of teenage pregnancy and contemporary educational gaps. # Includes non-nuclear family, indigenous household, sex (male) and age of head of household, number of equivalent adults in household, having no medical insurance, having Social Security coverage, and having a different birthplace from the place of residence. ß Includes size of place of residence (urban, metropolitan and rural as reference category). Þ Includes age (standardized) and the indicator variable for being 19 years old. ð modeled as latent variables

Statistical Analyses

Endogeneity in the teenage pregnancy-educational gap relationship rendered it difficult to identify the path from teenage pregnancy to educational gap. To tackle this problem, we ran a non-recursive structural equation model with instrumental variables (IV-SEM) (Paxton et al., 2011) including double directionality between teenage pregnancy and educational gap as our main analytical approach. The IV-SEM strategy controlled for differences between teenage girls who had/not experienced teenage pregnancy from observable variables; however, it also served to control for potential unobservable characteristics through the inclusion of instrumental variables indirectly related to the final outcome (i.e., educational gap), in this case through teenage pregnancy. Figure 1 presents a simplified version of the SEM along with the theoretical expected signs of the path coefficients.

Teenage pregnancy was instrumented by maternal teenage pregnancy and non-use of contraception at first sexual intercourse. Tests on the validity and weakness of instruments (Stock & Yogo, 2005) suggested that these instruments were adequate. They were also theoretically adequate since they would not be expected to explain educational gaps directly but by means of their path indirectly through mediators such as teenage pregnancy (null of valid IV: $p = 0.67$; null of weak IV: $p < 0.01$). We assumed that maternal teenage pregnancy could influence educational gaps only through its impact on the maximum number of years of schooling in the household, the SES of the household and the teenage pregnancy of the daughter. Bidirectional paths were also specified for the relationship between adolescent access to social programs and SES, since one or several of the criteria for program eligibility may be directly related to SES.

Using the SEM approach, we estimated the direct, indirect and total paths of each exogenous variable, including maternal teenage pregnancy, on each endogenous variable. Standard errors of indirect paths were obtained through the Delta method to build a z statistic for testing. Of special interest to our hypotheses were the total path (direct + indirect paths) of maternal teenage pregnancy on teenage pregnancy and its indirect path on educational gap. At the household level, our model implied that maternal teenage pregnancy could result in lower SES and fewer number of years of schooling for the household. It could also directly and indirectly (through the abovementioned household variables) increase the probability of teenage pregnancy in daughters. In turn, these implied changes entailed a higher probability of incurring an educational gap (see Fig. 1). A complete description of model equations is provided in Section A of the Supplementary Material. The model was fitted separately to data concerning moderate or severe (≥ 1 year) as well as severe (≥ 2 years) educational gaps. Since the observed teenage pregnancy, educational gap and social programs were binary indicators, we modeled them as latent variables.

We contrasted our SEM estimates with those obtained from propensity score matching and a naïve adjusted probit regression model with robust standard errors (SEs). This approach is known to reduce systematic differences between adolescent girls who have/not been pregnant based on observable variables. We estimated a propensity score based on the observable characteristics of both groups, which allowed us to address selection bias by building an adolescent comparison group and comparing similar adolescent girls based on their observable characteristics (Dehejia & Wahba, 2002). Using caliper = 0.01 and common support, we contrasted three algorithms: nearest neighborhood without replacement, kernel and radius matching (Dehejia & Wahba, 2002). Additional analyses (not shown) suggested that the matching processes met balancing and bias reduction conditions.

Having performed probit regression and SEM estimation, we assessed the changes in educational gap explained by teenage pregnancy through predictive margins, expressing them as probability ratios between those with and without teenage pregnancy. The predictive margins were obtained through the SEM procedure by following three steps: (1) substituting the solution of the subsystem of equations (SES, maximum years of schooling in household and social programs*) in the two main equations of the model (educational gap* and teenage pregnancy*) for each observation; (2) obtaining the bivariate density of educational gap* and teenage pregnancy* conditioned to the solution of SES, maximum number of years of schooling in the household and social programs* and the observed exogenous variables; and (3) calculating the four probabilities of the joint teenage pregnancy and educational gap outcomes for each observation, integrating the double integral of the bivariate density of the latent variables with the integration limits set accordingly using the thresholds. All effects were averaged according to the covariate characteristics of women who had experienced a pregnancy (also known as average treatment effect on the treated-ATT in the literature) (see details in Section A of the Supplementary Material). Standard errors from probit regression were obtained through the Delta method (Oehlert, 1992) and those from the SEM procedure by resampling primary sampling units with 1,000 bootstrap replications.

Mean and proportion differences between included ($n = 10{,}622$) and excluded ($n = 636$) individuals from SEM analyses were tested using a t statistic for means and a chi-squared statistic for proportions, adjusting standards for data dependencies within primary sampling units (Rogers, 1994). These differences as well as naïve and matching analyses were conducted on Stata v15.1, and SEM analyses on Mplus v7.1, using weighted least squares based on the mean and variance adjustment method of estimation and theta parameterization, with adjustment of standard errors for data dependencies within primary sampling units (Muthen & Muthen, 2017).

Results

Prevalence of teenage pregnancy was 2.6% (0.14% in adolescents aged 12–14 years and 4.37% in those aged 15–19 years). Among the 15–19-year olds, 60% exhibited moderate or severe educational gaps with an average gap of two years, while approximately 27% showed severe educational gaps with an average gap of 3.3 years (Table 1).

Compared to adolescents who had never been pregnant, those reporting a teenage pregnancy were older and more likely to live in large metropolitan areas (Table 2). A larger percentage reported not having health insurance (39.2% vs 32.8%) as well as not having used contraception in their first sexual intercourse (77.8% vs 2.9%), while a smaller percentage lived in indigenous households and a smaller percentage benefited from social programs. Teenage pregnancy prevalence was not independent from the teenage pregnancy history of the mothers: nearly 65% of adolescents who reported at least one teenage pregnancy had mothers who had experienced a teenage pregnancy themselves (approximately 20 percentage points more than those who did not). Finally, the proportion of female-headed households was higher and the average SES lower in the teenage pregnancy group.

Figure 2 shows the main path coefficients of statistical significance yielded by the IV-SEM procedure for severe educational gap among teenagers aged ≥ 15 years ($n = 10{,}622$). Teenage pregnancy was directly associated with a higher probability of a severe educational gap, but not the reverse. Furthermore, higher SES and the maximum number of years of schooling in the household were directly associated with a lower probability of a severe educational gap; the maximum number of years of schooling in the household was also related to a lower teenage pregnancy probability.

After obtaining the overall teenage pregnancy probability in the sample and adjusting for covariates, we found that adolescents whose mothers reported a teenage pregnancy at an age < 16 years faced a markedly higher (84%) probability of experiencing a teenage pregnancy than other adolescents, considering both direct and indirect paths (0.307 ± 0.100 increase in probit scale). We also noted that maternal teenage pregnancy at an age either < 15 or from 15 to 19 years had an indirect and significant path on the propensity of experiencing an educational gap, mainly as a result of its direct negative path on the maximum number of years of schooling in the household (0.465 ± 0.058 and 0.312 ± 0.035 in probit scale, respectively). When comparing teenagers whose mothers had not been pregnant at an age < 15 years, an association emerged between maternal teenage pregnancy and a lower SES. This, in turn, was related to a greater probability of experiencing an educational gap, given the proven connection between the latter and lower SES levels (Fig. 2). The indirect relation of maternal teenage pregnancy at an age < 15 years on severe educational gaps was similar in magnitude to the direct relation of the daughters' teenage pregnancy on severe educational gaps (0.465 ± 0.058 and 0.482 ± 0.045 in the probit scale). The effect of maternal teenage pregnancy at 15–19 years on severe educational gaps was also significant, although of lesser magnitude. That is, having a mother who had been pregnant either at < 15 years or between 15 and 19 years resulted in an increased probability of incurring a severe educational gap, particularly among adolescents whose mothers had been pregnant at an age < 15 years (0.465 ± 0.058 vs. 0.312 ± 0.035 in probit scale). Not using contraception at first sexual intercourse was strongly related to a greater probability of teenage pregnancy (see Fig. 2). All indirect and total effects under the proposed model structure as well as estimated coefficients (for severe and moderate educational gaps) are available as Supplemental Material B (B1 and B2).

Table 1 Pregnancy and educational gaps among Mexican adolescents

Age (yrs)	Sample size (n)	Teenage pregnancy (%) [SE]	Educational gap			
			Moderate or severe (≥ 1 year)		Severe (≥ 2 years)	
			% [SE]	Mean [SE]	% [SE]	Mean [SE]
12	2,497	0.04 [0.04]	58.6 [1.00]	1.31 [0.02]	11.0 [0.66]	2.63 [0.07]
13	2,677	ncr	59.2 [0.99]	1.40 [0.03]	12.4 [0.68]	2.92 [0.08]
14	2,805	0.36 [0.11]	58.0 [0.96]	1.48 [0.03]	15.0 [0.71]	2.86 [0.08]
12–14	7,979	0.14 [0.04]	58.6 [0.60]	1.40 [0.02]	12.9 [0.42]	2.82 [0.05]
15	2,473	0.81 [0.18]	62.9 [0.99]	1.54 [0.03]	16.5 [0.77]	3.06 [0.08]
16	2,307	1.30 [0.24]	59.6 [1.06]	1.67 [0.04]	17.3 [0.82]	3.31 [0.08]
17	2,259	3.63 [0.39]	62.5 [1.05]	1.99 [0.04]	32.4 [1.02]	2.90 [0.06]
18	1,906	7.71 [0.60]	67.7 [1.10]	2.49 [0.06]	39.1 [1.14]	3.57 [0.07]
19	1,677	11.0 [0.77]	44.4 [1.24]	2.96 [0.07]	33.0 [1.19]	3.64 [0.08]
15–19	10,622	4.37 [0.20]	60.0 [0.53]	2.02 [0.02]	26.7 [0.49]	3.30 [0.04]
Overall	18,601	2.55 [0.12]	59.4 [0.42]	1.76 [0.02]	20.8 [0.36]	3.17 [0.03]

ncr = no cases reported. Standard errors were adjusted by primary sampling units

Table 2 Sample characteristics by teenage pregnancy status among Mexican adolescents

Sample size	Mean or % (95% CI)		Mean or % Difference (95% CI)
	Teenage pregnancy	No teenage pregnancy	
	n = 475	n = 18,126	
Outcome variable			
Educational gap: ≥ 1 year (%)	85.7 (82.2, 88.6)	58.7 (57.9, 59.6)	27.0 (23.7, 30.2)
Gap (years)	3.30 (3.11, 3.49)	1.70 (1.67, 1.73)	1.60 (1.41, 1.79)
Educational gap: ≥ 2 years (%)	73.5 (69.3, 77.3)	19.4 (18.7, 20.1)	54.1 (50.0, 58.1)
Gap (years)	3.68 (3.49, 3.87)	3.12 (3.06, 3.18)	0.56 (0.37, 0.75)
Individuals			
Age (years)	17.9 (17.8, 18.0)	15.1 (15.1, 15.2)	2.7 (2.6, 2.9)
Reported having had sexual intercourse (≥ 15 years)	100	8.9 (8.4, 9.5)	91.1 (90.5, 91.6)
Age at first sexual intercourse (≥ 15 years)	15.32 (15.20, 15.44)	16.41 (16.32, 16.51)	− 1.09 (− 1.24, − 0.94)
Use of no contraception at first sexual intercourse (≥ 15 years)[a]	77.8 (73.7, 81.4)	2.9 (2.6, 3.2)	74.9 (71.1, 78.8)
Birthplace: different from place of residence	8.0 (5.9, 10.8)	7.9 (7.4, 8.4)	0.1 (− 2.4, 2.5)
Health insurance			
Social Security	22.5 (19.0, 26.5)	43.2 (42.2, 44.2)	− 20.7 (− 24.5, − 16.8)
Seguro Popular	38.3 (34.0, 42.8)	24.0 (23.1, 25.0)	14.3 (9.8, 18.8)
None	39.2 (34.8, 43.7)	32.8 (31.9, 33.7)	6.4 (1.9, 10.9)
Household			
Maternal teenage pregnancy			
< 15 years	15.8 (12.7, 19.4)	7.6 (7.1, 8.1)	8.2 (4.8, 11.5)
15–19 years	49.3 (44.7, 53.8)	38.0 (37.2, 38.9)	11.2 (6.7, 15.8)
> 19 years	34.9 (30.7, 39.4)	54.3 (53.4, 55.3)	− 19.4 (− 23.8, − 15.0)
Head of household			
Male	65.1 (60.7, 69.2)	79.8 (79.0, 80.5)	− 14.7 (− 19.0, − 10.4)
Age (years)	17.87 (17.75, 17.98)	15.12 (15.09, 15.16)	2.74 (2.63, 2.86)
Working	83.6 (80.0, 86.7)	88.3 (87.7, 88.9)	− 4.7 (− 8.1, − 1.4)
Maximum years of schooling in the household	10.60 (10.35, 10.84)	11.49 (11.42, 11.57)	− 0.90 (− 1.15, − 0.65)
Number of equivalent adults in the household	4.44 (4.29, 4.58)	3.73 (3.70, 3.76)	0.71 (0.56, 0.85)
Type of family (extended vs. nuclear)	92.6 (89.9, 94.7)	17.4 (16.8, 18.1)	75.2 (72.8, 77.6)
Indigenous status	6.5 (4.6, 9.2)	9.7 (8.8, 10.7)	− 3.2 (− 5.5, − 0.9)
Receives cash transfers from a social program	25.1 (21.3, 29.3)	29.3 (28.2, 30.5)	− 4.3 (− 8.3, − 0.3)
Socioeconomic status (SES), (SD)	− 0.15 (− 0.27, − 0.03)	0.06 (0.02, 0.10)	− 0.21 (− 0.33, − 0.09)
Place of residence			
Rural	16.8 (13.6, 20.7)	22.8 (21.4, 24.3)	− 5.9 (− 9.5, − 2.4)
Urban	30.3 (26.2, 34.8)	29.6 (28.3, 31.0)	0.7 (− 3.5, 4.9)
Metropolitan	52.8 (48.2, 57.5)	47.6 (46.2, 49.0)	5.3 (0.7, 9.8)

[a]Women who reported no sexual intercourse were included as non-users. Standard errors were adjusted by primary sampling units

We compared the relationship of teenage pregnancy with educational gap using three analytic approaches (Table 3): all three indicated the same direction, with teenage pregnancy increasing the probability of educational gaps. Regardless of the severity of the educational gap, the smallest relative probabilities were yielded by the IV-SEM approach. With respect to the non-teenage pregnancy group, the teenage pregnancy group showed a 33 ± 8 percent higher probability of severe educational gaps under IV-SEM analysis as opposed to a 61 ± 9 percent higher probability under NN-1 propensity score matching. The probit model yielded figures in between the two.

Analysis of differences between excluded and included individuals aged 15–19 years showed that those excluded were on average younger (− 0.23 ± 0.05, $p < 0.001$) and exhibited lower household SES (− 0.21 ± 0.06, $p = 0.001$) as well as a higher number of equivalent adults in their households (0.18 ± 0.06, $p = 0.002$). A lower percentage received income from social programs (27% vs 20%, $p < 0.001$), a higher percentage lived in non-nuclear households (35.5% vs 22.3%, $p < 0.001$), a lower

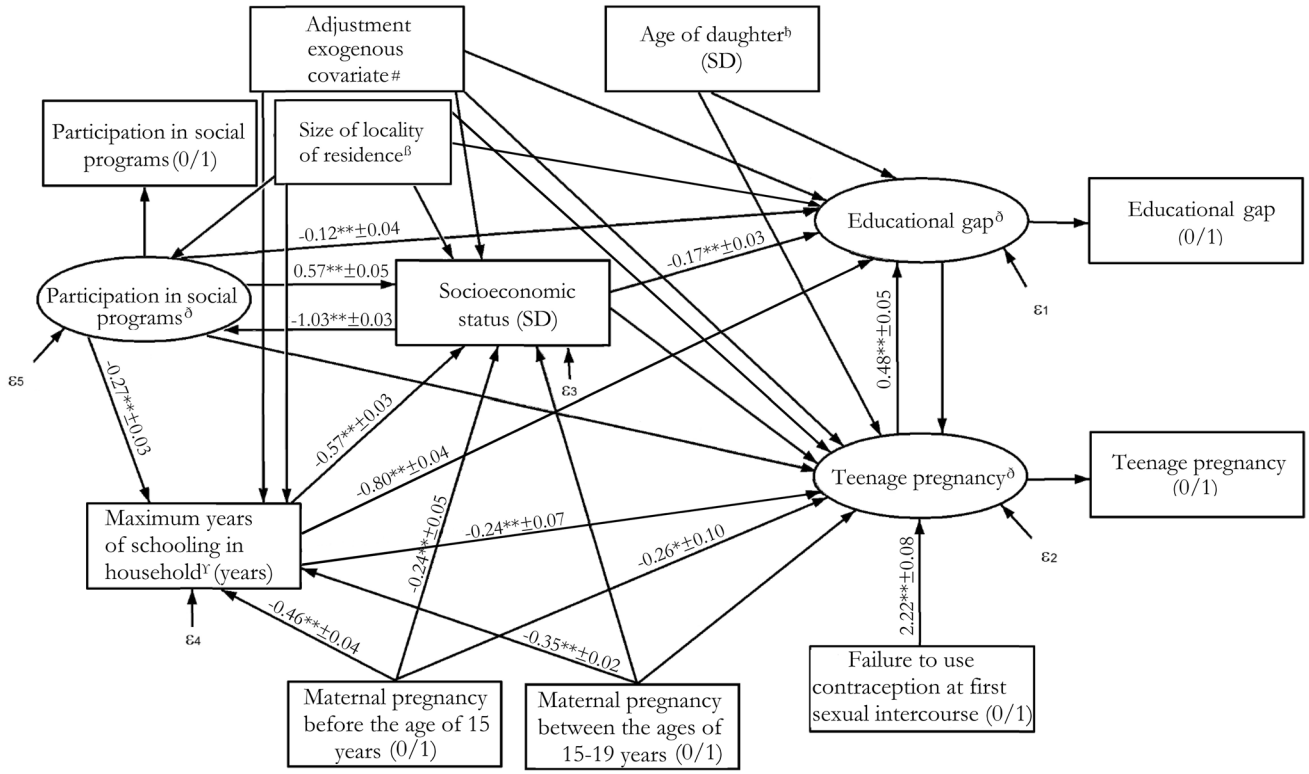

Fig. 2 Estimated structural equations for the intergenerational replication of teenage pregnancy and contemporary educational gaps defined as lags of ≥ 2 years. # Includes: non-nuclear family, indigenous household, sex (male) and age of head of household, number of equivalent adults in household, having no medical insurance, having social security, and birthplace different from place of residence. ß Includes: size of locality of residence were included (urban, and metropolitan, with rural as reference category). Ƭ Includes: age standardized and an indicator variable of being 19 years old. ð Modeled as latent variables

Table 3 Effect of teenage pregnancy on moderate and severe educational gaps among teenage women, and covariate characteristics of women who experienced teenage pregnancy

	Probit	Propensity score matching[b]			IV-SEM[a]
		NN-1	Kernel	Radius	
Educational gap defined as ≥ 1 year lag					
P(Educational gap = 1 | Teenage pregnancy = 1)	86.7 [1.42]	85.5 [1.76]	86.3 [1.66]	86.4 [1.66]	78.7 [3.82]
P(Educational gap = 1 | Teenage pregnancy = 0)	67.2 [1.02]	67.9 [2.62]	69.8 [2.06]	69.8 [2.13]	65.1 [3.37]
Relative probability	1.29 [0.03]	1.26 [0.05]	1.24 [0.04]	1.24 [0.04]	1.21 [0.05]
Educational gap defined as ≥ 2 years lag					
P(Educational gap = 1 | Teenage pregnancy = 1)	75.6 [1.67]	73.4 [2.17]	74.8 [2.02]	75.1 [2.04]	62.1 [4.21]
P(Educational gap = 1 | Teenage pregnancy = 0)	51.2 [1.12]	45.7 [2.83]	49.7 [2.24]	50.3 [2.48]	46.4 [3.07]
Relative probability	1.48 [0.05]	1.61 [0.09]	1.51 [0.07]	1.49 [0.07]	1.33 [0.08]

Propensity matching methods were used to estimate the average effect of treatment for those treated. Predicted margins were estimated for pregnant teenagers via Probit and IV-SEM analyses

[a]Standard errors obtained using the Delta method

[b]Standard errors obtained after running 1000 bootstrap replications

percentage lived in indigenous households (5.7% vs. 9.0%, $p=0.026$), a lower percentage lived in households with a male household head (74.0% vs. 78.1%, $p=0.041$), a higher percentage had a birthplace different from their place of residence, (11.6% vs. 8.2%, $p=0.003$) and a higher percentage lived in metropolitan areas (53.4% vs. 49.5%). Also compared to included individuals, those excluded exhibited a lower percentage of teenage pregnancy (1.9% vs. 4.4%, $p=0.017$), a lower percentage

of moderate-to-severe educational gaps (50.6% vs. 60.0%, $p=0.001$), and a lower percentage of severe educational gaps (19.2% vs. 26.7%, $p=0.003$).

Discussion

This study tested the hypothesis that the risk of women experiencing teenage pregnancy is greater if their mothers experienced teenage pregnancy. After controlling for the structural, intermediate and direct determinants of teenage pregnancy, our analysis showed a unidirectional relationship from teenage pregnancy to educational gap under the studied conditions.

The estimation of educational gap, defined as the difference between the expected and the actual years of schooling in our study population, revealed that teenage pregnancy increases the probability of adolescents experiencing moderate or severe (≥ 1 year) and severe (≥ 2 years) educational gaps by $21\% \pm 5$ and $33\% \pm 8$, respectively. Our analysis also showed that teenage pregnancy is replicated from mothers to daughters; that is, adolescents whose mothers reported having been pregnant at an age < 15 years are roughly 84% more likely to experience teenage pregnancy than other adolescents. The intermediate mechanisms that exacerbate this effect include low household SES and educational attainment. Our findings are consistent with those reported in other studies that have documented the intergenerational transmission of teenage pregnancy. In a previous study by Manlove (1997), which included 2,183 first-born girls, the daughters of adolescent mothers had odds of 1.61 of having their first child before the age of 21 years, compared to the daughters of women who became mothers at an older age (Manlove, 1997). In an analysis conducted by Hardy (1998) including 1,758 families from marginalized neighborhoods in the USA, the daughters of adolescent mothers had odds of 1.69 of experiencing a teenage pregnancy, compared to becoming pregnant at ages 20–24 (Hardy et al., 1998). Similarly, Meade (2008) found that the daughters of adolescent mothers had a relative risk of 1.66 (95%CI 1.29–2.12) of becoming adolescent mothers themselves (Meade et al., 2008). Other studies have shown that this association increases with the number of adolescent pregnancies experienced by the mother. For example, Liu (2018) showed that the a OR of daughters who experienced an adolescent pregnancy was 1.42 (95%CI 1.25–1.61) if their mothers had experienced one, 1.97 (95%CI 1.71–2.26) if they had experienced two, and 2.17 (95%CI 1.84–2.56) if they had experienced three or more adolescent pregnancies, when compared with none (Liu et al., 2018).

The observed relationship between intergenerational teenage pregnancies could be explained in part by socioeconomic factors that are shared between mothers and their daughters. The family environment can also play an important role. In this study, the number of educational years in the household and the type of family (extended or nuclear) in which the adolescents were brought up proved significant. This can be attributed, at least in part, to family environment factors such as the influence that parents have, either directly or indirectly, on the knowledge and attitudes of their children regarding sexual behavior (Kahn & Anderson, 1992; Wildsmith et al., 2012). In relation to fertility during adolescence, mothers who experience premature births can transmit messages—particularly positive ones—regarding the formation of a family at an early age (Kahn & Anderson, 1992).

In the Mexican context, teenage pregnancy bears primarily on the disadvantaged social sectors. It clearly manifests a capacity for intergenerational replication and is conducive to moderate and severe educational gaps, contributing to the poverty trap cycle. However, our findings on the directionality of the relationship between teenage pregnancy and educational attainment are not conclusive. Our results are consistent with those of several authors (Arceo-Gomez & Campos-Vazquez, 2014) but not with others who affirm that teenage pregnancy is caused by poor educational attainment and high-school-drop-out rates (Stern, 2012).

To assess the ways in which teenage pregnancy influences educational gaps, we compared different approaches including probit regression, propensity score matching algorithms and IV-SEM analysis. As the differences were calculated based on the ATT, a counterfactual model was estimated exclusively for those who had experienced teenage pregnancy. Notwithstanding some variation among methodologies as to the size of the effects, all estimates indicated the same direction, and all sizes proved practically and statistically significant. It should be noted that IV-SEM analysis captured mediating effects while the other methods considered them exogenous covariates. Finally, the IV-SEM approach enabled us to avoid bias regarding un/observable differences between exposure groups. Consistency among methodologies strengthened our results and highlighted the relevance of teenage pregnancy as a mechanism in poverty traps and human capital accumulation.

As mentioned above, we found significant directionality from teenage pregnancy to educational gap but not the reverse. It should be noted that the best means of estimating complex relationships is a carefully designed longitudinal study. However, the measurement lag should not be significantly greater than the time lag between cause and effect (Bollen, 1989). When it is impossible to meet these conditions, a cross-sectional analysis may be called for, with the caveat that this methodology addresses variation between rather than within subjects. It is also important to bear in mind that measurements obtained at a given moment are not necessarily contemporary. For example, a teenage pregnancy event could be related to something that occurred before the educational gap or vice versa. For this reason, we believed it was important that our model detect relationships in both directions. Given that educational gaps were defined using

the current age of participants, it was more likely that teenage pregnancy preceded the educational gap and, thus, that directionality would be more easily detected from teenage pregnancy to educational gap in this particular relationship. Finally, it should be noted that our model had good-fit indices. This does not imply that alternative structures might not also fit well with the data; the good-fit characteristic of the IV-SEM procedure highlights the importance of basing specifications on a conceptual framework prior to estimation. It is also worth mentioning that SEM literature uses the term "effect" assuming that the implied model is being used. In other words, causal interpretations are considered by the model structure; however, this does not imply that analysis actually establishes causality. An exception occurs when SEM is applied in experimental settings. We limited the use of causal language to avoid confusion arising from the use of the term "effect" in other disciplines.

As a result of our analyses, we began to disentangle the complex interrelation among education, poverty, type of household, family influence and adolescent fertility. We found that the relationship between teenage pregnancy and educational gap can be overestimated if endogeneity is not addressed, and confirmed that this is best corrected by using proxy variables indicating teenage pregnancy across generations as well as adolescent empowerment. This quality enables girls to make favorable decisions for their sexual and reproductive health, such as using contraception at first intercourse. These variables determine teenage pregnancy, not educational gap. We verified the robustness of our results by using two different statistical methods: propensity score matching and IV-SEM.

Our study had several limitations that should be noted. First, although ENADID is a high-quality, population-based survey, it is a cross-sectional investigation based on self-reported data; it is thus subject to the limitations of all observational studies, such as potential omitted-variable bias. Consequently, the conclusions reached lack the causal inference strength of a fully experimental design. Second, adolescents are especially prone to social desirability bias and therefore tend to under-report pregnancies, possibly leading to skewed results. Nonetheless, we used innovative methods to improve our inference. Third, we assumed that the wives of the male heads of households and the female heads of household were the biological mothers of the adolescents in our sample. While it might be reasonable to assume that women could be influenced by other women living under the same roof; ENADID did not allow for stratifying between nuclear and non-nuclear households. Nor did it allow for analyzing the influence of family members on the decisions of adolescent girls regarding their sexual and reproductive behavior. Fourth, unfortunately, ENADID 2009 did not collect the information of interest on the sexual and reproductive health of adolescents < 15 years old. This prevented us from applying our model to early adolescence. As has been recognized by other authors (Sawyer et al., 2018), a more inclusive definition of adolescence is essential in order to frame laws and social policies appropriately from a developmental perspective, and create relevant service systems. Accordingly, incorporating a more comprehensive vision in future ENADID editions would be of considerable use. We were unable to gather data on adolescents who reported no pregnancies at the time of the survey but may have subsequently experienced teenage pregnancy. Finally, we observed mean differences between individuals included/excluded in analysis for a number of variables.

Our study provides relevant and original contributions to knowledge regarding the relationships among teenage pregnancy, educational attainment and maternal teenage pregnancy in Mexico, based on a strong theorical framework. Thus, our findings carry useful implications for the design of policies and programs that not only improve the education of teenage girls, but also reduce the intergenerational transmission of poverty and curb behaviors conducive to teenage pregnancy. Mexico faces complex challenges in its efforts to effectively tackle teenage pregnancy and its consequences, as pledged under international commitments such as the United Nations Sustainable Development Goal *"Leaving no one behind."* It is imperative that the Government implement and expand early prevention strategies and teenage pregnancy care to include the most vulnerable sectors of the population. Like other low-and middle-income countries, Mexico needs to prioritize and reinforce strategies capable of achieving universal access to sexual and reproductive health services as well as to education on sexuality, health and other basic human rights. These strategies must be conducted at the individual, family and community levels, incorporating alliances with teenage networks, and actively engaging parents, teachers and health care providers. The Government urgently needs to implement public policies designed to empower teenage mothers and ensure synergies with social programs such as the Prospera conditional cash-transfer program, which achieved a favorable impact on the educational attainment of its beneficiaries. These actions will help mitigate the impact of teenage pregnancy on the suboptimal results of human capital accumulation.

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Data Availability (a) Data do not contain identifying or sensitive subject information; (b) there are no ethical restrictions to access the data; and (c) all data files are public.

Declarations

Conflict of interest The authors declare that they have no competing interests.

Ethical Approval This analysis was performed using secondary and public databases.

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