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Abstract
Public subsidies for contraception are often justified by claims regarding their benefits for women's lives, yet there is limited contemporary evidence supporting these arguments. Beginning in 2009 the Colorado Family Planning Initiative abruptly expanded access to the full range of contraceptive methods through Colorado's Title X family planning clinics. Using eleven years of American Community Survey data linked to decennial censuses, we assessed whether exposure to the program led to improvements in women's college completion. Exposure to the Colorado Family Planning Initiative at high school ages was associated with a 1.8–3.5-percentage-point population-level increase in women's on-time bachelor's degree completion, which represents a 6–12 percent increase in women obtaining their degrees compared with earlier cohorts. Federal and state policies restricting or expanding access to the full range of contraceptive methods can affect women's attainment of higher education in addition to their reproductive health.

Keywords: Education, Contraception, Access to Care
JEL Codes: J13, I21

Introduction

During the last fifty years, access to contraception in the US has been supported by dedicated public funding through the Title X federal family planning program. Benefits for women's lives are often cited as a key rationale for the program, yet there is limited contemporary evidence to support the claim that access to contraception affects important outcomes, such as attainment of higher education, at the population level. A bachelor's degree is increasingly critical for accessing the middle class in the US and has substantial benefits for health and socioeconomic trajectories. It is associated with higher lifetime earnings, intergenerational mobility, longer life expectancy, and reduced morbidity.[1–4]

Studies of the initial expansion of oral contraception in the 1960s and 1970s found that access to contraception affects college completion.[5,6] However, the impact of the introduction of the first hormonal method of contraception differs from the impact of expanded contraceptive access in the contemporary US. Current arguments that access to contraception improves women's college outcomes tend to rely on evidence demonstrating a negative relationship between family planning programs and early fertility combined with research showing a link between early fertility and lower educational attainment.[7,8] Teenage mothers disproportionately come from socioeconomically disadvantaged groups, however, and this underlying disadvantage predicts educational outcomes.[7] Such selection biases impede our understanding of whether expanded access to modern contraception has a causal impact on college completion.[9,10]

There are multiple pathways through which access to contraception could influence a young woman's on-time college completion. A primary potential pathway is the prevention of childbearing in adolescence and early adulthood. Avoiding early childbearing can free up time and money that could instead be used in pursuit of high school or college education. Research has shown that giving birth during the teenage years reduces educational attainment, with the strongest impact seen among those least likely to experience a teenage pregnancy.[7,11] Furthermore, childbearing after high school but before receipt of a bachelor's degree diminishes and delays college completion.[12,13]

Access to contraception could also influence on-time college completion through nonfertility pathways. Researchers have hypothesized that having the opportunity to reliably prevent childbearing may increase educational attainment by improving women's mental health or by expanding the confidence of women and their families that investments in education will yield benefits. Such influences may be particularly relevant for understanding college enrollment decisions and persistence to degree.[14,15]

At the same time, there are social forces that may work in opposition to these articulated pathways. The first is selection bias operating on early childbearing, as young women with the highest probabilities of teenage childbearing have comparatively few opportunities for socioeconomic advancement.[7,16] Second, early motherhood is not always detrimental to young women's educational attainment. Instead, the birth of a child can increase a mother's commitment to education for the sake of her child.[17]

In this study we assessed whether expanded access to contraception in adolescence led to an increase in college completion for young women. We used a natural experiment afforded by the Colorado Family Planning Initiative, implemented in late 2009, to estimate the population-level impact of expanded contraceptive access on women's "on-time" (by ages 22–24) completion of a bachelor's degree.

The Colorado Family Planning Initiative provided funding, training, social marketing, and provider support to ensure that all Title X family planning clinic clients in Colorado could choose any method of contraception approved by the Food and Drug Administration (FDA) without medically unnecessary barriers and at low or no cost.[18] The five full years during which the Colorado Family Planning Initiative was implemented (2010–14, "peak Colorado Family Planning Initiative") saw a dramatic increase in the use of long-acting reversible contraceptives (LARCs) and a corresponding dramatic reduction in birth and abortion rates for 15–19-year-olds.[19,20] Recently performed research found that the Colorado Family Planning Initiative increased women's high school completion statewide by 1.7 percentage points.[21] Importantly, women at risk of not completing high school may not be the same young women whose college completion is most likely to be affected by contraceptive access.[3,22] Thus, in the current study, we examined the next major milestone in human capital formation: completing a four-year college degree.

Study Data and Methods

Research Design

We used restricted data from two full-count decennial censuses (2000 and 2010) and eleven years of the American Community Survey (2009–19) to create an individual-level longitudinal data set containing demographics, educational attainment, and state of residence during adolescence. These data were linked at the individual level, using the Census Bureau–provided Protected Identification Key. Data on women both inside and outside Colorado allowed us to compare levels of on-time bachelor's degree completion for birth cohorts of young women with improved contraceptive access through the Colorado Family Planning Initiative with completion by earlier cohorts who experienced no change in contraceptive access.

We took an intent-to-treat approach, which means that we estimated the effect of the Colorado Family Planning Initiative on young women residing in Colorado at program initiation regardless of whether they directly used the program and regardless of whether they remained in Colorado for the duration of the study period. This allowed us to estimate the population-level impact of expanded access to contraception and not simply the effect among self-selected users of the program.

We used an event-study design to identify the impact of exposure to the Colorado Family Planning Initiative in high school on college completion.[23] We used American Community Survey data to measure educational attainment at ages 22–24, which provided a measure of on-time bachelor's degree (which we refer to as "college completion"). The American Community Survey is a nationally representative survey that samples approximately 3.5 million addresses yearly, covering approximately 1.5 percent of the population. We examined changes in the percentage of women who attained an on-time bachelor's degree over time, comparing women in Colorado from distinct birth cohorts with women in comparison places across the same birth cohorts. As illustrated in online appendix A,[24] our approach draws on data from women in eight single-birth-year cohorts (1987–94).

Adolescence is a period of heightening sexual activity, when reliable access to contraception could still affect high school completion as well as college planning, enrollment, and completion. We defined birth cohorts 1987–90 as pretreated cohorts because women born in these years were ages 19–22 in 2010, at the start of peak Colorado Family Planning Initiative—too old to have been exposed to the program during high school. We defined birth cohorts 1992–94 as treated cohorts because they were ages 15–17 at the start of peak Colorado Family Planning Initiative, and thus were exposed to the program in high school if they resided in

Colorado. Women in these treated cohorts who remained in Colorado would also have been exposed to peak Colorado Family Planning Initiative from age eighteen to age twenty-two. The 1991 birth cohort was age eighteen in 2010—between high school and college age—and therefore, we separated this cohort from the pretreated and treated cohorts.

Because the Colorado Family Planning Initiative was statewide, our area of exposure was all of Colorado. The census linkage was used to identify state of residence during adolescence. For women born in 1987–91, we used state of residence in 2000, when these women were ages 8–12. For women born 1992–94, we used state of residence in 2010, when these women were age 15–17. Results were not sensitive to changes in the census used for cohorts at the cut points. Although the ages at which state of residence was identified varied across cohorts, all cohorts' state of residence was determined before high school completion, and thus preceded migration that could be related to our outcome of interest. This is important because many young adults move out of state for college and work after high school.[25] In our data, 26.3 percent of respondents who were identified as being in Colorado at the relevant census were residing in another state when they responded to the American Community Survey. Migration in the other direction was even more common—33.1 percent of 22–24-year-olds in Colorado at the time of the American Community Survey were residing in another state during adolescence (see appendix F). Had we used a cross-sectional approach to exposure, we would have erroneously included in-migrants who were not exposed to the Colorado Family Planning Initiative during adolescence. A cross-sectional approach would also not address the selectivity of migration, which is relevant for our analysis, as young adults who migrated across state lines were more educated, on average, than nonmovers.

A key assumption of our event-study design is that the change in the outcome over time would have been the same in the intervention and comparison places in the absence of the Colorado Family Planning Initiative. Therefore, our principal comparison was between women in Colorado during adolescence and women who resided in states that had similar levels and trends in on-time bachelor's attainment in the period before the Colorado Family Planning Initiative. We identified so-called parallel trend states as those that were not statistically different in level or slope of on-time bachelor's attainment for women during 1987–90. This approach identified nine states: Delaware, Hawaii, Kansas, Maine, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. We also compared Colorado with all other US states ("rest of the US").

Statistical Analysis

To conduct our event study, we fitted individual-level regression models of attainment using data on women in birth cohorts 1987–94. For ease of interpretation and to allow for state-level clustering, we used ordinary least squares regressions.[26] Models included indicators of Colorado residence during adolescence for each cohort, which was our main estimator. We used the 1990 cohort, which was the last fully pretreated cohort in the event study, as the comparison. Models included the state-level unemployment rate, as the period under study includes the Great Recession; age and state fixed effects; and cohort fixed effects that account for secular trends across treated and untreated cohorts. Estimating equations and details on the analysis are available in appendix C.[24] Models were weighted using the American Community Survey–provided sample weights adjusted to account for group-level differences (cohort, age, racial and ethnic group) in Protected Identification Key assignment and linkage rates between the American Community Survey and census (76.8 percent of women from our cohorts in the American

Community Survey data were linked to the relevant census; see appendix I). Each Colorado birth cohort consisted of between 950 and 1,100 women.

Another key assumption of our event-study approach is that there were no other policies introduced in Colorado during the period under study that could explain observed changes in college completion. We identified two candidate policies: a 2009–10 expansion of concurrent enrollment in Colorado that widened access to courses that could be taken for both high school and college credit[27] and a 2013 policy that expanded eligibility for in-state college tuition to undocumented residents.[28] We addressed the possibility that these policies might explain the increase in college completion that we documented in two ways. First, although we expected the concurrent enrollment policy to affect young men and women roughly equally,[29] the impact of the Colorado Family Planning Initiative on on-time bachelor's attainment should predominately benefit women. Women's education is more likely to be curtailed through the aforementioned pathways, and fathers of teenage pregnancies tend to be older than their partners, which makes the Colorado Family Planning Initiative less likely to affect their on-time college completion.[30] Thus, we conducted a triple-difference analysis to determine whether college completion increased across all Colorado residents or only for young women, as we would expect if it were being caused by the Colorado Family Planning Initiative. The estimating equation and details of the analysis are available in appendix C.[24] Second, we re-ran the analysis, limiting the sample to individuals who were born in the US and thus would not have been affected by the change in undocumented residents' access to in-state tuition.

Limitations

Our study had several limitations. First, women's college completion was measured at ages 22–24, which were the oldest ages for which data are currently available for the treated cohorts. Many adults in the US complete college later, particularly young mothers,[13] so our study design missed some women's subsequent attainment of a bachelor's degree. Nonetheless, the sequencing of motherhood and education is important, with greater benefits accruing when college precedes childbearing,[31,32] making our focus on this age range appropriate. Second, our linkage of census and American Community Survey data, although essential for the careful identification of exposure, introduced potential bias to our sample because of missing linkages. We minimized this bias by adjusting the American Community Survey sampling weights for differential linkage rates by demographic characteristics.

Study Results

Exhibit 1 shows trends in women's on-time bachelor's degree across the three populations. Colorado's trend in college completion was generally flat between the 1987 and 1990 birth cohorts. These women were ages nineteen and older at the start of peak Colorado Family Planning Initiative. The Colorado 1991 cohort experienced a decline in college completion relative to pretrends, which was mirrored among Colorado men and thus unlikely to be related to the Colorado Family Planning Initiative (see appendix B).[24] Starting in the 1992 birth cohort, the oldest cohort to be exposed to the Colorado Family Planning Initiative at high school ages, there was a sizeable increase in women's college completion in Colorado that continued through the 1994 cohort.

Exhibit 2 presents the results of three event-study models estimating the effects of women's exposure to the Colorado Family Planning Initiative on attaining an on-time bachelor's degree. Point estimates comparing women in Colorado with women in parallel trend states and women in the rest of the US were similar, although confidence intervals were unsurprisingly larger for the former. Relative to the 1990 cohort, there was little variation in on-time bachelor's completion among Colorado women not exposed to the Colorado Family Planning Initiative at high school ages in Colorado compared with either comparison group. Beginning with the 1992 birth cohort (the oldest exposed to the Colorado Family Planning Initiative at high school age), there was a large percentage point increase observed in Colorado relative to comparison places (versus parallel trend states: 3.79, $p < 0.001$; versus rest of US: 3.21, $p < 0.001$). The percentage point increase was smaller for the 1993 birth cohort (versus parallel trend states: 3.01, $p = 0.036$; versus rest of US: 2.23, $p < 0.001$) and no longer statistically different for the 1994 birth cohort (see exhibit 3).

The triple-difference model included a third comparison to men, which accounted for Colorado-specific patterns across treated cohorts. This comparison erased the decrease in college completion among the 1991 cohort, as this decline was present among both Colorado women and men and showed a sustained increase in college completion among women in Colorado exposed to the Colorado Family Planning Initiative. Relative to Colorado men and similar cohorts in the parallel trend states, Colorado women in cohorts 1992–94 experienced 3.34-, 4.62-, and 2.52-percentage-point increases, respectively ($p < 0.001$ for all). Although the previous specifications showed that women in other states had caught up to Colorado women by the 1994 cohort, gains made among Colorado women relative to Colorado men persisted in this cohort. Exhibit 3 also shows that estimates limited to US-born women were of similar magnitudes and patterns.

Supplementary analyses in the appendix[24] confirmed that our primary results were not sensitive to changes in model specification or comparison populations. As a robustness test we estimated a synthetic control model, which yielded similar results to the event study, showing a sizeable increase in bachelor's attainment among the 1992–94 cohorts compared with estimated trends in a synthetic version of Colorado. See appendix E.[24] We also estimated the primary event study using only cross-sectional American Community Survey data without the census linkage that differentiated residence during adolescence from residence at ages 22–24. These estimates, which do not capture location at the time of the Colorado Family Planning Initiative implementation and are thus subject to both error and bias because of selective migration, were inconsistent in their identification of the impact of the Colorado Family Planning Initiative on attainment of a bachelor's degree. See appendix F.[24]

Thus far, our design has focused on exposure during the high school years, but the Colorado Family Planning Initiative could potentially have affected college completion for birth cohorts 1987–91. These cohorts were 18–22 in 2010, which is too old for the Colorado Family Planning Initiative to have affected their high school completion but young enough for it to have affected their college experience. We tested this possibility by conducting an event study for college-age exposure. This event study found no consistent effect relative to any comparator. See appendix G.[24]

Finally, to clarify whether college initiation or persistence was the main mechanism for the increase in college completion, we assessed the impact of the Colorado Family Planning Initiative on having ever attended college and on being currently enrolled in college. The analysis that focused on having ever attended college identified similar increases as those for college completion. In contrast, analyses of being currently enrolled at ages 22–24 found only a consistent increase for the 1994 cohort, which may explain the weakened impact on college completion for this cohort, as many were still enrolled. Together, these supplementary analyses offer suggestive evidence that college initiation rather than college persistence was the principal driver of the increases in college completion we document. See appendix H.[24]

Discussion

This study found that Colorado's expansion of contraceptive access through its Title X network led to a population-level increase in women's college completion. As opposed to earlier contraceptive expansions, such as the introduction of the oral contraceptive pill, the Colorado Family Planning Initiative expanded contraceptive access by making it easier for women to get any FDA-approved method of contraception, including LARCs, at low or no cost through a Title X clinic. Exposure to the Colorado Family Planning Initiative at high school age was associated with an increase in women's on-time college completion of between 1.8 and 3.5 percentage points. Our findings translate to an average 6–12 percent increase in women's level of college completion compared with the 1990 baseline cohort and to an additional 2,300 Coloradan women in the three birth cohorts we studied completing a four-year degree by ages 22–24.

Such a large increase in women's on-time college completion is notable, particularly as the Colorado Family Planning Initiative did nothing to change the myriad structural barriers that prevent many low-income women, who make up the subpopulation most likely to access contraception from a Title X clinic, from enrolling and persisting in college. Education is a fundamental cause of health and a key determinant of later socioeconomic outcomes.[1,33] In demonstrating that exposure to the Colorado Family Planning Initiative increased women's on-time attainment of a bachelor's degree, this study provides critical evidence that access to contraception not only gives women control over their fertility but also improves their lives in additional important ways.

Title X clinics are a critical source of the most effective contraception for adolescents and young women.[34] In recent years the Title X family planning program, which was first introduced by President Nixon in 1970, has been affected by policy changes. Restrictions put in place in 2019 led to a constriction of the Title X network and the inclusion of providers who offered only limited methods.[35] In 2021 the federal government reversed these changes.[36] Our results suggest that policies expanding or contracting access to the full range of contraceptive methods will reverberate beyond reproductive health and fertility to affect women's prospects for higher education. Policy makers should consider this breadth of consequences when considering changes to Title X policy or other policies influencing contraceptive access.

Our study design precluded us from distinguishing the specific pathways through which expanded contraceptive access improves college graduation. Our approach assumed, and our supplementary analyses confirmed, that exposure to the Colorado Family Planning Initiative during the high school ages was critical for improving women's college completion. The effect size we detected is somewhat larger than that estimated for the impact of the Colorado Family Planning Initiative on high school completion among a younger cohort who were first exposed to the Colorado Family Planning Initiative at ages 13–15.[21] Some women for whom exposure to the Colorado Family Planning Initiative facilitated high school graduation may have gone on to college as a result of averted teenage births. The Colorado Family Planning Initiative may have also helped women delay fertility in their late teens and early twenties in ways that facilitated their timely college initiation and completion. The effect sizes we detect, however, are unlikely to be accounted for by changes in fertility alone. Thus, we suspect that part of the impact of the Colorado Family Planning Initiative on college completion worked through increasing women's and their families' confidence that investments in higher education would not be derailed by an unanticipated pregnancy.

Comparing our results with prior work attributing a smaller 2–4 percent increase in college completion to the introduction of the oral contraceptive pill[5,6] highlights the role of historical context and innovation type in shaping the magnitude of any effect of contraceptive shocks on life course outcomes. As a medical innovation diffusing at a time when the concept of modern fertility control was new and women's engagement in the labor force and education was more constrained, the pill's introduction was fundamentally different than the change we study here. Reestimates of the pill's impact on births point to smaller effects than previously estimated, which may explain its more modest impact on college attainment.[37] In contrast, an expansion of Title X services at a historical moment when nearly all women use contraception at least sometimes could be more consequential because of its greater accessibility for adolescents, because of existing unmet demand for more expensive and longer-acting methods, and because higher education is now normative for women. In addition, our study focused on on-time college completion, whereas these older studies measured women's college completion at or after age thirty, which allowed for women who may have delayed college because of early fertility time to catch up.

A secondary contribution of our study is in demonstrating the importance of using longitudinal data to examine the impacts of policies, especially those aimed at adolescents. Early adulthood is "demographically dense,"[38] a period of rapid and frequent change, and educational and labor force transitions are the life events most closely linked to migration.[25] Using longitudinal data allowed us to carefully define exposure to the Colorado Family Planning Initiative as residence in Colorado during high school ages and to follow exposed individuals through early adulthood regardless of intervening mobility. When we adopted a cross-sectional approach to our analysis, we did not find a consistent program impact, presumably because of the high levels of in- and out-migration during young adulthood.

Conclusion

An initiative designed to improve women's access to all contraceptive methods—and particularly the most effective ones—through Colorado's Title X clinics led to a population-level increase in women obtaining bachelor's degrees. At a time when some US states are expanding public subsidies for contraception while others seek to restrict them,[39,40] our finding provides important contemporary evidence that access to contraception benefits women's lives.

Notes

1. Tamborini CR, Kim C, Sakamoto A. Education and lifetime earnings in the United States. Demography. 2015;52(4):1383–407 PubMed.

2. Case A, Deaton A. Life expectancy in adulthood is falling for those without a BA degree, but as educational gaps have widened, racial gaps have narrowed. Proc Natl Acad Sci U S A. 2021;118(11):e2024777118 PubMed.

3. Torche F. Is a college degree still the great equalizer? Intergenerational mobility across levels of schooling in the United States. Am J Sociol. 2011;117(3):763–807.

4. Zajacova A, Lawrence EM. The relationship between education and health: reducing disparities through a contextual approach. Annu Rev Public Health. 2018;39:273–89 PubMed.

5. Hock H. The pill and the college attainment of American women and men [Internet]. Tallahassee (FL): Florida State University; 2007 Oct 9 [cited 2022 Oct 6]. Available from: https://coss.fsu.edu/econpapers/wpaper/wp2007_10_01.pdf

6. Ananat EO, Hungerman DM. The power of the pill for the next generation: oral contraception's effects on fertility, abortion, and maternal & child characteristics. Rev Econ Stat. 2012;94(1):37–51 PubMed.

7. Kane JB, Philip Morgan S, Harris KM, Guilkey DK. The educational consequences of teen childbearing. Demography. 2013;50(6):2129–50 PubMed.

8. Bailey MJ. Reexamining the impact of family planning programs on US fertility: evidence from the war on poverty and the early years of Title X. Am Econ J Appl Econ. 2012;4(2):62–97 PubMed.

9. Bailey MJ, Lindo JM. Access and use of contraception and its effects on women's outcomes in the U.S [Internet]. Cambridge (MA): National Bureau of Economic Research; 2017 Jun [cited 2022 Oct 6]. (NBER Working Paper No. 23465). Available from: https://www.nber.org/papers/w23465

10. Stange K. A longitudinal analysis of the relationship between fertility timing and schooling. Demography. 2011;48(3):931–56 PubMed.

11. Diaz CJ, Fiel JE. The effect(s) of teen pregnancy: reconciling theory, methods, and findings. Demography. 2016;53(1):85–116 PubMed.

12. Hofferth SL, Reid L, Mott FL. The effects of early childbearing on schooling over time. Fam Plann Perspect. 2001;33(6):259–67 PubMed.

13. Augustine JM. Exploring new life course patterns of mother's continuing secondary and college education. Popul Res Policy Rev. 2016;35(6):727–55 PubMed.

14. Goldin C, Katz LF. The power of the pill: oral contraceptives and women's career and marriage decisions. J Polit Econ. 2002;110(4):730–70.

15. Raley RK, Kim Y, Daniels K. Young adults' fertility expectations and events: associations with college enrollment and persistence. J Marriage Fam. 2012;74(4):866–79 PubMed.

16. Geronimus AT. Teenage childbearing and social and reproductive disadvantage: the evolution of complex questions and the demise of simple answers. Fam Relat. 1991;40(4):463–71.

<bok17. Edin K, Kefalas M. Promises I can keep: why poor women put motherhood before marriage. Berkeley (CA): University of California Press; 2005.

<bok18. Colorado Department of Public Health and Environment. Taking the unintended out of pregnancy: Colorado's success with long-acting reversible contraception. Denver (CO): Colorado Department of Public Health and Environment; 2017.

19. Lindo JM, Packham A. How much can expanding access to long-acting reversible contraceptives reduce teen birth rates? Am Econ J Econ Policy. 2017;9(3):348–76.

20. Kelly A, Lindo JM, Packham A. The power of the IUD: effects of expanding access to contraception through Title X clinics. J Public Econ. 2020;192:104288.

21. Stevenson AJ, Genadek KR, Yeatman S, Mollborn S, Menken JA. The impact of contraceptive access on high school graduation. Sci Adv. 2021;7(19):eabf6732 PubMed.

22. Bailey MJ, Dynarski SM. Gains and gaps: changing inequality in US college entry and completion [Internet]. Cambridge (MA): National Bureau of Economic Research; 2011 Aug [cited 2022 Oct 6]. (NBER Working Paper No. 17633). Available from: https://www.nber.org/papers/w17633

23. Cunningham S. Causal inference: the mixtape. New Haven (CT): Yale University Press; 2021.

24. Appendix located below.

25. Horowitz J, Entwisle B. Life course events and migration in the transition to adulthood. Soc Forces. 2021;100(1):29–55 PubMed.

26. Hellevik O. Linear versus logistic regression when the dependent variable is a dichotomy. Qual Quant. 2009;43(1):59–74.

27. Buckley P, Pendergast P, Klopfenstein K, Ramsay L, Poast K, Vente M, et al. Does concurrent enrollment improve college access, success, time-to-degree, and earnings? Denver (CO): Evaluation and Action Lab at the University of Denver; 2020. (Report No. 19-15A).

28. Grosz M, Hines A. In-state tuition policies and the college decisions of undocumented students: evidence from Colorado. Educ Finance Policy. 2022;17(2):232–54.

29. Colorado Commission on Higher Education, Colorado Department of Education. Annual report on concurrent enrollment: for 2010-2011 school year; 2012.

30. Barber JS, Kusunoki Y, Gatny H, Melendez R. The relationship context of young pregnancies. Law Inequal. 2017;35(2):175–97 PubMed.

31. Augustine JM, Negraia DV. Can increased educational attainment among lower-educated mothers reduce inequalities in children's skill development? Demography. 2018;55(1):59–82 PubMed.

32. Miech RA, Shanahan MJ, Boardman J, Bauldry S. The sequencing of a college degree during the transition to adulthood: implications for obesity. J Health Soc Behav. 2015;56(2):281–95 PubMed.

33. Masters RK, Link BG, Phelan JC. Trends in education gradients of ‘preventable’ mortality: a test of fundamental cause theory. Soc Sci Med. 2015;127:19–28 PubMed.

34. Darney BG, Biel FM, Hoopes M, Rodriguez MI, Hatch B, Marino M, et al. Title X improved access to most effective and moderately effective contraception in US safety-net clinics, 2016–18. Health Aff (Millwood). 2022;41(4):497–506 PubMed.

35. Office of the Assistant Secretary for Health, Office of the Secretary, Department of Health and Human Services. Compliance with statutory program integrity requirements. Fed Regist. 2019;84(42):7714–91.

36. Office of the Assistant Secretary for Health, Office of the Secretary, Department of Health and Human Services. Ensuring access to equitable, affordable, client-centered, quality family planning services. Fed Regist. 2021;86(192):56144–80.

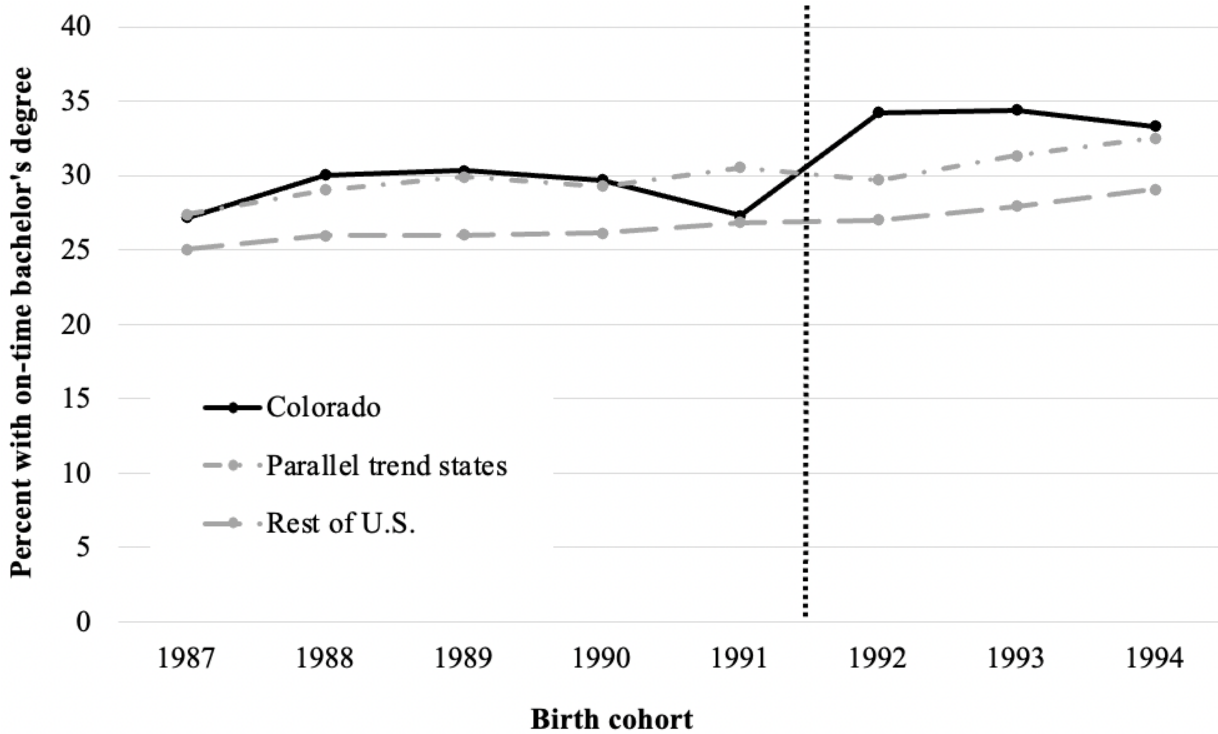
37. Myers CK. The power of abortion policy: reexamining the effects of young women's access to reproductive control. J Polit Econ. 2017;125(6):2178–224.

38. Rindfuss RR. The young adult years: diversity, structural change, and fertility. Demography. 1991;28(4):493–512 PubMed.

39. Guttmacher Institute. State family planning funding restrictions [Internet]. New York (NY): Guttmacher Institute; 2021 [last updated 2022 Sep 1; cited 2022 Oct 6]. Available from: https://www.guttmacher.org/state-policy/explore/state-family-planning-funding-restrictions

40. Guttmacher Institute. Medicaid family planning eligibility expansions [Internet]. New York (NY): Guttmacher Institute; 2021 [last updated 2022 Sep 1; cited 2022 Oct 6]. Available from: https://www.guttmacher.org/state-policy/explore/medicaid-family-planning-eligibility-expansions

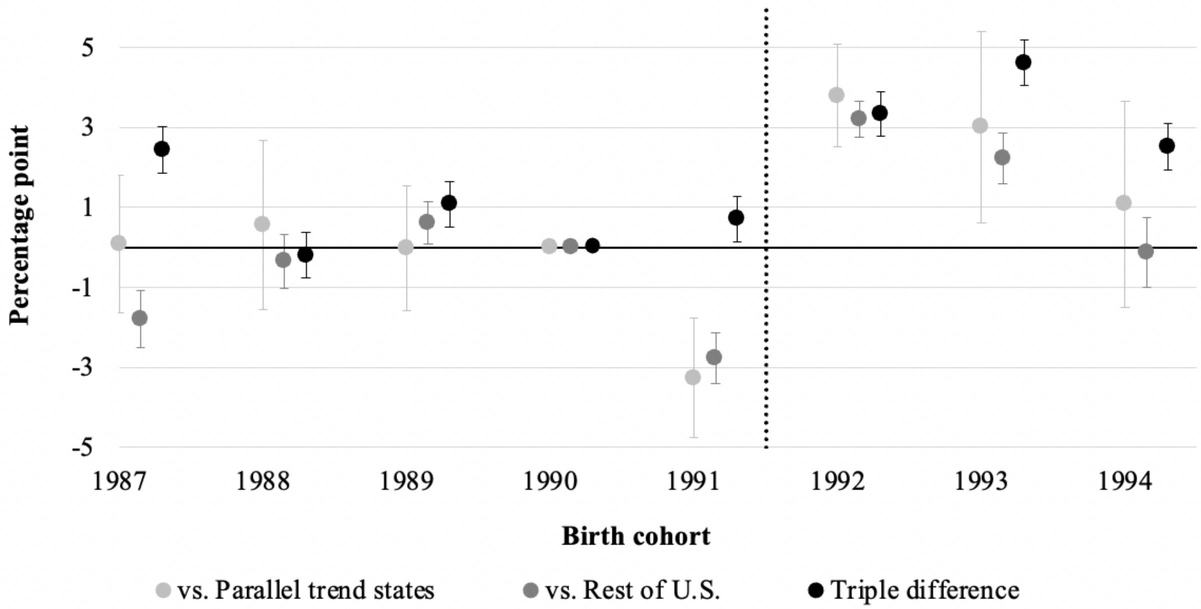
Exhibit 1 Single-year birth cohort trends in women's on-time bachelor's degree completion for Colorado, parallel trend states, and the rest of the US, 2009–19 (birth cohorts 1987–94)



Source: Authors' analysis of 2000 and 2010 decennial census and 2009–19 American Community Survey 1-year data. For more information on sampling and estimation methods, confidentiality protection, and sampling and nonsampling errors in the American Community Survey, see Census Bureau. Code lists, definitions, and accuracy [Internet]. Washington (DC): Census Bureau; [cited 2022 Oct 6]. Available from: https://www.census.gov/programs-surveys/acs/technical-documentation/code-lists.html.

Notes: Groups are by state of residence during adolescence. The dashed vertical line denotes exposure to the CFPI during high school ages, with cohorts to the left of the line not exposed and those to the right of the lines exposed. All results were approved for release by the Census Bureau, Data Management System number P-7515912 and approval numbers CBDRB-FY22-ERD002-008 and CBDRB-FY22-ERD002-012. CFPI is Colorado Family Planning Initiative.

Exhibit 2: Event-study estimates of the effects of Colorado Family Planning Initiative (CFPI) exposure on women's on-time bachelor's degree completion, 2009–19 (birth cohorts 1987–94)



Source: Authors' analysis of 2000 and 2010 decennial census and 2009–19 American Community Survey 1-year data.

Notes: The figure shows the percentage point estimates and 95% confidence intervals from three separate event-study models estimating the effects of the CFPI on on-time bachelor's degree completion for different birth cohorts. "Parallel trend states" and "Rest of US" indicate estimates from models that compare women in Colorado during adolescence with women in parallel trends states and women in the rest of the US, respectively. "Triple difference" indicates estimates from a triple-differences model that compares women in Colorado with men in Colorado and with men and women in parallel trend states. The dashed vertical line denotes exposure to the CFPI during high school ages, with cohorts to the left of the line not exposed and those to the right of the lines exposed. Estimating equations and model output are available in appendices C and D. (See note 24 in the text) All results were approved for release by the Census Bureau, Data Management System number P-7515912 and approval numbers CBDRB-FY22-ERD002-008 and CBDRB-FY22-ERD002-012.

Exhibit 3: Percentage point increase in on-time bachelor's completion among Colorado women by birth cohort, primary models and select robustness checks, 2009–19 (birth cohorts 1987–94)

	Colorado women versus parallel trend state women	**Colorado women versus rest of US women**	**Triple difference: Colorado women versus Colorado men versus parallel trend states**	**Triple difference: US-born sample only**
Treated birth cohorts				
1992	3.79****	3.21****	3.34****	2.67****
1993	3.01**	2.23****	4.62****	4.36****
1994	1.08	−0.12	2.52****	2.52****
Average percentage point increase	2.63	1.77	3.49	3.18

Source: Authors' analysis of 2000 and 2010 decennial census and 2009–19 American Community Survey 1-year data.

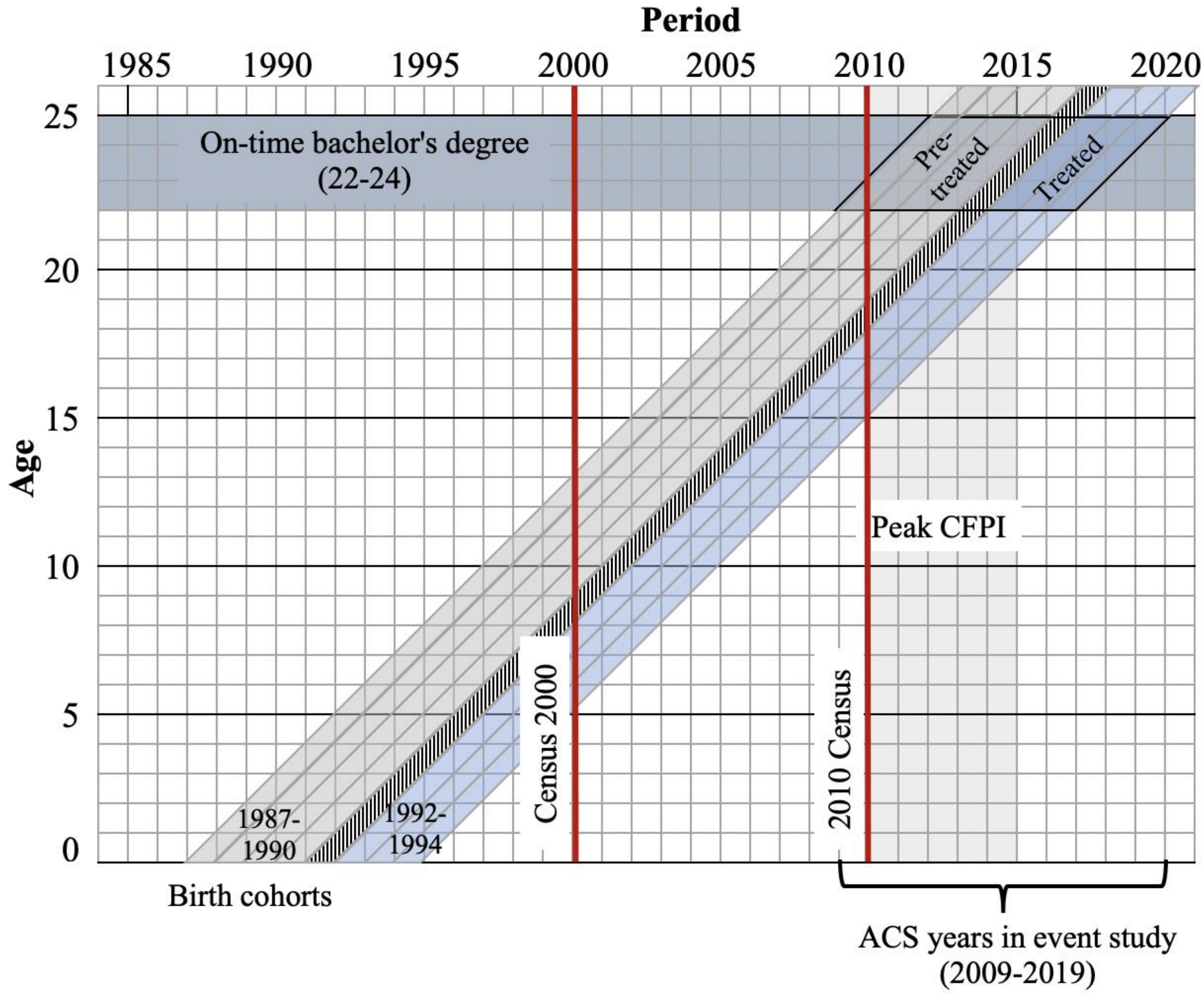
Notes: Results estimated from 4 event-study models that include age and state fixed effects and standard errors clustered at the state level. Estimating equations and model output are available in online appendices C and D (see note 24 in the text). Average percentage point increase was estimated as the mean across the 3 single-year birth cohorts. All results were approved for release by the Census Bureau, Data Management System number P-7515912 and approval numbers CBDRB-FY22-ERD002-008 and CBDRB-FY22-ERD002-012. ****$p < 0.001$ **$p < 0.05$

APPENDIX: SUPPLEMENTAL MATERIAL

This appendix provides additional detail on the methods and analysis described in the main paper. It also describes and presents output from numerous supplementary and sensitivity analyses designed to test the robustness of the main results to alternative specifications and analytic approaches, as well to shed light on potential mechanisms using alternate outcomes.

APPENDIX A: Lexis diagram of cohorts in analyses

Figure A1: Lexis diagram depicting birth cohorts and periods of observation in the census and American Community Survey (ACS)

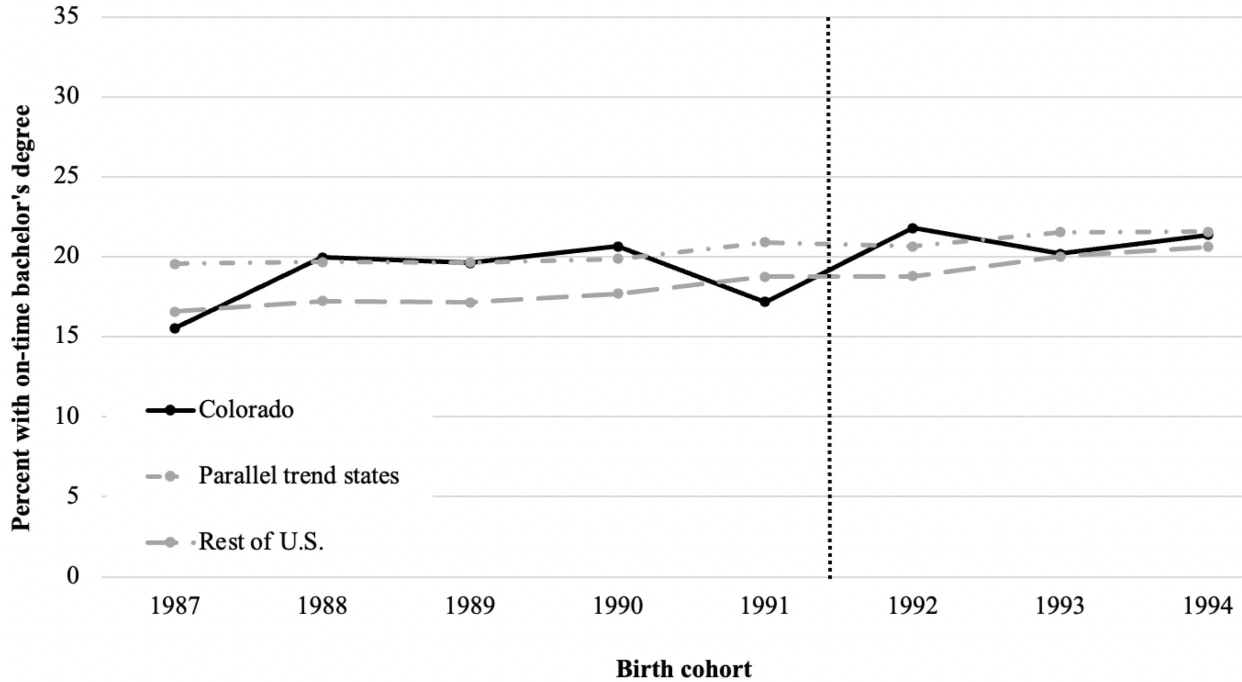


Source: Authors' depiction of the timeline for data used in the analysis.

Notes: The gray-shaded diagonals represent the trajectory of birth cohorts born between 1987-1990 whose members were not exposed to CFPI until ages 19-22 ("pre-treated"). The striped diagonal represents the trajectory of the 1991 birth cohort whose members were 18 at the onset of CFPI. The blue-shaded diagonals represent the trajectories of the 1992-1994 birth cohorts whose members were 15-17 at the onset of CFPI ("treated"). The black parallelogram represents the period during which we measure on-time (ages 22-24) bachelor's degree for each of the eight cohorts in the event study. The red vertical lines indicate the two decennial censuses used for geographic identification in the cohorts.

APPENDIX B: Trends in men's on-time bachelor's completion

Figure B1: Single-year birth cohort trends in men's on-time bachelor's degree completion for Colorado, parallel trend states, and the rest of the U.S.



Source: Authors' analysis of 2000 and 2010 Decennial Census and 2009-2019 ACS 1-year data.

Notes: Figure B1 replicates Exhibit 1 in the main text for men between the ages of 22-24 from 8 single-year birth cohorts, 1987-1994. Parallel trend states for the figure are the same as those identified for the women's analysis: Delaware, Hawaii, Kansas, Maine, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. Rest of the U.S. refers to all states apart from Colorado. The vertical line separates cohorts who were not (to the left) and cohorts who were (to the right) exposed to CFPI during high school ages. Groupings are determined by residence during adolescence. All results were approved for release by the U.S. Census Bureau, Data Management System number P-7515912 and approval numbers CBDRB-FY22-ERD002-008 and CBDRB-FY22-ERD002-012.

APPENDIX C: Estimating equations of primary analyses

The American Community Survey (ACS) asked the following question to measure educational attainment: "What is the highest degree or level of school this person has completed?" We combined responses for 22–24-year-olds reported to have a bachelor's degree or a degree beyond a bachelor's into a single category that we refer to as on-time college completion.

We used a series of event studies to estimate the impact of CFPI on on-time college completion. Event studies are similar to difference-in-differences but allow the treatment effect to change over time. Additionally, they can be used to assess whether there are differential trends for treatment and comparison groups in the pre-period that could challenge a parallel trends assumption (Cunningham 2021; Miller et al. 2021).

To assess the effect of being exposed to CFPI in high school on college completion, we estimated specifications of the following form using only women in birth cohorts 1987 through 1994:

$$Grad_{iacs} = \sum_{c=1987}^{1994} \theta_c * Colorado_{ic} + \beta * Unemployment_{cs} + \gamma_a + \delta_c + \psi_s$$

where $Grad_{iacs}$ is a binary indicator for whether individual *i* of age *a* in cohort *c* linked with state *s* completed college on time. $Colorado_{ic}$ is an indicator that individual *i* in cohort *c* resided in Colorado at the appropriate census linkage. We used 1990 as the reference year, so every θ coefficient therefore compares the relative attainment of Colorado women in cohort *c* to the performance of Colorado women in the 1990 birth cohort. We controlled for the state level unemployment rate for the year in which each cohort turned 17[1], when young women were presumably making plans for whether or not to attend college. Also included in our specifications were age fixed effects, γ_a, which include estimates of time-invariant differences in completion by age, cohort fixed effects, δ_c, which control for secular trends across treated and untreated female cohorts alike, and state fixed effects, ψ_s, which control for time invariant heterogeneity in college completion among women across states. Since Colorado women were not exposed to CFPI during high school until birth cohort 1992, our coefficients of interest are θ_{1992}, θ_{1993} and θ_{1994}, which estimate how much more likely Colorado women in those cohorts were to complete college than earlier cohorts of Colorado women net of all the items listed above.

Additionally, we showed that these effects were concentrated in women in Colorado and not due to increasing rates of college completion across all who were in Colorado. Specifically, we combined men's and women's data and performed the event-study analysis adding a binary indicator for women, an interaction between women and each of the Colorado birth cohorts, and state-age and cohort-age interactions. We used women's parallel trend states as the comparison population, but findings were consistent when using the rest of the U.S.

The estimating equation for this triple-difference specification is as follows:

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[1] We alternatively estimated specifications for the year cohorts turned 18 and 19 and found no differences.

$$Grad_{iacs} = \sum_{c=1987}^{1994} \theta_c Colo_{ic} Woman_i + \sum_{c=1987}^{1994} \tau_c Colo_{ic} + \beta_1 Woman_i + \beta_2 Unemployment_{cs} + \gamma_a + \delta_c + \psi_s + \eta_{ac} + \mu_{as}$$

where a separate coefficient is estimated for Colorado as a whole and Colorado women in each cohort. We also included state-by-age and cohort-by-age fixed effects (μ_{as} and η_{ac}), as omitting these could lead to bias in our triple-difference specification (Cragun 2021). Here, each of the θ_c coefficients tracks how the likelihood of Colorado women graduating from college on time varies from that of Colorado men. If graduation rates were going up equally for Colorado men and women, we would expect to see a positive and significant τ_c but an insignificant θ_c. If, on the other hand, we have a positive and significant θ_c across both specifications, that means that on-time college completion rates are going up for Colorado women both compared with women in other states and compared with Colorado men. Therefore, any identification threat to our specifications would have to be something that increased on-time college completion only for Colorado women and not for Colorado men.

All models were fitted in Stata 15.1 using robust clustered standard errors at the state level.

APPENDIX D: Model output from primary event studies

Table D1: Results from primary event-study models presented in Exhibits 2 and 3
Exhibit 2

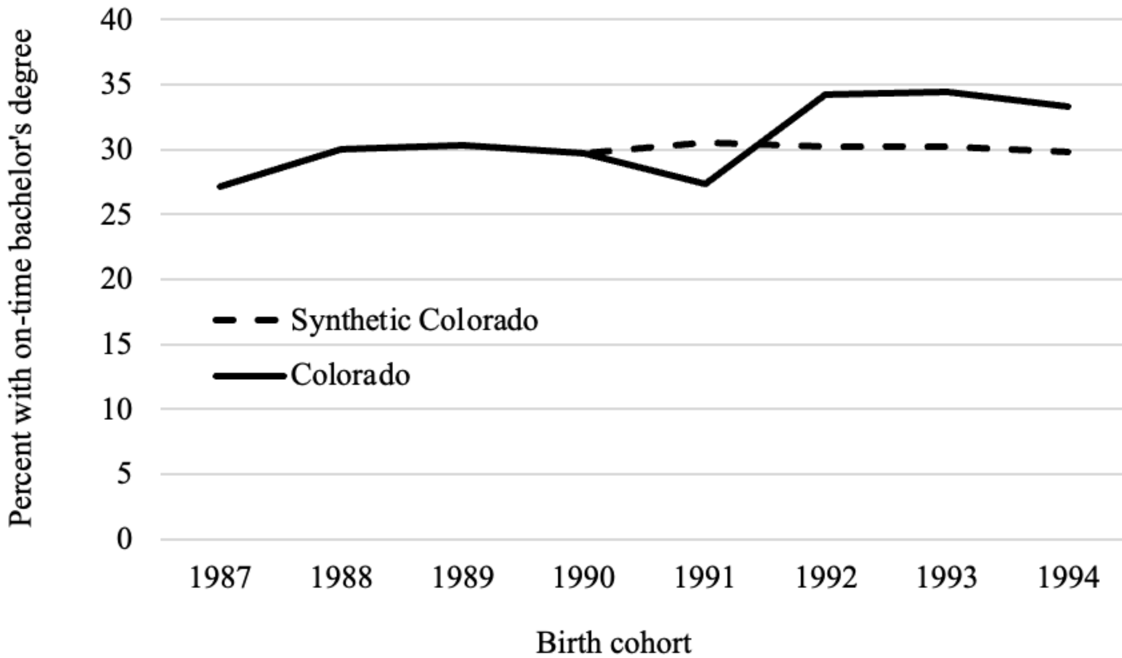
	(1) Colorado women vs. Parallel trend state women		(2) Colorado women vs. Rest of U.S. women		(3) Triple Difference: Colorado women vs. Colorado men vs. Parallel trend states		(4) Triple Difference: U.S.-born only	
	Coef	SE	Coef	SE	Coef	SE	Coef	SE
Colorado women's birth cohort								
1987	0.0009	0.0088	-0.0179	0.0036	0.0243	0.0030	0.0185	0.0039
1988	0.0006	0.0108	-0.0035	0.0035	-0.0019	0.0029	-0.0075	0.0040
1989	-0.0002	0.0079	0.0062	0.0027	0.0109	0.0029	0.0078	0.0039
1990	ref		ref		ref		ref	
1991	-0.0326	0.0076	-0.0276	0.0033	0.0071	0.0029	-0.0037	0.0039
1992	0.0379	0.0065	0.0321	0.0023	0.0334	0.0028	0.0267	0.0039
1993	0.0301	0.0122	0.0223	0.0032	0.0462	0.0029	0.0436	0.0040
1994	0.0108	0.0132	-0.0012	0.0044	0.0252	0.0029	0.0252	0.0040
Women (ref=men)					0.0953	0.0029	0.0979	0.0039
Age (ref=22)								
23	0.1236	0.0067	0.1042	0.0031	0.1306	0.0133	0.1164	0.0102
24	0.1724	0.0067	0.1492	0.0034	0.1980	0.0162	0.1918	0.0216
Birth cohort (ref=1987)								
1988	0.0140	0.0058	0.0042	0.0034	0.0079	0.0078	0.0199	0.0112
1989	0.0211	0.0048	0.0050	0.0032	0.0066	0.0093	0.0046	0.0133
1990	0.0133	0.0072	0.0067	0.0035	0.0130	0.0087	0.0088	0.0142
1991	0.0299	0.0044	0.0105	0.0031	0.0338	0.0093	0.0403	0.0172
1992	0.0438	0.0229	0.0169	0.0053	0.0493	0.0228	0.0418	0.0229
1993	0.0573	0.0229	0.0249	0.0063	0.0580	0.0221	0.0500	0.0201
1994	0.0659	0.0146	0.0403	0.0050	0.0557	0.0122	0.0637	0.0131
Colorado men's birth cohort								
1987					-0.0292	0.0096	-0.0350	0.0110
1988					0.0078	0.0131	-0.0085	0.0102
1989					-0.0044	0.0059	-0.0098	0.0050
1990					ref		ref	
1991					-0.0373	0.0101	-0.0547	0.0104
1992					0.0051	0.0061	-0.0074	0.0056
1993					-0.0089	0.0117	-0.0302	0.0105
1994					0.0005	0.0145	-0.0223	0.0134
State unemployment at age 17	-0.0060	0.0058	0.0002	0.0015	-0.0087	0.0042	-0.0060	0.0039
State fixed effects	Yes		Yes		Yes		Yes	
Cohort-age interaction					Yes		Yes	
State-age interaction					Yes		Yes	
Constant	0.2185	0.0304	0.1159	0.0093	0.1516	0.0158	0.1500	0.0144
N	67000		535000		135000		86000	
R^2	0.0271		0.04064		0.04018		0.04224	

Source: Authors' analysis of 2000 and 2010 Decennial Census and 2009-2019 ACS 1-year data.

Note: The models above present coefficients from the four primary event study specifications. The results in Exhibits 2 and 3 in the manuscript are based on these models with coefficients converted to percentage point differences. We identified parallel trend states as those that were not statistically different in level or slope of on-time bachelor's completion for women in the pre-treatment birth cohorts. We defined birth cohorts between 1987-1990 as pre-treated cohorts because women born in these years were 19-22 in 2010, too old to have been exposed to CFPI during the critical high school years. We identified parallel trend states separately for the primary analyses (models 1 and 3: Delaware, Hawaii, Kansas, Maine, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin) and the U.S.-born only analyses (model 4: Delaware, Hawaii, Kansas, Maine, Nebraska, North Dakota, South Dakota, and Wisconsin). All results were approved for release by the U.S. Census Bureau, Data Management System number P-7515912 and approval number CBDRB-FY22-ERD002-012. All numbers are rounded in accordance with U.S. Census Bureau disclosure review guidelines.

APPENDIX E: Synthetic control

Figure E1: Results of synthetic control approach, Colorado vs. synthetic Colorado



Source: Authors' analysis of 2000 and 2010 Decennial Census and 2009-2019 American Community Survey 1-year data.

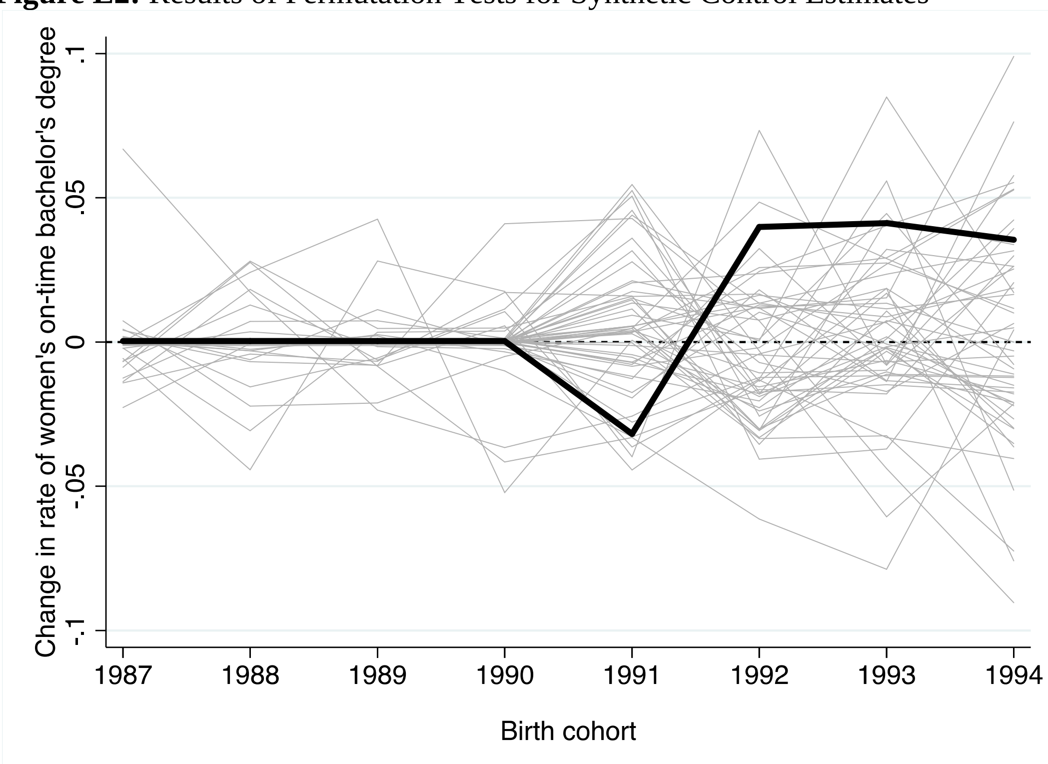
Note: All results were approved for release by the U.S. Census Bureau, Data Management System number P-7515912 and approval number CBDRB-FY22-ERD002-008.

As briefly described in the main text, we examined the robustness of our main findings using a synthetic control approach. This approach created a control group comprised of a weighted average of all possible control states which minimized the squared error in the pre-treated period. By matching trends in pre-treated outcomes as closely as possible, the synthetic control provides a reasonable approximation as to what would have happened in Colorado in the absence of CFPI (Abadie and Gardeazabal 2003; Abadie, Diamond, and Hainmueller 2010). Using Stata's synth command, we identified a synthetic control group of states that together closely match Colorado's bachelor's attainment during the pre-treatment birth cohorts 1987-1990. The algorithm assigned a weight of 0 to 1 to each state contributing to the synthetic control so as to closely match the pre-treated trend in college completion in Colorado. Almost all states contributed to the synthetic control (see Table E1 below), but the largest weights were given to Rhode Island (25.2%), Delaware (25.0%), and Hawaii (9.8%).

As in our identification of pre-trends in the event study, we excluded 1991 because its inclusion with the pre-treated cohorts could result in the over-estimation of CFPI's effect on subsequent cohorts. Additionally, the 1991 birth cohort were aged 18 at the start of peak CFPI and thus on the cusp between high school age and college age. The implication of doing so is that in the synthetic control approach treatment started in 1991 rather than in 1992. Even so, the increase in college completion for the 1992-1994 cohorts seen in Figure E1 above relative to synthetic Colorado mirrors that identified in the event studies.

The distribution of estimates generated by permutation tests estimating "placebo effects" for each state in the U.S. is displayed in Figure E2, along with the actual treatment effect for Colorado in bold. Each line shows how a particular state evolved compared to its synthetic control across cohorts. To draw inference, we followed Abadie et al. (2010) and computed the ratio of root mean squared predicted error (RMSPE) in the post- versus pre-treatment periods. Of the 50 estimates, Colorado had the 10th largest ratio, which corresponds to a p-value of 0.2. It is clear from the figure, however, that the states with the largest RMSPE ratios were ones moving erratically in the post period and not necessarily showing true "treatment effects". Colorado appeared to have the largest stable increase in women's college completion after 1991, with an improvement of between three and four percentage points relative to its synthetic control in each of birth cohorts 1992 through 1994.

Figure E2: Results of Permutation Tests for Synthetic Control Estimates



Source: Authors' analysis of 2000 and 2010 Decennial Census and 2009-2019 American Community Survey 1-year data.

Note: All results were approved for release by the U.S. Census Bureau, Data Management System number P-7515912 and approval number CBDRB-FY22-ERD002-012.

Table E1: States included in estimation of synthetic control and corresponding weights

State	Weight	State	Weight	State	Weight
Alabama	0.016	Louisiana	0.006	Oregon	0.006
Alaska	0.023	Maine	0.011	Pennsylvania	0.007
Arizona	0.007	Maryland	0.011	Rhode Island	0.252
Arkansas	0.006	Michigan	0.006	South Carolina	0.005
California	0.008	Minnesota	0.009	South Dakota	0.006
Connecticut	0.003	Mississippi	0.005	Tennessee	0.009
Delaware	0.250	Missouri	0.006	Texas	0.009
DC	0.004	Montana	0.037	Utah	0.006
Florida	0.007	Nebraska	0.008	Vermont	0.006
Georgia	0.006	Nevada	0.007	Virginia	0.007
Hawaii	0.098	New Hampshire	0.006	Washington	0.008
Idaho	0.008	New Jersey	0.007	West Virginia	0.012
Illinois	0.009	New Mexico	0.016	Wisconsin	0.008
Indiana	0.009	New York	0.005	Wyoming	0.006
Iowa	0.006	North Carolina	0.006		
Kansas	0.019	Ohio	0.009		
Kentucky	0.010	Oklahoma	0.008		

Source: Authors' analysis of 2000 and 2010 Decennial Census and 2009-2019 American Community Survey 1-year data.

Note: All results were approved for release by the U.S. Census Bureau, Data Management System number P-7515912 and approval number CBDRB-FY22-ERD002-008.

APPENDICES F-H: Supplementary Analyses

We conducted three types of supplementary analyses: (1) cross-sectional analyses using only ACS data at ages 22-24 without census linkage; (2) event studies of college-age exposure to CFPI; and (3) event studies examining the impact of CFPI on two alternate outcomes: having ever attended college and current college enrollment.

APPENDIX F: Cross-sectional approach

The primary analyses used a longitudinal approach that identified state of residence in adolescence and followed women through ages 22-24 in the ACS. We examined the robustness of the results to alternative measures of exposure to CFPI that can be captured with the cross-sectional ACS alone. This approach avoids the link to the census and thus retains the full ACS sample; however, it assumes women in the treated cohorts who resided in Colorado at ages 22-24 were exposed to CFPI in ways that would have been meaningful to their college completion. The extremely high levels of in- and out-migration in our sample (33.1% and 26.3%, respectively) challenge this assumption, particularly as some of this mobility will be related to our outcome of interest: on-time college completion. Using a cross-sectional approach to estimating the impact of CFPI on on-time bachelor's degree yielded inconsistent findings (see Figure F1). Relative to women in parallel trend states at ACS interview and to women in the rest of the U.S., there was no difference in bachelor's completion for women in the 1992-1993 cohorts. Both comparisons find a modest, statistically significant effect for the 1994 cohort. When we included the comparison to men with the triple difference, however, there was an increase in college completion across all treated cohorts. We further found that the results did not hold when exposure was measured using state of birth alone (available in the ACS). The sensitivity of the findings to these less precise methods of identifying exposure to CFPI points to the importance of careful measurement of exposure when relationships are premised on exposure at particular ages.

Figure F1. Event-study estimates of the effects of CFPI exposure on women's on-time bachelor's degree completion: cross-sectional ACS-only analyses

Source: Authors' analysis of 2009-2019 ACS 1-year data.

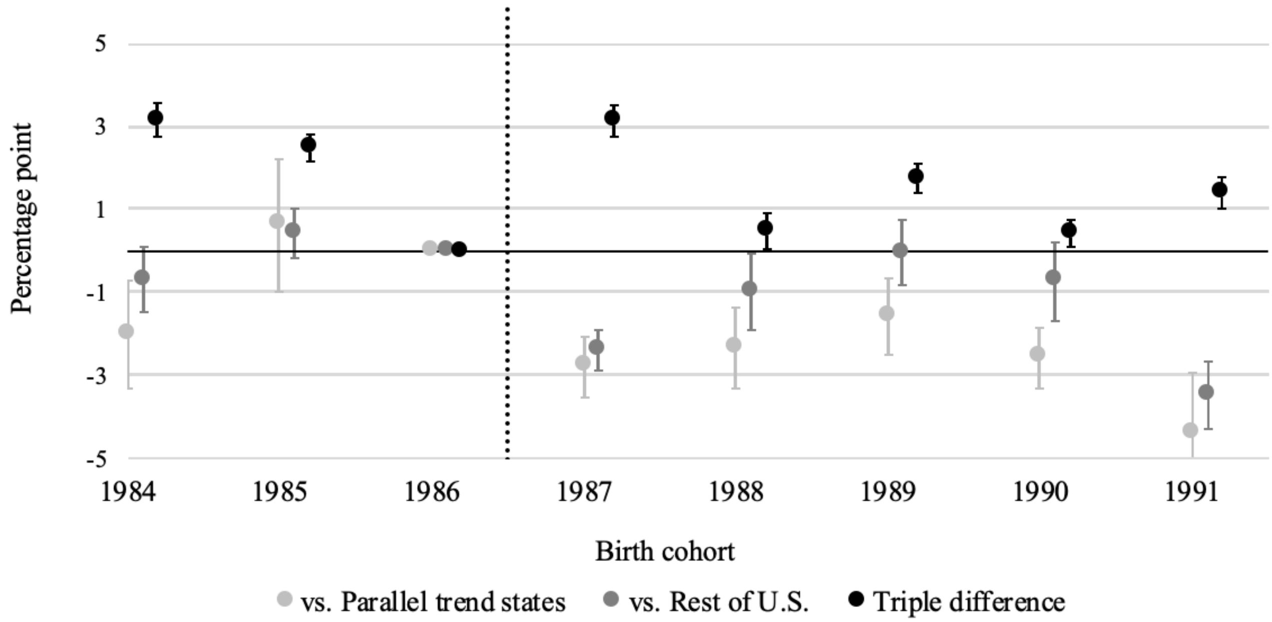
Note: All results were approved for release by the U.S. Census Bureau, Data Management System number P-7515912 and approval number CBDRB-FY22-ERD002-013.

APPENDIX G: College-age exposure

Our main analyses are predicated on the assumption that exposure to CFPI during high school ages will be most impactful for college completion. It is possible, however, that exposure to CFPI at "college ages" will have an impact on college completion. This would be the case, for example, if the impact of expanded access to contraception on college completion worked predominantly through gains in college persistence rather than college enrollment. To explore this idea, and the appropriateness of our assumptions about high school-age exposure, we conducted an additional set of event-study analyses that sought to identify whether women exposed to CFPI at ages 18-22 but not during high school experienced gains in college completion. To do so, we replicated the main event-study analyses using different cohorts to identify pre-trends and impact. Specifically, our event-study analyses used birth cohorts 1984-1986 who were ages 23-25 at the start of peak CFPI to identify parallel trends states and as pre-trends in the analyses. Following the approach to identifying parallel trends described for the main analyses, we identified the following six states as having parallel trends to Colorado for these cohorts: Illinois, Iowa, Kansas, Maine, Ohio, and Wisconsin. As in the main analyses, we additionally compared women in Colorado to women in the rest of the U.S. and conducted a triple-difference analysis.

The event study included a total of eight cohorts, three pre-treatment cohorts (1984-1986) and five post-treatment cohorts (1987-1991). The latter were first exposed to peak CFPI at ages 18-22, ages when expanded contraceptive use could impact college—but not high school—completion. Figure G1 shows the results are sensitive to comparator, sometimes negative and sometimes positive. Although some estimates are statistically significant, there is no clear pattern across the models pointing to an impact of CFPI on college completion when exposure was limited to post-high school ages.

Figure G1. Event-study estimates of the effects of CFPI exposure at "college ages" on women's on-time bachelor's degree completion



Source: Authors' analysis of 2000 and 2010 Decennial Census and 2006-2016 ACS 1-year data.

Notes: The figure shows the percentage point estimates (dots) and 95% confidence intervals (whiskers) from three separate event-study models estimating the effects of exposure to CFPI on on-time bachelor's degree completion for birth cohorts who were only exposed to CFPI during "college ages" (18-22). The vertical dotted line separates cohorts that were exposed to CFPI only beginning at ages 23-25 (to the left) and cohorts who were exposed to CFPI beginning at ages 18-22 (to the right). All results were approved for release by the U.S. Census Bureau, Data Management System number P-7515912 and approval number CBDRB-FY22-ERD002-012.

We used the same technique to identify state of residence during adolescence as employed in the high school-age exposure analyses. However, at the ages of the treatment cohorts in the college-age exposure analyses, it could be argued that state of residence in 2010, rather than state of residence during adolescence, is most salient. Thus, we re-estimated the college-age exposure analyses above using only the 2010 Census to identify state of residence. These analyses yielded different estimates but, similar to the above, revealed no clear patterns.

Taken together, the college-age exposure analyses found no clear impact of exposure to CFPI after high school on college completion. This conclusion supports the approach of our main analyses that focus on cohorts who were exposed to CFPI initially while still in high school (ages 15-17).

APPENDIX H: Alternative outcomes

The study was designed to test whether exposure to CFPI during adolescence impacted women's on-time bachelor's completion. College completion can increase through increases in college enrollment (i.e., more people initiating college) or improvements in college persistence (i.e., greater rates of completion among those who initiate college). Whether CFPI predominately impacted college enrollment or college persistence is an important secondary question. Using the same longitudinal, cohort-based approach employed in the primary analyses, as supplementary analyses we examined the relationship between exposure to CFPI in adolescence and (i) having ever attended college and (ii) current college enrollment, both measured at ages 22-24. Respondents were considered to be currently enrolled in college if they were reported to have attended college in the past three months. They were considered to have ever attended college if they were currently enrolled in college or had their highest level of attainment reported as some college or higher.

Figure H1 presents results from three event studies assessing the relationship between CFPI exposure and having ever attended college. Using the same set of parallel trend states as in the primary analyses, the results show that regardless of comparator, exposure to CFPI in adolescence is associated with increases in having ever attended college in each of the three treated cohorts.

Figure H1. Event-study estimates of the effects of CFPI exposure on women having ever attended college at ages 22-24

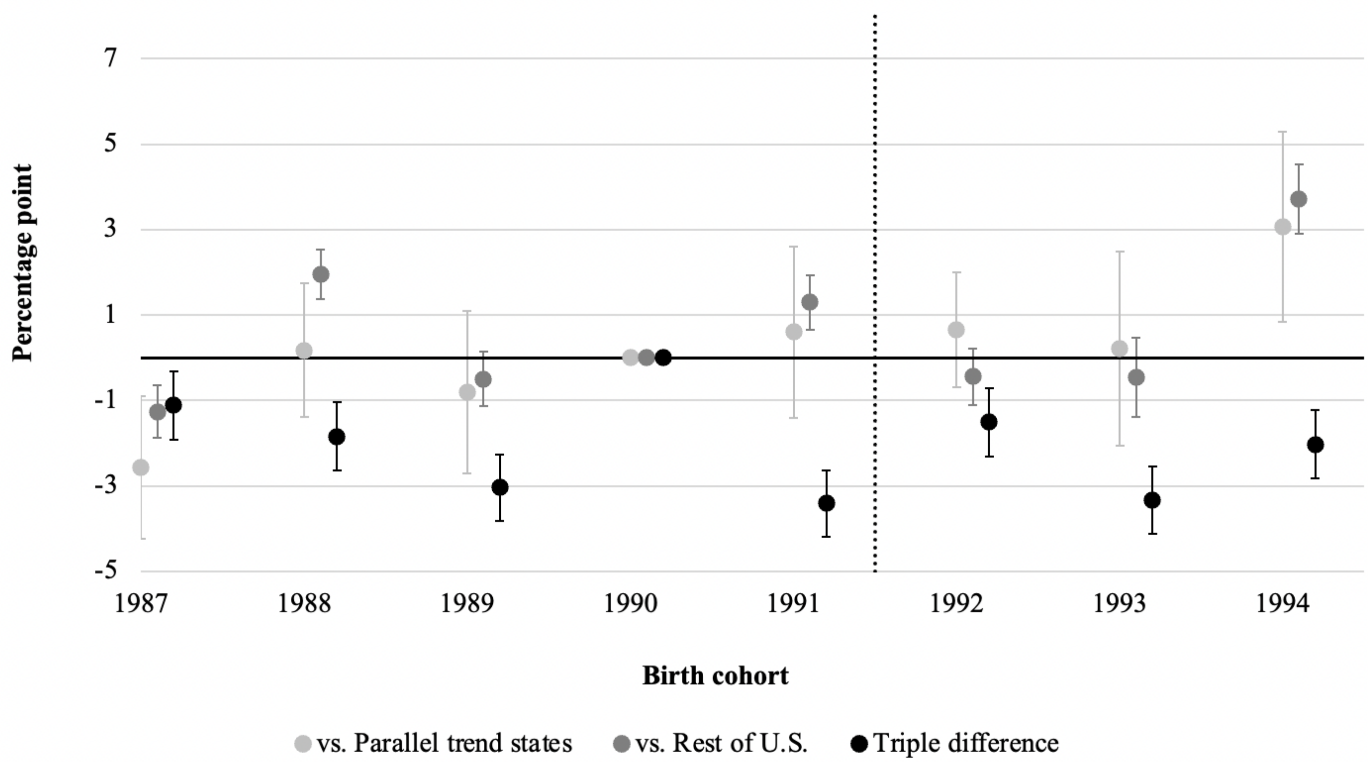
Source: Authors' analysis of 2000 and 2010 Decennial Census and 2009-2019 ACS 1-year data.

Note: All results were approved for release by the U.S. Census Bureau, Data Management System number P-7515912 and approval number CBDRB-FY22-ERD002-012.

Figure H2 presents results from similar event studies examining current college enrollment at ages 22-24. Here, the estimates showed a delayed relationship. That is, it was not until the 1994 cohort that there was a clear and consistent relationship across models between CFPI and current enrollment. Taken together with the primary analyses that showed a weakened relationship between CFPI and college completion for this cohort, these results suggest that some of the weakening may have been due to students progressing more slowly through college.

Finally, when these analyses are considered alongside the college-age exposure analyses, there is suggestive evidence that increases in initiation rather than persistence were the dominant force driving the gains in college completion we documented.

Figure H2. Event-study estimates of the effects of CFPI exposure on women's current college enrollment at ages 22-24



Source: Authors' analysis of 2000 and 2010 Decennial Census and 2009-2019 ACS 1-year data.

Note: All results were approved for release by the U.S. Census Bureau, Data Management System number P-7515912 and approval number CBDRB-FY22-ERD002-012.

APPENDIX I: Additional sensitivity tests

We conducted additional analyses to assess the sensitivity of results to model specification, the composition of the comparator, and weighting approaches. We assessed the sensitivity of our findings to the use of OLS by fitting our event-study models using a logistic function. We then fitted our models with and without age fixed effects and with and without a state fixed effect. Additionally, we ran our primary models with and without state-specific linear trends to account for the possibility that pre-existing state-specific trends in college completion could bias our results. Although changes in model specification led to small fluctuations in the results, the results did not change substantively across any of these specifications.

As a second set of sensitivity analyses, we examined the robustness of the results to changes in the comparison group. In our primary specification presented in the paper, we compared women in Colorado during adolescence both to women in states with parallel trends in bachelor's degree attainment in the pre-treated period and to an additional comparator of women in the rest of the U.S. As a sensitivity test, we estimated our models excluding each of the nine parallel-trend states in turn to ensure that no single state was driving the findings. The results were robust to these modifications.

In a third set of sensitivity analyses, we examined the sensitivity of the findings to the ACS-census linkage weight. As noted in the text, we use the ACS as our base sample. The ACS is meticulously created to be representative with weights. We linked the ACS and census data using U.S. Census-created personal identification keys (PIKs). Failure to match using PIKs is unequally distributed because of established limitations of probabilistic record matching processes (2010 Census Planning Memoranda Series No. 247, 2012). Table I1 presents linkage rates by age, cohort, and race/ethnicity within our data. Linkage differentials were particularly notable by race/ethnicity. Because we knew who is missing, their characteristics, and original weights, we created additional weights that we combined with ACS-created weights so that our final sample was again representative. We examined the sensitivity of the findings to the ACS-census linkage weight by fitting models with just the individual-level ACS weight and models that exclude the largest one percent of weights (see Table I2). Although estimates changed when we did so, the patterns were broadly similar to our primary findings, particularly for the models that used ACS weights.

Table I1. ACS to Decennial Census linkage rates by demographic characteristics

		ACS respondents linked to relevant census
Cohort		%
	1987	76.81
	1988	75.79
	1989	75.24
	1990	75.19
	1991	75.45
	1992	76.74
	1993	76.93
	1994	76.66
	Combined	76.75
Age		
	22	74.95
	23	76.48
	24	76.78
Race/Ethnicity		
	White	84.59
	Black	69.69
	Asian	49.17
	Amer Indian/Alaskan Native/Asian Pacific Islander	67.18
	Other/Multiracial	75.10
	Hispanic	60.29

Source: Authors' analysis of 2000 and 2010 Decennial Census and 2009-2019 ACS 1-year data.

Note: All results were approved for release by the U.S. Census Bureau, Data Management System number P-7515912 and approval number CBDRB-FY22-ERD002-012.

Table I2. Percentage point increase in on-time bachelor's completion among Colorado women by birth cohort: assessing sensitivity of primary models to different weighting approaches

	Using ACS weights			Excluding largest 1% of weights		
	Colorado women vs. Parallel trend state women	Colorado Women vs. Rest of U.S.	Triple Difference: Colorado women vs. Colorado men vs. Parallel trend states	Colorado women vs. Parallel trend state women	Colorado Women vs. Rest of U.S.	Triple Difference: Colorado women vs. Colorado men vs. Parallel trend states
Treated birth cohorts						
1992	3.79 ****	2.81 ****	3.62 ****	4.40 ****	3.36 ****	2.95 ****
1993	3.00 **	1.88 ****	4.67 ****	1.36	0.59 *	4.24 ****
1994	2.11	0.24	3.39 ****	1.21	0.04	2.43 ****
Average percentage point increase	2.97	1.64	3.89	2.32	1.33	3.21

****p<0.001; **p<0.05; *p<0.1

Source: Authors' analysis of 2000 and 2010 Decennial Census and 2009-2019 ACS 1-year data.

Note: All results were approved for release by the U.S. Census Bureau, Data Management System number P-7515912 and approval number CBDRB-FY22-ERD002-012.

References Cited

2010 Census planning memoranda series No. 247 (available at https://www.census.gov/content/dam/Census/library/publications/2012/dec/2010_cpex_247.pdf). 2012.

Abadie A, Diamond A, Hainmueller J. Synthetic control methods for comparative case studies: Estimating the effect of California's tobacco control program. J Am Stat Assoc. 2010; 105(490):493-505.

Abadie A, Gardeazabal J. The economic costs of conflict: A case study of the Basque Country. Am Ec Rev. 2003; 93(1):113-132.

Cragun R. Difference-in-differences estimates by levels of a moderator in the Power of the Pill literature. 10.13140/RG.2.2.18178.61121. Working paper. 2021.

Cunningham S. Causal inference: the mixtape. New Haven: Yale University Press; 2021.

Miller S, Johnson N, Wherry LR. Medicaid and mortality: new evidence from linked survey and administrative data. Q J Econ. 2021;136(3):1783-829.