



Original Contribution

Joint Effects of Age, Period, and Cohort on Conduct Problems Among American Adolescents From 1991 Through 2015

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Although arrest rates among juveniles have substantially decreased since the 1990s, US national trends in conduct problems are unknown. Population variation in conduct problems would imply changes in the social environment, which would include emergent or receding risk factors. In the present study, we separated age, period, and cohort effects on conduct problems using nationally representative surveys of 375,879 US students conducted annually (1991–2015). The summed score of 7 items measuring the frequency of conduct problems was the outcome. Conduct problems have decreased during the past 25 years among boys; the total amount of the decrease was approximately 0.4 standard deviations ($P < 0.01$), and by item prevalence, the total amount of the decrease was 8%–11%. Declines are best explained by period effects beginning approximately in 2008, and a declining cohort effect beginning among those born after 1992, which suggests not only declines in population levels, but more rapid declines among younger cohorts of boys. Trends were also consistent with age-period-cohort effects on evenings spent out, which suggest a possible mechanism. Conduct problems among girls were lower than boys and did not demonstrate trends across time. These changes may reflect the changing nature of adolescence toward less unsupervised interaction.

adolescents; age-period-cohort effects; conduct problems; Monitoring the Future

Abbreviations: CI, confidence interval; MTF, Monitoring the Future.

Conduct problems in adolescence are characterized as persistent disregard for rules, aggression, delinquency, and violence and are associated with strain on the justice system, property crime, and adverse comorbid mental health conditions (1, 2). Recent estimates suggest that approximately 6% of adolescent girls and 8% of adolescent boys meet the clinical threshold for conduct disorder (3), although a much larger proportion of adolescents demonstrate conduct problems without meeting full diagnostic criteria. For many individuals, conduct problems are limited to adolescence (4); however, for some, conduct problems continue throughout the life course. Historical trends in the occurrence of conduct problems in adolescence may signal changes in the prevalence of social and environmental risk factors, the emergence of new risk and protective factors, or changes in policy.

Conduct problems are heritable (5–7) yet are linked to dynamic environmental factors such as family structure, school climate,

and peer deviance (8). As risk factors for conduct problems change across time, so too might prevalence and distribution. For example, increasingly prevalent disruptions in family structure and low family income level (9) might foreshadow an increase in conduct problems. In contrast, 2 family risk factors, maternal smoking during pregnancy (10) and adolescent childbearing (11), have declined during the past decades (12–14), which might auger a decline in conduct problems. Furthermore, changes in environmental risk factors are occurring within the context of a rapidly changing social landscape for adolescents, characterized in large part by adolescents' ubiquitous exposure to technology (15, 16). Such technology has increased the capacity of adolescents to communicate and connect without needing physical interaction and, as such, may reduce the amount of time that adolescents spend together unsupervised, which may reduce the propensity for engaging in deviant conduct.

Accurately measuring historical trends requires consistent measurement of constructs on subsequent generations of individuals. In various studies, few investigators have examined trends in the occurrence of conduct problems with the same instrument on different cohorts of adolescents; of those who have (17), few researchers have included data on cohorts that have been sampled in the last decade (18–20). To the best of our knowledge, no studies to date have addressed the potential variation in conduct problems that might arise due to age-period-cohort effects (21–23). Period effects arise when conduct problems systematically change across time for all age groups, which could indicate changes in the broader context (policy; risk factors) to which the majority of adolescents are exposed. Variations in conduct problems that are apparent in some age groups more than others during a given period manifest as cohort effects; such variations indicate that adolescents who are coming of age in a given period may have different exposure or susceptibility to risk factors.

Many symptoms of conduct disorder overlap with behaviors for which an adolescent could be arrested (e.g., violence, property damage). Examination of juvenile arrest rates clearly demonstrates that these rates—for boys and girls—have decreased since peaking in the mid-1990s (24). Boys have demonstrated a much steeper decline in arrests for violent crimes than girls, and indeed the sex gap in arrests for violent crimes has steadily decreased since 1980 (24). However, in the United States, whether an individual is arrested often has less to do with his or her criminal behavior than with differences in laws and their application; policing policies and practices; and thresholds for arrest, diversion, or conviction (25, 26), all of which may be applied differentially by race, class, and sex and are themselves dynamic across time (25, 27, 28). As such, examination of behaviors that underlie juvenile arrest remains critical.

In the present study, we used an ideally suited data source, the Monitoring the Future (MTF) Study, which overcomes many of the data limitations summarized beforehand. We conduct formal separation of time trends into age, period, and cohort effects across approximately 375,000 US students who were sampled to be nationally representative of every year since 1991. The wording of the questions and survey administration have remained constant across time. We estimate age-period-cohort effects for adolescent conduct problems across 25 consecutive years, including estimation across sex, race/ethnicity, and parental education subgroups. We use publicly available arrest data on adolescents to compare trends in conduct problems and arrests. Furthermore, we examine potential changes in the social environment among youth by examining the number of evenings spent away from home.

METHODS

MTF includes an annually conducted cross-sectional national survey; 8th, 10th, and 12th grade students in approximately 400 US public and private high schools have been surveyed annually since 1991 through 2015, representing modal birth cohorts 1973–2002. Schools are selected under a multistage random-sampling design and are invited to participate for 2 years. Schools that decline participation are replaced with schools that are similar in location, size, and urbanicity.

The overall rates of school participation (including replacements of schools that decline to participate) range from 92% to 99% for all study years. Rates of student response have averaged 86.5% (range, 85.0%–87.3%), with no systematic trend. Almost all nonresponses are due to absenteeism; less than 1% of students refuse to participate. A detailed description of design and procedures is provided elsewhere (29, 30). MTF uses multiple forms of self-report questionnaires, which are distributed randomly; in the present study, we focus on students who received a form that included the questions on conduct problems. The total eligible sample size was 365,798 (153,114 8th graders, 141,780 10th graders, and 70,904 12th graders).

Measures

Conduct problems. We used 7 items to measure conduct problems: 4 questions about theft/property damage and 3 questions about interpersonal aggression. We created 3 scales: overall/total conduct problems, theft/property damage only, and interpersonal aggression only. Respondents rated all questions on a scale of 1 (not at all) to 5 (≥ 5 times). Scale scores were calculated as the mean of the relevant items. We used the chained equations to conduct multiple imputations in Stata, version 13.1 (StataCorp LP, College Station, Texas) on respondents who missed 1 or more items (1.84% missed 1 item, 0.29% missed 2 items, and 13.47% missed >2 items), using the variables sex, race, age, grade, level of parental education, and evenings out in order to inform the imputation. We performed imputations on each item separately and combined them after imputation for a sum score. After the data were imputed, we analyzed 10 data sets together using Rubin's Rules for combining imputed data sets for analysis.

Subscale items regarding theft/property damage asked how often during the past 12 months participants had “taken something not belonging to you worth under \$50,” “taken something not belonging to you worth over \$50,” “gone into some house or building when you weren't supposed to be there,” and “damaged school property on purpose.” Across grades, Cronbach's α ranged from 0.73 (in 1991) to 0.78 (in 1998). Subscale items regarding interpersonal aggression asked how often during the past 12 months participants had “gotten into a serious fight in school or at work,” “taken part in a fight where a group of your friends were against another group,” or “hurt someone badly enough to need bandages or a doctor.” Cronbach's α ranged from 0.78 (in 2014) to 0.82 (in 2006). A summary measure of conduct problems included all 7 items. Cronbach's α for the summary score ranged from 0.80 (in 1991) to 0.84 (in 1998).

Demographic characteristics. We stratified analyses by self-reported sex (48% male), race/ethnicity (60% non-Hispanic white, 16% non-Hispanic black, and 12% Hispanic; students who reported “Asian” and “other” races/ethnicities were too few for reliable estimates by sex). We also stratified by parental educational level, which we measured as the highest level of education of either the mother or the father, as reported by the student (\leq high school (31%) vs. $>$ high school (66%)). Students who reported that they did not know (3%) were excluded from the present study.

Rates of juvenile arrest. We compared trends in mean conduct problems versus trends in total juvenile arrests, separating property crime and violent crime, using data from the

Office of Juvenile Justice and Delinquency Prevention within the US Department of Justice (<https://www.ojjdp.gov/>). National data were available by year from 1991 through 2014, for those 10–17 years of age. Although this age range is slightly different from the age range included in MTF data (13–18), the estimates provide an overall summary of trends across the adolescent period.

Evenings out. MTF questionnaires included the following item: “During a typical week, how many evenings do you go out for fun and recreation? (Don’t count things you do with your parents or other adult relatives.)” We examined age, period, and cohort effects on the mean number of evenings out per week as reported by the student. As demonstrated in Web Table 1 (available at <https://academic.oup.com/aje>), the number of evenings out was positively associated with the overall score on conduct problems ($\beta = 0.59, P < 0.01$), interpersonal aggression ($\beta = 0.25, P < 0.01$), and theft/property damage ($\beta = 0.33, P < 0.01$).

Statistical analysis

We estimated the mean of the conduct problems summary score by age and year, across the 25 years of data collection, by sex (31, 32). We then proceeded to age-period-cohort modeling. Age, period, and cohort are linear functions (Cohort = Period – Age); thus, the linear effects of age, period, and cohort are not identifiable parameters in a traditional least-squares regression without placing constraints on the underlying parameters (23). We used the intrinsic estimator approach for this investigation (33–36), which places constraints in the design matrix that are unbiased to the underlying age, period, and cohort effects that give rise to the data. Using decomposition techniques, an intrinsic estimator can be estimated that is invariant to model constraints that are identified through the Moore-Penrose generalized inverse (37). The intrinsic estimator is particularly suitable for continuous scalar outcomes, such as the conduct problems scales that we use for the present investigation. Researchers who have examined direct comparisons of the intrinsic estimator versus other types of age-period-cohort modeling have found superior statistical properties and valid estimation of the underlying results (33).

We conducted 4 sets of analyses. First, we examined trends across time for the 2 subscales (interpersonal aggression and theft/property damage) and the individual items. Second, for the interpersonal aggression subscale, we overlay trends in violent crime on a second axis, and for the theft/property damage scale, we overlay trends in property crime. Third, we estimated age-period-cohort models in the summary and subscales by race/ethnicity, and parental educational level. Fourth, we examined trends across time in the mean number of evenings out per week as a potential explanatory mechanism for trends across time in conduct problems.

We conducted data management in SAS, version 9.4. (SAS Institute, Inc., Cary, North Carolina) For age-period-cohort analysis, we used the publicly available add-on file for the “intrinsic estimator” algorithm available in StataMP, version 9.0 (38). We also used Stata version 13.1 for descriptive analyses and imputation. Graphs were generated in ggplot2 (39) in R software (R Foundation for Statistical Computing, Vienna,

Austria). We provide all of our modeling code in Web Appendix 1.

RESULTS

Trends in conduct problems by age and period from 1991 to 2015

Figure 1 shows the mean summary conduct problems summary score, by sex, for year groupings from 1991 to 2015 across all ages. Scores for all years ranged from 7 to 35; mean across all years was 10.25 with a standard error of 0.013 for boys and 8.78 with a standard error of 0.009 in girls; in Web Table 2, we provide the mean and standard error for boys and girls for each year. On a secondary axis in Figure 1, we overlay trends in juvenile arrest rates across the same period. Among boys (Figure 1A), mean conduct problems decreased across time from 10.66 in 1991–1995 to 9.38 in 2011–2015, which represents approximately 40% of a standard deviation. Arrest rates show a remarkably similar trend. Among girls (Figure 1B), mean scores were lower, with very little evidence of a trend across time, although the lowest mean conduct problems and lowest mean arrest rates were observed for the most recent period of 2011–2015 (8.48 and 0.022, respectively).

In Figure 2, we separate the trends across time in conduct problems by age. Among boys (Figure 2A), those who were 15 and 17 years of age had the highest conduct problems across time, yet there were consistent decreases across time across all age groups. The most substantial change was observed for 14-year-old boys (from 1991 to 1995, mean = 10.86, standard error, 0.06; from 2011 to 2015, mean = 9.46, standard error 0.06) and 15-year-old boys (from 1991 to 1995, mean = 10.87, standard error, 0.06; from 2011 to 2015, mean = 9.49, standard error, 0.07). Among girls (Figure 2B), those who were 14 years of age had the highest mean conduct problems (with a peak in 1996–2000; mean = 9.26, standard deviation, 0.05), with little evidence for change across time, although all ages had a decrease in the most recent period (2011–2015).

Age, period, and cohort effects on conduct problems

Figure 3 shows age-period-cohort effects on conduct disorder problems among boys. Those who were 15 years of age (estimate = 0.228, 95% confidence interval (CI): 0.173, 0.283) and 17 years of age (estimate = 0.156, 95% CI: 0.087, 0.226) have the highest mean problems, compared with the mean of adolescents of all ages. Adolescents 15 and 17 years of age are most likely to be in different grades, 10th and 12th, respectively; thus, these trends in age may also be indicative of a grade effect. We did not capture 11th grade, which would have included a broader range of 16-year-old students. By period (Figure 3B), mean problems have been generally declining across time, although there was no significant change between 1997 and 2008. After 2008, there is a sharp decline. By cohort (Figure 3C), those who were born in the early 1980s have higher mean problems compared with the overall mean (e.g., 1985 estimate = 0.278, 95% CI: 0.110, 0.445) with problems generally declining by cohort thereafter.

Among girls (Figure 4), those who were 14 years of age (estimate = 0.313, 95% CI: 0.277, 0.350) have the highest

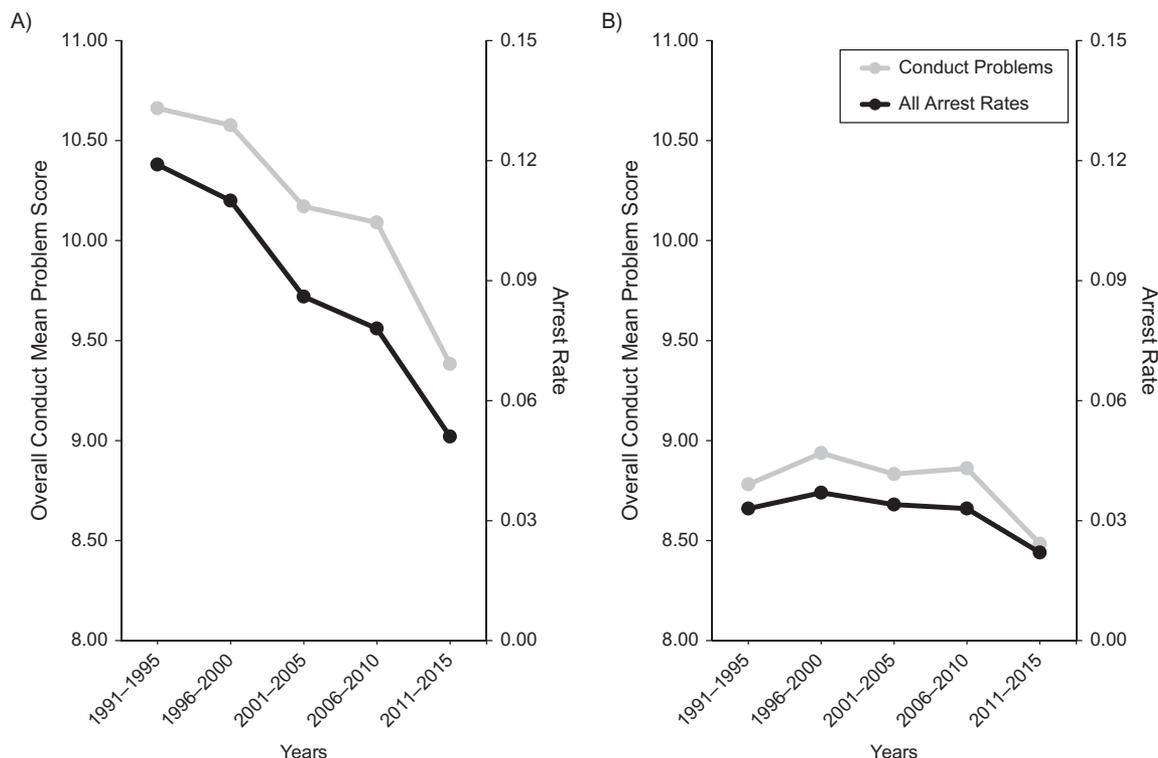


Figure 1. Mean overall conduct problem score based on Monitoring the Future Study students 13–18 years of age (*y*-axis) and all crime arrest rates for persons 10–17 years of age (*z*-axis), 1991–2015. A) Boys; B) girls. Arrest rates are per 100,000 persons in the resident population from 1991 to 2014. Data are from the Office of Juvenile Justice and Delinquency Prevention (52).

mean conduct problems compared with the mean of all ages. By period (Figure 4B), little evidence exists of any trend across time, although mean problems are slightly lower starting with 2012 (estimate = -0.159 , 95% CI: -0.256 to -0.06) compared with the mean for all years. By cohort (Figure 4C), we observed significantly positive cohort effects for those born from 1980 to 1987 (thus beginning adolescence in the mid 1990s through the early 2000s) and, conversely, significantly negative cohort effects for those born after 1997.

Trends separating subscales of conduct problems

In Web Figures 1 and 2, we provide summary estimates for interpersonal aggression and theft/property damage, respectively. Both show consistent decreases across the study period for boys, and there is little evidence of change across time for girls. In Web Figures 3 and 4, we provide trends by age for each subscale. Trends across time were consistent, although age differences varied. Interpersonal aggression was highest for both boys and girls at 14 years of age and lowest for both sexes at 18 years of age; for theft/property damage, the mean among boys was lowest for those who were 13 years of age; the mean among girls was lowest for those who were 18 years of age. Few differences among adolescents of other ages were visually apparent.

In Web Figures 5–11, we dichotomize each item used to measure conduct problems at any reported experience versus

none. Among boys, there were decreases across time in every item. The item that had the largest decrease across time was taking something not belonging to you worth less than \$50; in contrast, hurting someone badly enough for that person to need medical attention had little trend across time for boys. Among girls, fewer trends emerged.

In Web Figures 12 and 13, we present age-period-cohort models for the interpersonal aggression subscale for boys and girls, respectively. For boys, results were consistent with overall trends. For girls, there was no evidence of a period effect in interpersonal aggression and the cohort effect was lower in magnitude; property damage suggested lower period and cohort effects among girls. In Web Figures 14 and 15, we present age-period-cohort models for the theft/property damage subscale for boys and girls, respectively. Results were consistent with overall models of total conduct problems.

Age-period-cohort effects on conduct problems by demographic characteristics

In Web Figures 16–19, we present age-period-cohort models for total conduct problems stratified by race/ethnicity and highest level of parental education, for boys and girls separately. Although standard errors were larger for some groups (e.g., nonwhite students), overall trends were similar across these demographic categories. Cohort effects for conduct problems among both boys and girls were most apparent among

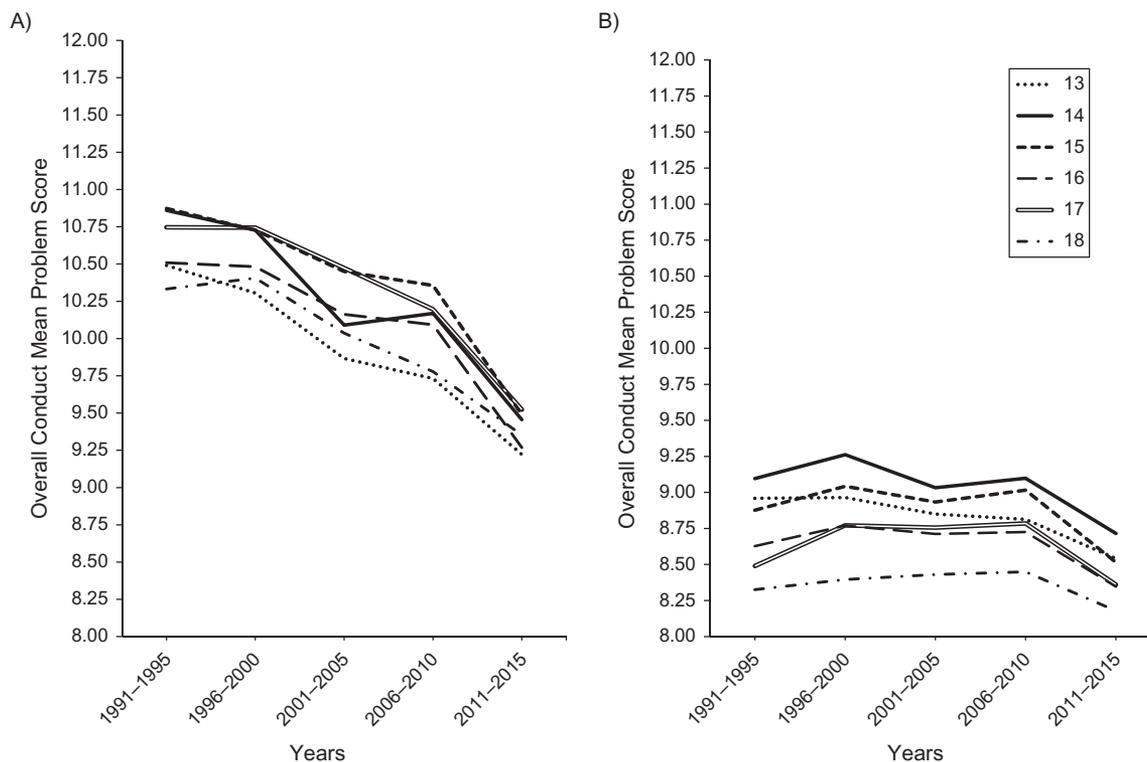


Figure 2. Mean overall conduct problem scores by age (in years) and period among US adolescents, 1991–2015. A) Boys; B) girls.

whites and among those with a parent who had at least a college education.

Age, period, and cohort effects on evenings out

We hypothesized that one potential explanation for the declining conduct problems was fewer opportunities to engage in conduct violations if students spend less time out of the house. In Web Figure 20, we present mean evenings out by year and grade. Both boys and girls demonstrated declines in mean evenings out, across all grades, across time. Web Figures 21 and 22 present age-period-cohort models for boys and girls, respectively. Indeed, for both boys and girls, there is a declining period effect with notable decreases starting in 2009 for girls and 2010 for boys. By 2015, the mean evenings out for boys was -0.320 points lower than the mean for all periods (95% CI: -0.381 to -0.259), and -0.347 points lower than the mean for all periods for girls (95% CI: -0.402 to -0.292). Cohort effects on evenings out for boys and girls mirrored cohort effects for conduct problems.

DISCUSSION

In the present study, we examined national trends in adolescent conduct problems across 24 years in the United States. Conduct problems among boys have been declining substantially since 2010, across all age groups. This decline was more pronounced among boys in more recent birth cohorts, beginning with those born around 1992, who became adolescents in

the mid- to late-2000s. Declines in other age groups were less pronounced but were still appreciable. In contrast, the rate of conduct disorder among girls remains lower than that among boys, has not changed substantially, and has shown no period or cohort trends. Trends are consistent across various subscales of conduct problems and mirror overall national trends in juvenile arrest rates, which have also been declining. Trends are consistent across race/ethnicity and parental educational level, although these trends are most apparent among whites and among adolescents who have parents with higher educational levels.

Conduct problems are often characterized in theories of crime, as well as in biological psychiatry, as a disorder with genetic underpinnings (5, 7, 10) that is developmentally rooted in brain function and structure (40, 41). Although individual differences explain a portion of variance in conduct problems at a single point in time, they cannot explain changes across time. Our findings indicate that secular environmental changes are also responsible for significant overall mean changes in conduct problems in the population. Although most researchers have established that individual-level risk factors such as childhood poverty and abuse predict subsequent involvement in crime during adulthood (e.g., 42), other researchers have shown that prediction of individual-level trajectories of crime is poor (43, 44). In terms of public health, we may generate more changes at a population level by focusing on the environmental correlates of conduct problems and juvenile crime (e.g., social norms, police surveillance, and parent supervision) than on individual determinants of variance distributions at any one point in time.

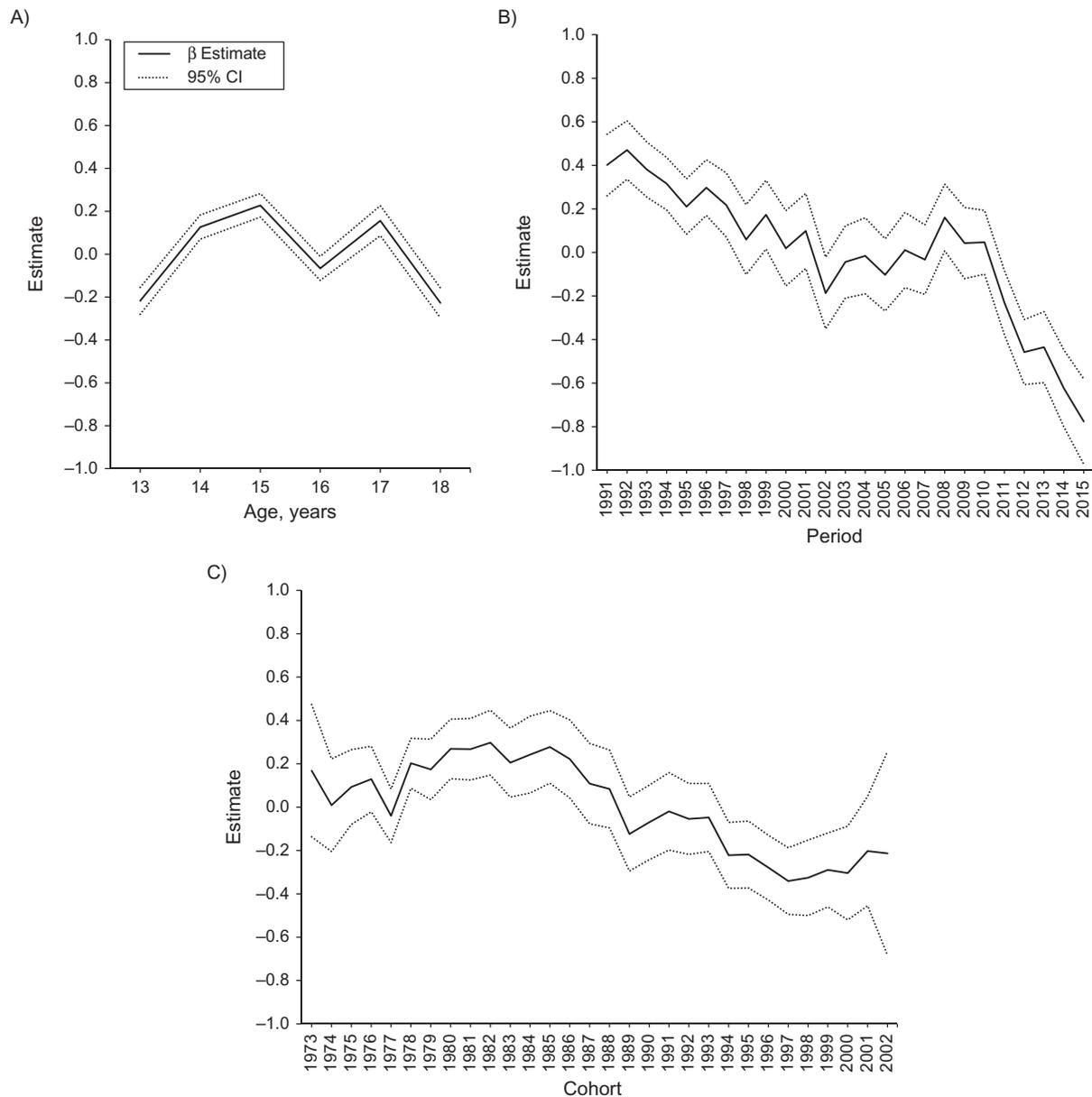


Figure 3. Age (A), period (B), and cohort (C) effects on overall conduct problem scores among adolescent boys in the United States, 1991–2015. Each estimate from the intrinsic estimator is compared with the mean estimate from the whole sample. For example, those who were observed in 2015 had an estimate of -0.776 . That estimate indicates that the period effect is significantly lower than the period effect for the whole sample after controlling for age and cohort effects. CI, confidence interval.

Mechanisms that might underlie these decreases remain hypotheses. Some of the decreases may be attributable to changes in the rates of high school dropouts. There have been decreases in high school dropout rates by 12th grade (from approximately 15% before 2002 to a gradual decline to approximately 8% in 2015) (45); thus, more 12th grade students in recent years would have dropped out of high school in previous years. However, the declines observed in conduct problems predate the decrease in dropout rates, which suggest that although changes in dropout rates may account for some of the decline in conduct problems, it is

unlikely to account for all of them. Maternal risk factors for offspring conduct problems, such as maternal smoking in pregnancy and adolescent childbearing, may also underlie the observed decline, as these risk factors have demonstrated robust cohort effects (10–14) that may translate downstream to declining conduct problems among the offspring. The strong period effects may be explained by factors such as the changing landscape of adolescent interaction. With increasing competition for educational positions in higher education leading to a greater focus on extracurricular activities, as well as a rapid increase in the use of technology that allows adolescents to interact without

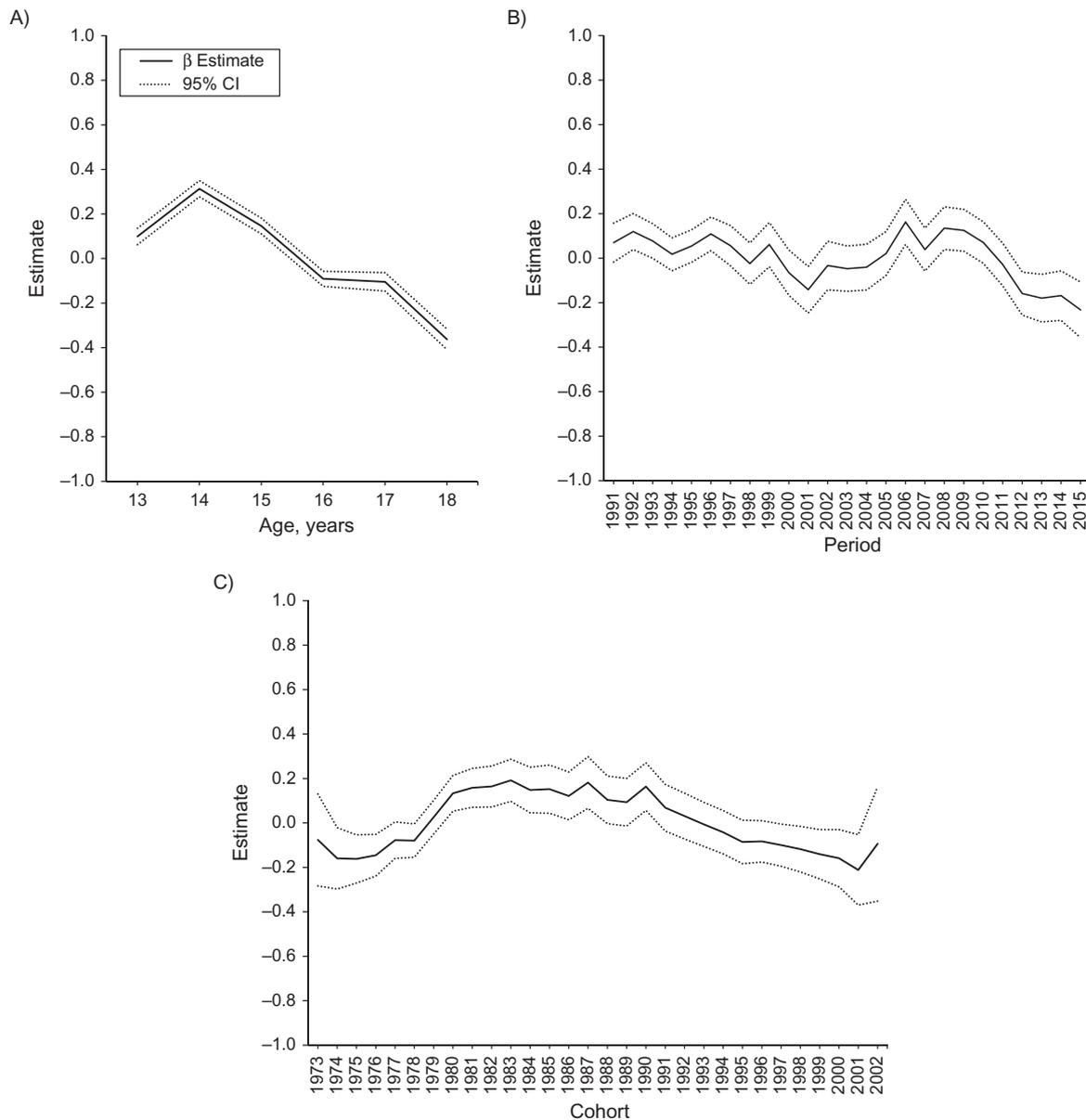


Figure 4. Age (A), period (B), and cohort (C) effects on overall conduct problem scores among adolescent girls in the United States, 1991–2015. Each estimate from the intrinsic estimator is compared with the mean estimate from the whole sample. For example, those who were observed in 2015 had an estimate of -0.233 . That estimate indicates that the period effect is significantly lower than the period effect for the whole sample after controlling for age and cohort effects. CI, confidence interval.

meeting, the phenomenon of unsupervised adolescent groups may be fading. This hypothesis is supported by our analysis, which shows that the mean evenings out per week reported by adolescents have declined for the past 24 years and demonstrates similar period and cohort effects as are observed for conduct problems, at least for boys. We present these analyses as hypothesis generating and suggest that future studies examine not only the phenomenon of fading unsupervised interaction between adolescents, but also shifts from in-person interaction to social media and other technologically enhanced ways for adolescents to interact. Furthermore, the conduct

problem indicator that had substantial declines was stealing something worth less than \$50; the shift in consumerism to online shopping, as opposed to shopping centers, may underlie adolescents access to goods in order to steal. In previous studies, researchers have shown that evenings out and unsupervised time with friends are associated with marijuana use among adolescents (46, 47), indicating that engaging in deviant behavior is a phenomenon consistent with adolescents spending unsupervised time together. Indeed, data from the MTF and other studies are showing that marijuana use among adolescents is also decreasing, despite widespread legislation

that is making cannabis use more permissible and available for adults (29, 48, 49). Nonetheless, formal tests of mediation were beyond the scope of the present analysis and these hypotheses are only speculative.

It is worth noting that boys' conduct problems declined whereas girls' did not, although girls had substantially lower problems in all years. The declining trajectory of boys' conduct problems and the stability of conduct problems in adolescent girls suggest that the absolute difference in conduct problems between the sexes may be decreasing and is consistent with the declining sex gap in violent arrests (24). This trend is consistent with other MTF data that found that offending by females, based on a self-reported assault index (e.g., serious fight at school, physically injuring another person), remained relatively stable between 1991 and 2003 among a combined sample of girls in the 8th, 10th, and 12th grades (50, 51).

A major strength of these data are that there have been no changes in survey administration mode or questions asked across the study period. However, as documented in the MTF monograph (29), there have been some sample composition changes (including the decline in dropout rates discussed previously) across time that reflect changes more generally in the United States. For example, there have been increases in the percentage of students who plan to go to college, as well as increases in parental educational levels (which increased until approximately 1996 and have remained relatively constant thereafter). Furthermore, by race/ethnicity, there have been declines in students reporting white race, and increases in students reporting Hispanic ethnicity and "other" race. However, we do not believe that these compositional changes account for the differences observed in our analyses, given that trends are consistent across race and parental educational level, although we do note that cohort effects were strongest among whites and adolescents who had a parent with at least a college education. Although question wording is invariant across time, we do not know whether there are trends in question interpretation or in adolescents' comfort in revealing potential criminal activity. Underreporting is likely; thus, point estimates are likely lower-bound estimates. However, surveys are given under strict conditions of confidentiality, which may reduce this type of reporting bias. Finally, the MTF study includes only adolescents who attended 3 grades of high school, which limits generalizability. Thus, students who are not the modal age within grade may not be representative of all students in that age, and we do not have widespread coverage of students who are the modal age in grades that are not covered by MTF. Given that high school dropout rates increase with age, our 12th grade sample of high school attendees may include fewer high-risk adolescents than the 8th and 10th grade samples.

In summary, 25-year trends in conduct problems suggest a largely decreasing trajectory of conduct problems for boys and stability for girls. Results are generally consistent across demographic categories of race/ethnicity and parental educational level, although they suggest that decreases are principally concentrated in advantaged groups. Findings provide evidence for new hypotheses about underlying social factors that may be shaping risk, including fewer evenings spent outside of the home. Conduct problems continue to generate harm and disability for children and their families and predict long-term adverse outcomes (2). A focus on understanding

population-level trends and determinants of these outcomes is critical to achieving public mental health success.

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