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Dain Jung
Liaoning University

Jun Hyung Kim
KAIST and IZA

Do Won Kwak
Korea University

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IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

Who Benefits from Single-Sex Schooling? Evidence on Mental Health, Peer Relationships, and Academic Achievements

Single-sex schooling is a controversial policy whose effects are inconsistent across different studies with its mechanisms poorly understood. Leveraging the random allocation of high school students in South Korea, we study the effect of single-sex schooling on mental health while considering its interactions with peer relationships and academic achievement. Our results closely align with gender-specific responses to competitive pressure in the literature. Female students with better academic achievement than their peers experience better mental health and peer relationships. However, relatively underperforming female students, subject to intense competitive pressure at school, do not benefit from being in the company of other female students in a single-sex environment. Impacts on male students do not significantly depend on the competitive pressures they face. Our study calls for caution in implementing educational policies that may affect competitive pressure or gender composition in schools.

JEL Classification: I21, I24, J16

Keywords: single-sex schooling, gender and competition, mental health, peer relationship

Corresponding author:
Jun Hyung Kim
School of Digital Humanities and Computational Social Sciences
KAIST
291 Daehak-ro, Yuseong-gu
Daejeon 34141
Republic of Korea

E-mail: kimjunhyung@kaist.ac.kr

1 Introduction

Do single-sex schools benefit students? Single-sex schooling is a widely popular but controversial schooling choice that homogenizes gender composition at school (Jackson, 2021; Ribeiro, 2019). It is well known that attending single-sex schools can benefit students' academic achievements (Dustmann, Ku, and Kwak, 2018; Eisenkopf et al., 2015; Jackson, 2021; Park, Behrman, and Choi, 2013). Studies have also examined various non-academic outcomes such as non-cognitive skills (Cardona and Kaufmann, 2017), labor income (Sullivan, Joshi, and Leonard, 2011; Lee and Nakazawa, 2022), mental health (Kim and Kim, 2022), crime rates and teen pregnancy rates (Jackson, 2021), childbirth (Brenøe and Zölitz, 2020), out-of-school activities (Hahn and Wang, 2019), and competitiveness (Lee et al., 2014). However, the findings are inconsistent across studies, often without any discussion of the underlying mechanisms. For instance, Lee and Nakazawa (2022) and Brenøe and Zölitz (2020) show that single-sex schooling lowers the probability that female students choose STEM majors, depresses their earnings, and increases their likelihood of having more children, whereas others suggest that single-sex schooling does not affect students' choices of STEM major (Sohn, 2016; Park, Behrman, and Choi, 2018). Kim and Kim (2022) show that single-sex schooling improves noncognitive outcomes of female students, including depression, self-esteem, and school aspirations, but do not discuss how these effects are generated.

In this study, we investigate the impacts of single-sex schooling on both academic and nonacademic outcomes, including various mental health and peer relationship measures. Moreover, we focus on students' gender and the pressure from academic competition as a source of heterogeneity in effects across students. Our data consists of high school students in South Korea, where college admission decisions depend critically on the within-school ranking and the performance at the national college entrance examination, which is strongly predicted by high school academic performance. We, therefore, use a proxy measure of competitive pressure felt by students based on their within-school ranking of pre-high school test scores. [1]

[1]There are two types of college applicants in Korea: regular applicants and rolling applicants. Regular applicants rely mostly on CSAT scores while rolling applicants rely largely on high school GPA. The proportion of rolling applicants increased every year, accounting for 66.7% (33.3% of regular applicants) as of 2016.

To identify causal effects, we employ random assignment of students to coeducational or single-sex high schools in South Korea based on the student random assignment policy. We use data from the Seoul Education Longitudinal Study (SELS), which follows students in Seoul from grades 7 to 12 (i.e., three years of middle school and three years of high school). Although the policy was modified in 2010 to allow some students to partially reflect their preferences in the school assignment process, our empirical strategy ensures the identification of causal impacts by solely focusing on a randomly selected subsample of students whose assignments were completely randomized even after the 2010 reform. A similar identification strategy is employed in studies using Korean samples (Dustmann, Ku, and Kwak, 2018; Lee and Nakazawa, 2022; Park, Behrman, and Choi, 2013), but they rely on the pre-2010 policy that implemented full randomization for all students.[2]

We find that the effects of single-sex schooling depend on the student's gender and the pressure of academic competition. Although the overall impact on mental health is negative, it is positive for female students whose academic achievements rank higher than most of their high school peers. These students are likely to face less pressure to compete academically while benefiting from having female peers, who tend to be better disciplined and perform better academically compared to male students. Similarly, the positive impacts of single-sex schooling on peer relationships are the largest among high-performance female students. For female students who are not at the top of their school's academic achievement distribution and therefore experience greater competitive pressure, the costs of single-sex schooling due to academic stress may outweigh its benefits for mental health and peer relationships. Our study suggests that the positive female-to-female peer effects on mental health and peer relationships observed in (Gong, Lu, and Song, 2021; Kim and Kim, 2022) might be attributed to overlooking the high academic pressure experienced by lower-performing female students in single-sex schools. Unlike the case of female students, high-

[2]The policy before 2010 enforced a complete random assignment of students to schools. It was criticized for overly restricting students' right to choose schools (Lee, 2004), and in 2010, the policy was relaxed to better reflect students' school preferences for those selected through the random lottery. However, approximately 40% of students who were not selected through the lottery were still completely randomly assigned to schools. As explained later, we only use these 40% of students in all our estimations.

performance male students attending single-sex schools show better academic performance but suffer in mental health and do not enjoy better peer relationships that other male students enjoy. Competitive pressure is not a consistent explanation for the effects on male students.

Our results are consistent with studies emphasizing the importance of gender differences in responses to competitive pressure in determining students' outcomes. The literature shows that female students tend to be less competitive than their male classmates (Horn, Kiss, and Lénárd, 2022) and choose less competitive fields of study (Buser, Peter, and Wolter, 2017; Kam and Lee, 2023; Landaud, Ly, and Maurin, 2020). Even outside the academic environment, women tend to perform less well in competitive environments compared to men (Backus et al., 2023; Gneezy, Niederle, and Rustichini, 2003; Gneezy and Rustichini, 2004). When faced with other women, however, women do not avoid competition and may even increase efforts to compete (Booth and Nolen, 2012; Laury, Lee, and Schnier, 2019; Mago and Razzolini, 2019). Unlike women, men are relatively immune to the negative impacts of competitive pressure (Booth and Nolen, 2012; Laury, Lee, and Schnier, 2019; Mago and Razzolini, 2019). The results of our studies are in line with these studies in that the positive impacts of having same-sex peers are observed only among those least likely to suffer from the negative impacts of competitive pressure, such as high-performing female students and male students.

Our findings contribute to understanding the sources of the effects of single-sex schooling on students' outcomes that go beyond test scores. Although the literature shows that female students benefit in mental health and peer relationships from having same-gendered peers (Gong, Lu, and Song, 2021; Kim and Kim, 2022), we find that the benefits are observed only among a subset of students who plausibly do not experience high competitive pressure at school. This adds nuance to the literature showing positive effects of single-sex schooling on academic achievements and behavioral outcomes (Dustmann, Ku, and Kwak, 2018; Eisenkopf et al., 2015; Jackson, 2021) but heterogeneous and inconsistent results on other outcomes such as STEM major choices and long-run labor market outcomes, which often favor male students over female students (Jackson, 2012; Lee and Nakazawa, 2022; Park, Behrman, and Choi, 2018). We show that the heterogeneous

effects of single-sex schooling may be explained by different responses of male and female adolescents to competition against school peers of different gender composition, consistent with the findings by Niederle and Vesterlund (2010).

We also contribute to the understanding of the sources of mental health problems among adolescents. Up to 20% of adolescents worldwide suffer from mental health problems (Kieling et al., 2011; Lee et al., 2014), and the rate has been growing substantially in the past decades, affecting adolescents across genders, social classes, and family types, with a notable impact on girls and young women (Collishaw et al., 2004; Gunnell, Kidger, and Elvidge, 2018). Our study emphasizes the importance of the gender-specific effects of competition for understanding adolescent mental health development. In particular, single-sex schooling may have affected adolescent mental health through peer relationships under environments of different competitive pressures. This is consistent with previous studies that have identified serious academic pressure, poor peer relationships, and socioeconomic disadvantages as risk factors for adolescents' mental health, highlighting the critical importance of peer relationships (Kieling et al., 2011; Birkeland, Breivik, and Wold, 2014; Kiessling and Norris, 2022). Our study's findings suggest that research on adolescent mental health should consider gender differences in how students cope with and respond to academic competition while also recognizing the importance of peer relationships.

Our findings imply that single-sex schooling can be a double-edged sword in which improvements are not guaranteed across all outcomes and for all students. The benefits of single-sex schooling and the strategic manipulation of student composition for academic achievement should be carefully weighed against potential harms to other outcomes, particularly for certain sub-groups. For example, intense competition that leads to a deterioration in peer relationships may negatively impact the mental well-being of students who do not cope well with such pressure. The overall null effects of single-sex schooling on mental health that we find may lead to misleading conclusions if its heterogeneous impacts are not taken into account. Furthermore, given the intense academic competition in Korean high schools, the positive effects of single-sex schooling on mental health and peer relationships observed in studies from other countries are not necessarily contradictory

to the null effects found in our study. Policies that fail to consider the adverse effects of competition on different students may inadvertently harm them, potentially widening gender inequality in non-academic outcomes. Analysts evaluating educational policies should also account for the moderating role of competitive pressure on student outcomes.

The rest of this paper is organized as follows. Section 2 provides an overview of the literature on the effects of single-sex schooling on adolescent outcomes and the institutional details of Seoul's educational system, including student assignments and college admissions. Section 3 presents our empirical framework. Section 4 describes our data and presents balance tests and plots of pre-treatment outcomes to examine whether the random assignment of students between treatment and control groups was well implemented. Section 5 shows our estimation results, and Section 6 shows the robustness of our results. Section 7 includes a discussion of the results and concluding remarks.

2 Background

2.1 Single-Sex Schooling and Adolescent Outcomes

How can single-sex schooling impact high school students' mental health, peer relationships, and academic achievements? Some suggest that the more competitive attitudes of male students negatively affect female students' self-confidence and academic motivation in coeducational schools (Booth and Nolen, 2012; Streitmatter, 2002), leading them to avoid competitive majors in science and math and receive lower earnings in the long run (Booth and Nolen, 2012; Lee and Nakazawa, 2022). Female students in female-only schools do not suffer these disadvantages (Streitmatter, 2002), consistent with the implications of gender-specific responses to competition (Niederle and Vesterlund, 2010). Further, female students can benefit from interacting with other female students in terms of improved school-life satisfaction and classroom environment (Gong, Lu, and Song, 2021). A different explanation is that a single-sex schooling environment puts less emphasis on adolescent culture centered on physical attractiveness and interpersonal relationships (Riordan, 1985). Such an environment may allow adolescents to focus on academic learning rather than on

popularity among peers based on physical attractiveness or participation in the dating market.[3]

Adolescents' mental health can be significantly affected by the gender-specific responses to competition and peer interactions that differ by coeducational and single-sex school environments. Adolescence is a highly vulnerable period for mental health problems because of hormonal and neural development, making adolescents more susceptible to peer influence and heightened emotional reactivity (Lee et al., 2014). In addition, the high school period is characterized by intense academic pressure, fueled by rising returns to university education (Bound, Hershbein, and Long, 2009). The intense academic competition in high school directly contributes to adolescent mental health problems and indirectly through issues with peer relationship (Högberg, Strandh, and Hagquist, 2020; Long et al., 2020; Roseth, Johnson, and Johnson, 2008) and academic performance (Bond et al., 2007; Fletcher, 2010; McLeod, Uemura, and Rohrman, 2012). Therefore, we expect differences to emerge in mental health and peer relationships between students in coeducational and single-sex schools.

High schools in South Korea are well-suited to study the impact of a single-sex schooling environment on adolescent outcomes and the potential implications of a competitive school environment because both single-sex and coed schools coexist in substantial numbers, and most high school students compete intensely to advance to elite colleges. Heightened competition and academic pressure characterize most high schools around the world, but high schools in Korea are known for unusually high levels of competition (Kwon, Lee, and Shin, 2017; Lee and Larson, 2000). A high school student's college admission is almost entirely determined by the within-school ranking based on high school test scores and the scores in the nationally-administered College Scholastic Ability Test (CSAT). Within-school rankings are determined by the midterm and final test scores in every semester during the high school period. The CSAT is given once a year in November and is designed to be challenging, with only a handful of students attaining a perfect score each year (Lee, 2018). Because the academic pressure is intense throughout the high school

[3]Yet other explanations are based on the gender-specific impact of teachers who are better guides and role models for students of the same gender. This paper focuses on explanations that focus on academic competition and peer relationships. See Park, Behrman, and Choi (2013) for more discussion.

period to improve one's school rank, and CSAT questions are drawn from nationally standardized components of the high school curriculum, high school test scores are good predictors of CSAT performances. Unsurprisingly, mental health and peer relationship problems are common among Korean high school students (Koo, Kwak, and Smith, 2008; Lee and Larson, 2000).

2.2 Student Assignment System for Middle Schools and High Schools in Seoul

The education system in Seoul mandated random assignments of students in high school admissions until 2009. The random assignment system was first implemented in 1974 when the High School Equalization Policy abolished school assignments based on high school entrance exam scores to reduce concerns about the academic burden and educational inequality across households. Following the reform, the students were randomly assigned to high schools within their residential districts as of the final year of middle school (i.e., grade 9) by computerized lottery.[4] When students moved to a different district, they were randomly assigned to a school within the new one. The assignments were made regardless of whether the schools were public or private, or whether they were single-sex or coeducational schools. The middle school assignment followed a similar procedure.

In 2010, the student assignment system for high school admissions in Seoul was modified, relaxing the randomization requirement from complete to partial (Jung, 2022). In the modified system, high school assignment is completed in three rounds, and in each round students were randomly drawn across schools by lottery. In the first round, students apply to at most two schools out of all high schools in Seoul, and each school fills 20% of the available slots at random. In the second round, the remaining students apply to two schools in their school districts (based on their residential address), and 40% of the slots are randomly assigned among the students who applied to each school.[5] In the third round, the remaining 40% of slots are assigned entirely by

[4]The residence district is based on Seoul's 26 administrative districts ("gu"). There are 11 school districts in Seoul, and each school district is a combination of two or three administrative districts.

[5]Some slots may remain unfilled if students are selected by both of the schools they applied to, as they can only

lottery among schools located in two school districts closest to each student's residential address. In contrast, among public middle schools, the assignment of students to middle schools remains completely random within their school districts, even after 2010.[6]

Our data set covers the period after 2010. For all students in our sample, therefore, the high school assignment process is based on the application-based partial random assignment. Although we cannot rely on the full randomization assumption invoked in studies that used pre-2010 samples (Dustmann, Ku, and Kwak, 2018; Park, Behrman, and Choi, 2013; Park, Behrman, and Choi, 2018; Sohn, 2016), we have information on the round in which students were assigned to their schools. Therefore, all estimations in the main results section are based on students assigned to high schools in the third round in which random assignment protocol was used for all students.

We show statistical evidence supporting random assignment in Table 1, Figure 1, and Table A1 in Section 4. Further, we conduct another test of random assignment in the robustness section by estimating the main results with only district fixed effects (FEs) and year FEs. Our test results are consistent with the random assignment of students to schools.

3 Empirical Framework

For the main analysis, we estimate the average treatment effects of single-sex schooling on student outcomes with observations from the high school period (grades 10 to 12),[7] using the following equation:

$$y_{isrt} = \alpha_0 + \alpha_1 y_{i0} + \delta Treat_i + X_{it}\pi + \mu_s + \phi_r + \upsilon_t + \epsilon_{it}, \tag{1}$$

enroll in one school. Any remaining slots at the end of the second round are filled by the remaining applicants before moving to the third round.

[6]However, some private middle schools may conduct entrance exams and select specific students. Our data do not provide relevant information about these cases. We therefore excluded students who attended private middle schools from the final sample.

[7]In the robustness section, we estimate difference-in-differences (DiD) models using both middle school and high school observations.

where y_{isrt} is the outcome of interest, including mental health, peer relationships, and academic achievements, for a student i in school district s, residential district r, and grade t; $Treat_i$ is a binary indicator that takes 1 if the student i attends a single sex high school and 0 otherwise; y_{i0} is a baseline value of the outcome calculated as the mean of the outcome during middle school years; X_{it} is a vector of baseline characteristics, including the grades 7–9 average value of the outcome variable of interest, socio-demographic and school characteristics variables as shown in Table 1,[8] an indicator for attending a private high school, and indicators for the main reasons for the stated preference of a high school in the first two rounds of assignment; μ_s and ϕ_r represent school district and residential (administration) district FEs and v_t represents year (or grade) FEs; and ϵ_{it} is an idiosyncratic error term. The coefficient of interest is δ, the effect of attending a single-sex school as opposed to a coeducational school. The effect is interpreted as a causal effect whose identification is supported by the random assignment protocol and the empirical model.

Furthermore, we investigate the heterogeneous effects of single-sex schooling by examining the pressure of academic competition within a school and the gender of the students. The literature emphasizes the impact of peer gender composition on competition and well-being, particularly for female-only groups. Research shows that female students in all-girls schools are more competitive than those in mixed-gender schools (Booth and Nolen, 2012; Laury, Lee, and Schnier, 2019). Additionally, women tend to be more productive and exert more effort when competing with other women in a competitive environment (Gneezy, Niederle, and Rustichini, 2003; Mago and Razzolini, 2019). These studies suggest there are significant interaction effects between gender and competition on both productivity and mental well-being.

In our analysis, we construct a proxy measure of competitive pressure based on student's academic performances during the middle school years relative to their high school peers. As explained in the Background section, a student with high school test scores below many of her peers would feel immense pressure to improve her performance to increase her chance of college ad-

[8]They include an indicator for a student's gender, log of household disposable income per month, the monthly private education expenditure for math and English, class size, the mean tenure of teachers in the school, and an indicator for having attended a single-sex middle school. These variables are averages of values from grades 7–9.

mission. Since middle school academic performance is a strong predictor of high school performance and is not influenced by the type of high school (i.e., whether single-sex or coeducational), a student's high school rank based on middle school test scores serves as a good proxy for the competitive pressure she faces in high school.

Specifically, we use middle school math scores to construct each student's within-school ranking in the first year of high school (the tenth grade) as the proxy measure of competitive pressure.[9] The ranking of students within a school is based on the middle school test scores of all students in the SELS, regardless of whether students are randomly assigned in the third round or the previous rounds. The average number of sampled students in a high school used to calculate student ranking is 16.8 in our sample. We divide the students into three groups: high-ranked students in the top 10% of each school; mid-ranked students; and low-ranked students in the bottom 60% of each school.[10] Our estimating equation includes rank terms as interaction terms in the equation (2):

$$\begin{aligned} y_{isrt} = \alpha_0 &+ \alpha_1 y_{is0} + \alpha_2 Rank_{Mid,i} + \alpha_3 Rank_{Low,i} \\ &+ \delta_H Treat_i \\ &+ \delta_{HM} Treat_i \times Rank_{Mid,i} \\ &+ \delta_{HL} Treat_i \times Rank_{Low,i} \\ &+ X_{it}\pi + \mu_s + \phi_r + \upsilon_t + \epsilon_{it}, \end{aligned} \tag{2}$$

where binary indicators $Rank_{Mid,i}$ and $Rank_{Low,i}$ equal 1 if a student i is ranked in the middle or in the low group, respectively, in prior academic achievements compared to her high school peers.

Based on equation (2), the impact of single-sex schooling on high-ranked students is identified by δ_H. Also, $\delta_H + \delta_{HM}$ and $\delta_H + \delta_{HL}$ identify impacts on mid-ranked and low-ranked students,

[9]Results are consistent when using both math and English scores in grades 8–9 or grades 7–9. We use middle school math scores as a proxy for academic competence in high school because math grades are difficult to improve in a short period of time and the the scores are predetermined before the intervention of single-sex schooling. They are therefore less likely to be correlated with unobserved factors.

[10]The High school GPA system in Korea divides students into nine levels based on their within-school ranking. Students at the top 10% of test scores (i.e., top-ranked students in our analyses) are classified into top 2 levels. Students in the top 40% of test scores (i.e., mid-ranked students in our analyses) are classified into the top 4 levels. Although the top level only applies to students in the top 4% of test scores, we use the top 10% to define high-ranked students so that there are a sufficient number of students in each group.

respectively. There are high schools in the data where only one or two students are observed. There are 19 such students in our sample. These students are categorized into the reference group (high-ranked students in coeducational schools) when estimating equation (2). The results are robust to excluding them from the sample.

4 Data

We use the SELS, a panel study based on a cohort of students who entered high school in 2016 in Seoul, South Korea. The sample is constructed based on a three-stage stratified cluster sampling method. First, in 2010, 20% of elementary schools were randomly selected in each of the 11 school districts in Seoul. Second, two fourth-grade classes in the selected school were randomly selected. Finally, all students in the class were sampled. SELS includes information about students' mental health, peer relationships, academic achievement, sociodemographic background, and characteristics of schools they attended from 2010 (wave 1, grade 4) to 2018 (wave 9, grade 12).[11] The surveys were conducted around July each year, right after the spring semester ended. Because the academic calendar in Korea starts in spring, students in the tenth grade in single-sex schools receive the single-sex schooling treatment for one semester. Similarly, students in the eleventh and twelfth grades received the treatment for 3 and 5 semesters, respectively.

We restrict the sample to those who were assigned to schools in the third round of the school assignment protocol, which uses the random assignment rule. As discussed in Section 2.2, once students state their preferences, whether they proceed to the next round is determined at random. Although most students cite distance or career fit as their primary reasons for school preferences (from the observations in all three rounds; results available upon request), our sample under-represents students who have a strong preference against having no control over their school assignments.[12] The main sample has an annual observation of 340 students attending 142 high

[11] SELS collected information on these mental health measures after wave 4, which is grade 7. Thus, we use six waves of data from 2013 (grade 7) to 2018 (grade 12) for our main analysis.

[12] Such students may have targeted schools whose slots are less likely to be filled in the first two rounds.

schools in Seoul for 3 high school years.[13]

Dependent Variables: We focus on three sets of outcome variables: mental health,[14] peer relationships, and standardized test scores. First, we measure students' overall mental health and well-being with six mental health items. The "Life satisfaction" variable is based on the response to the statement "I am satisfied with my life"; "Happiness" is based on the response to "I am very happy"; "Vitality" is based on the response "I am full of energy"; "amusement" is based on the response to "I find most things amusing"; "Laughter" is based on the response to "I laugh a lot"; and "Joy" is based on the response to "I often experience joy and pleasure." These variables are measured by how much students agree with each statement on a Likert scale from 1 (none of the time) to 5 (all the time). We use the average value of these items as our main outcome for the overall mental health of students and use individual items as dependent variables in the appendix. In addition, we also present the outcomes of self-esteem and resilience to show the robustness of the single-sex schooling effects on mental health.

Second, we use two variables for students' peer relationships: "Bullying" and "Social." "Bullying" variable measures students' perception of the prevalence of bullying at school. It is based on their responses to the statement, "School violence is quite severe in the current school." "Social" measures their own social interactions, based on the statement "I do not get along well with others." All responses are recorded using a Likert scale from 1 ("not at all") to 5 ("strongly agree"). We reverse the "Social" measure so that greater value indicates better peer relations.

Third, across all grades, SELS provides the nationally standardized test scores in math and English, which we use to evaluate the effects of single-sex schooling on academic achievements.

[13]Special-purpose and autonomous high schools, which are similar to the typical private schools in countries like the US, were exceptions to the random assignment system in Seoul. Students attending these schools are excluded from our sample by our sample restriction. See Hahn and Wang (2019) for details.

[14]We use the term "mental health" in a broad sense to refer to a state of well-being in which individuals realize their abilities, cope with the normal stresses of life, work productively, and contribute to their community (World Health Organization, 2001). In addition to mental disorders, mental well-being or positive mental health has emerged as an important aspect of mental health in recent research, consisting of positive feelings (subjective well-being) and psychological functioning (Ryan and Deci, 2001; Tennant et al., 2007). A growing number of studies have investigated mental well-being in terms of life satisfaction, happiness, vitality, resilience, and self-esteem (Hills and Argyle, 2002; Konaszewski, Niesiobędzka, and Surzykiewicz, 2021; Las-Hayas et al., 2022; Lombardo et al., 2018; Masciocchi et al., 2020; Veselska et al., 2010).

All students take the same tests each year (30 questions in math and 35 questions in English). Therefore, we can compare raw scores across students in different schools and analyze the change in competency level and academic performance growth of all students over the three grades on a common scale.

Policy Variable: SELS provides information on whether the school is a coeducational or single-sex school for each middle and high school. The treatment indicator of single-sex schooling takes the value of 1 if a student attended a single-sex high school and 0 otherwise. The type of middle school (coeducational or single-sex) is included as a control variable in all analyses.

Baseline Statistics: Table 1 presents the pre-treatment (middle school period) mean and standard deviations (SD) of the variables used in the estimations. There are 163 students in single-sex schools and 177 in coeducational schools.

We conduct three sets of tests to examine the validity of the random assignment assumption of students across high schools. The results support the identification assumption that the students in our sample were randomized into different high schools within each school district.

First, we conduct balance tests by comparing the raw pre-assignment means between the treatment (single-sex schools) and the control group (coeducational schools), as shown in Table 1 (Table A1 in the appendix presents results for detailed measures of outcomes). There is no significant difference in the means of most outcomes and control variables between the treatment and the control group for the overall and gender subsamples. Few differences are small in magnitude and borderline significant. There is one large and significant difference, the proportion of private schools. Whereas the baseline sample includes both private and public schools, we conduct a robustness check with only public schools and show that the results are consistent.

Second, we further estimate an event-study model (i.e., an extended DiD framework) using the following equation to test for no difference in outcomes (i.e., the parallel trends assumption)

during pre-treatment periods:

$$y_{isrt} = \beta_0 + \beta_1 Treat_i + \beta_2 Grade_{it} + \sum_{\substack{t=7,\\ k\neq 9}}^{12} \gamma_t Treat_i \times Grade_{it} + X_{jt}\pi + \mu_s + \phi_r + \varepsilon_{it}, \tag{3}$$

where $Grade_{it}$ is a vector of indicator variables from grade 7 to grade 12. The reference cohort is grade 9, which is the last year of middle school. The dataset has only one cohort, and the treatment occurs at grade 10 for all students, so it is unnecessary to account for the time relative to the treatment separately.

Using the estimation results of equation (3), we plot the coefficient estimates of γ_t and their 95% confidence intervals in Figure 1. The estimates in each panel measure the average outcome difference between the treatment and control groups from grade 7 to grade 12, using grade 9 as the reference category. The first three points represent the outcome differences before the single-sex schooling treatment, and the fourth point represents the outcome difference one semester after the treatment began. Similarly, the fifth and sixth points represent outcome differences 3 and 5 semesters after the treatment began, respectively. In all panels of Figure 1, we find no statistically significant estimate for the coefficients on outcome differences in the pre-treatment periods.

Finally, we examine the sensitivity of single-sex schooling effects with various model specifications. As we show in the Results section Tables, we obtain a similar magnitude of estimates and statistical significance for the effects of single-sex schooling with a full set of control variables in the main estimation models (Table 2) and with a different set of controls (Table A3 and Table A4 in the Appendix). Further, we obtain similar estimates for the heterogeneous single-sex schooling effects from the main results (Table 2) and from the results obtained by the DiD specification (Table 7). In sum, across a variety of model specifications and estimation methods, we obtain stable and robust coefficient estimates for the effects of single-sex schooling, as well as for the heterogeneous effects of single-sex schooling.

5 Results

5.1 Overall Effects on Mental Health, Peer Relationships, and Academic Performance

In Table 2, we present the effects of attending single-sex schools as opposed to coeducational schools, based on the estimation of equation (1) using observations of high school students in grades 10–12. The effect on the mental health measure is significant and negative. The effect on social interactions is positive and significant, indicating that students in single-sex schools are more likely to report that they get along with others. Also, single-sex schooling decreases the perceived prevalence of bullying, although the estimated effect is not significant. Academic performances, as measured by math and English test scores, are significantly greater by about 0.15 and 0.25 SD, respectively.

Although better academic achievement and improved peer relationships are associated with better mental health in the literature (Bond et al., 2007; Fletcher, 2010; McLeod, Uemura, and Rohrman, 2012), our results based on the overall sample show that better academic achievement and improved peer relationships were observed without any improvement in mental health. One potential reason is the heterogeneous mental health effects across subgroups. Therefore, in the next section, we examine how the mental health impact of single-sex schooling may be different across different subgroups.

5.2 Effects by Students' Gender

In this section, we investigate the heterogeneous effects of single-sex schooling by the gender of the students. We suspect that student gender may be an important moderator of the effect for two reasons. First, studies show that male and female students react differently to academic competition and peer interactions at school, implying that the effects of single-sex schooling on cognitive and noncognitive outcomes may be heterogeneous by students' gender (Buser, Peter, and Wolter, 2017; Horn, Kiss, and Lénárd, 2022; Landaud, Ly, and Maurin, 2020). Second, Gong,

Lu, and Song (2021) find that greater exposure to female peers improves social acclimation and school-life satisfaction, because of improved teacher behaviors and classroom environments. Thus, the effects of female-only schools may be different from those of male-only schools.

In Table 3, we show the gender-specific heterogeneous effects of single-sex schooling. The first row shows the effects on male students, and the third row shows the effects on female students (the sum of estimates in the first and second rows). We find evidence of large gender heterogeneity. The negative effect on mental health is observed for both genders, but the magnitude is twice as large for the male students. The positive effects on social interactions are similar in magnitude and significance for both genders, but bullying reduction is observed only among female students. Finally, positive impacts on academic achievements are concentrated on male students, consistent with the findings in the literature (Jackson, 2012; Park, Behrman, and Choi, 2013). Given that mental health, peer relationships, and academic achievements likely all move in the same direction, it is difficult to reconcile these differences based on gender differences in peer interactions alone.

Another potential moderator of the single-sex schooling effect is the students' competitive pressures. Studies indicate that competitive attitudes change depending on the gender composition of the group to which one belongs (Booth and Nolen, 2012; Gneezy, Niederle, and Rustichini, 2003; Laury, Lee, and Schnier, 2019; Mago and Razzolini, 2019). Moreover, Korean high schools are known for high competitive pressure. Therefore, we next investigate whether the effects of single-sex schooling depend on proxy measures of competitive pressure within schools.

5.3 Effects by Competitive Pressure at School

The literature shows that female students compete more intensely with other students in female-only schools (Booth and Nolen, 2012; Laury, Lee, and Schnier, 2019), and that competition in general is more detrimental to women's well-being than men's (Buser, Peter, and Wolter, 2017; Horn, Kiss, and Lénárd, 2022; Landaud, Ly, and Maurin, 2020). Therefore, increased competition from single-sex schooling may impair the mental health of female students and help explain the non-existence of a positive link between the effects on mental health and other outcomes in the

overall sample.

The results on mental health outcomes in Table 4 and Figure 2 show that the effects of single-sex schooling on female students vary significantly depending on the level of competitive pressure, for which school ranking is used as a proxy. The effects of single-sex schooling on female students who are ranked at the top of their schools are reported in the first row. The positive effects of attending female-only schools on mental health are apparent only for high-ranked students. High-ranked female students also perceive less bullying at school ("Bullying") and interact more with friends ("Social"). The positive impacts for the high-ranked group are completely offset by the effects on female students ranked at the middle and bottom of their schools, as seen by the negative coefficient estimates of interaction terms for these groups in the second and third rows. The impacts on mid- and low-ranked female students' perceptions of bullying prevalence and social interaction are, therefore, close to zero and insignificant. In particular, mid-ranked female students, who are likely to be under the most pressure to improve their academic performance, are subject to the most negative impact on all peer relationship outcomes compared to top- and low-ranked students in single-sex schools.

For male students, the heterogeneity of effects by competitive pressure is smaller in magnitude compared to those of female students and is the opposite in sign. Low-ranked male students experience positive impacts on peer relationships without negative impacts on mental health. High-ranked students experience negative impacts on mental health and no positive impact on peer relationships.

We also present the single-sex schooling effects by competitive pressure on academic performance in Table A2 in the appendix. The positive effects on test scores are concentrated on the high-ranked students for both male and female students. The effects are close to zero for those not at the top. These results suggest that high-ranked students benefit the most in terms of academic achievement by attending single-sex schools.

These results are consistent with the interpretation that the impact of single-sex schooling on the mental health of female students is determined by the competitive pressure they face. Students

at the top of the within-school distribution do not feel as much pressure to improve their academic performance compared to those ranked lower because they already stand a reasonable chance of being admitted to good universities. Not bothered by competitive pressure, they can enjoy the positive effects of the company of other female peers (Gong, Lu, and Song, 2021; Kim and Kim, 2022). Although lower-ranked female students may try hard to compete against others in single-sex schools (Booth and Nolen, 2012; Mago and Razzolini, 2019), they nevertheless mentally suffer from it, as shown by their reduced mental health and worse peer relationships.

5.4 Additional Results: A Falsification Test

Because what matters for a student's college applications is the within-school academic rank, we used a student's relative position, or rank, within her school in terms of school test scores as a proxy for perceived competitive pressure. An implication of this reasoning is that a student's rank among all the students in our sample ("absolute" rank) would poorly capture the within-school competitive pressure when schools differ in the average quality of students. If schools across school districts differ greatly in the average quality of students, the student's absolute rank will not reflect perceived competitive pressure. In Table 5, we re-estimate Table 4 while replacing the student's relative rank with absolute rank in the universal tests common to all students. We find no large or significant differences in effects across groups defined by absolute rank for female students across all the outcomes we consider. The effects on male students are comparable to those in Table 4. These findings add confidence to our interpretation that the heterogeneous effects in Table 4 are explained by gender-specific responses to competitive pressure at school.

To further test the validity of our main findings associated with competitive pressure, we conduct another falsification test by replicating Table 4 using household income and tutoring expenses as alternative outcomes. The results in Table 6 show that there is no significant effect of treatment and no difference in effects by the ranking-based groups, supporting the validity of our main findings.

Although our proxy measure is not a direct measure of pressure from competition faced by each

student, the pattern of results lends support to the importance of pressure from academic competition in understanding the effects of single-sex schooling. These effects on mental health and peer relationships are not apparent in the analysis of the overall sample or even in the heterogeneity analysis by gender, but emerged only after accounting for the intensity of competitive pressure. Clearly, the effects of single-sex schooling are not equal across students but depend critically on their gender and the academic pressure they face. Female students under severe competitive pressure may be hurt by attending single-sex schools.

6 Robustness Checks

6.1 Test for Random Assignment

Students are randomly assigned to schools within each school district based on their residential district. Thus, if the random assignment was properly implemented, we should find no significant difference in the treatment effect estimates with different sets of control variables once we account for the school and residential district FEs. Therefore, to test the random assignment assumption, we estimate equation (1) using only the school and residential region FEs and year FEs, while excluding the pre-treatment outcome and time-varying covariates:

$$y_{isrt} = \alpha_0 + \delta Treat_{is} + \mu_s + \phi_r + v_t + \epsilon_{it}. \tag{4}$$

If the within-district assignment is completely random, the estimate of δ in equation (4) should be comparable to the estimate of δ in equation (1) because both are from consistent estimators. Tables A3 in the Appendix show that the estimates from the two equations are comparable to each other.

6.2 Alternative Estimation Models

To examine whether there are any pre-treatment differences in outcome variables across students and to show the robustness of our main findings, we estimate the same model using the DiD model. We expand sample coverage by including the pre-treatment period of the middle school years in addition to the high school years, covering grades 7 to 12. The equation is:

$$\begin{aligned} y_{isrt} = \beta_0 + \beta_1 Treat_i + \beta_2 After_{it} + \gamma Treat_i \times After_{it} \\ + X_{it}\pi + \alpha_1 y_{i0} + \mu_s + \phi_r + v_t + \varepsilon_{it}. \end{aligned} \tag{5}$$

The coefficient of interest is γ for the $Treat_{is} \times After_{it}$ term captures the effect of attending a single-sex school as opposed to attending a coeducational school. We expect the estimate of γ to be similar to the estimate of δ in equation (1) because they both identify the effects of within-district randomized school assignments.

We further investigate heterogeneity by the competitive pressure proxy using the DiD model on male and female students. The equation is:

$$\begin{aligned} y_{isrt} = \beta_0 &+ \beta_1 Treat_{is} + \beta_2 After_{it} + \beta_3 Rank_{Mid,i} + \beta_4 Rank_{Low,i} \\ &+ \beta_5 Treat_i \times Rank_{Mid,i} + \beta_6 Treat_i \times Rank_{Low,i} \\ &+ \beta_7 After_{it} \times Rank_{Mid,i} + \beta_8 After_{it} \times Rank_{Low,i} \\ &+ \gamma_H Treat_i \times After_{it} \\ &+ \gamma_{HM} Treat_i \times After_{it} \times Rank_{Mid,i} \\ &+ \gamma_{HL} Treat_i \times After_{it} \times Rank_{Low,i} \\ &+ X_{it}\pi + \mu_s + \phi_r + v_t + \varepsilon_{it}, \end{aligned} \tag{6}$$

where $After_{it}$ has a value of 1 for high school period (grades 10–12) and 0 for middle school period (grades 7–9). In equation (6), the coefficients γ_H, $\gamma_H + \gamma_{HM}$, and $\gamma_H + \gamma_{HL}$ identify the

impacts on high-ranked students, mid-ranked students, and low-ranked students, respectively. As in the case of equation (5), we expect the estimates of γ_H, γ_{HM}, and γ_{HL} to be comparable to those of δ_H, δ_{HM}, and δ_{HL} in equation (2).

Tables 7 and 8 and Figure A1 in the Appendix show the estimates of the DiD model. These estimates are all comparable to those in Tables 2, 3, and 4, further confirming that our results are robust to using this alternative estimation method.

6.3 Sample Restrictions

For our main analyses, we include both public and private high schools in our sample. Although the government uses a standardized curriculum and strictly regulates school operations, including teacher salaries, tuition fees, and enrollment size for both public and private schools, private schools have more autonomy than public schools in teacher compensation and teacher activities (Kim, 2018). The main differences between public and private schools in South Korea are that (i) private schools have more autonomy in teacher hiring decisions and incentive provisions, and (ii) public school teachers cannot work at the same school for longer than five years, whereas private school teachers can work at the same school until retirement. Thus, teachers in private schools may have more discretion in classroom management and may adjust their behaviors more flexibly and efficiently to compensate for any negative effect of single-sex schooling compared to teachers in public schools. Therefore, including private school students in the sample could introduce unknown confounders into the empirical model. As a robustness test, we restrict the sample to public school students and replicate the results in Table 2 and Table 4. The results in Table A5 and Table A6 in the Appendix show that all results are consistent with our main findings, even with smaller sample sizes and an added sample restriction.

6.4 Alternative Measures of Outcomes and Competitive Pressure

We conduct another set of robustness tests using alternative measures of outcomes and competitive pressure. For mental health, we individually use six mental health items that are used to construct

our main mental health variable. We also examine the effects of single-sex schooling on two sets of noncognitive outcomes, including self-esteem and resilience, as alternative measures of mental health. Self-esteem and resilience are closely related to adolescent mental health (Konaszewski, Niesiobędzka, and Surzykiewicz, 2021; Veselska et al., 2010). For the self-esteem outcome, we use three variables from the Rosenberg Self-Esteem Scale (Rosenberg, 1989): "Self-worth," "Self-satisfaction," and 'Self-positiveness." They are each based on responses to the statements: "I feel that I am a person of worth," "I am satisfied with myself," and "I have a positive attitude toward myself." For the resilience outcome, defined as the capacity to handle significant changes and rebound from adversity, uncertainty, and both negative and positive changes, we use the resilience scale for Korean adolescents (Shin, Kim, and Kim, 2009), consisting of "Causal analysis," "Emotional regulation," and "Gratitude." These are each based on responses to the statements: "I believe I have a good understanding of the cause of the problem in most situations," "I tend to keep my emotions under control when things get tough," and "When I look around, I see much to be grateful for." All items are measured on a 5-point Likert scale, with higher values indicating better status. Tables A7 and A8 confirm the robustness of our results using different outcome measures, showing the same pattern of heterogeneous effects by gender and competitive pressure on mental health as those shown in Table 4.

We also use alternative measures for peer relationships. We use two variables, "Friendship" and "Friend-time." "Friendship" measures friendship strength, based on the statement "I make up easily with friends when fighting."[15] "Friend-time" measures the time students spend with friends at school, based on "I spend time with friends during recess and lunch at school." All responses are recorded using a Likert scale from 1 ("not at all") to 5 ("strongly agree"). Results are presented in Table A9, supporting our main findings.

Finally, our heterogeneity analysis based on the competitive pressure at school uses cutoffs of 90% and 60% to define the three groups of students by their within-school ranking of academic performance. Also, the relative ranking is constructed based on students' math scores in the last

[15]Conflict resolution is one of many aspects of the friendship measurement scale (Parker and Asher, 1993).

two years of middle school. We examine the robustness of our results by using rankings based on the scores of math and English in the final year of middle school (i.e., grade 9) and using cutoffs of 95% and 50%. The results in Table A10 in the Appendix show that the heterogeneous effects on the mental health and peer relationships of female students by competitive pressure remain robust to alternative definitions of competitive pressure.

7 Conclusion

We leverage the random allocation of students to coeducational and single-sex high schools in South Korea to identify the effects of single-sex schooling on mental health, peer relationships, and academic achievements. We find that the benefits of single-sex schooling are not shared across all students, and may even hurt some students, depending on the student's gender and the pressure of academic competition at school. Female students facing intense academic competition at school because of their low within-school academic ranking may not reap the benefits of interacting with other peers, whereas the high-ranked female students who plausibly do not face intense competition enjoy better mental health, peer relationships, and academic achievements compared to their counterparts in coeducational schools. The effects on male students do not seemingly depend on the competitive pressure at school. High-ranked male students experience lower mental health but better academic achievements, whereas mid- and low-ranked male students enjoy better peer relationships but not better academic achievements and no impact on mental health.

Our study suggests that gender-specific responses to the pressure from academic competition at school play an important role in determining the effects of single-sex schooling. The literature shows that positive effects on academic achievements are greater for male students (Dustmann, Ku, and Kwak, 2018; Jackson, 2012), as we confirm. The results for noncognitive skills, behaviors, and earnings are inconsistent across studies (Kim and Kim, 2022; Lee and Nakazawa, 2022; Sohn, 2016). A plausible explanation based on our results is that the positive effects of having female peers (Gong, Lu, and Song, 2021) and of a more focused school environment (Riordan, 1985)

are offset by the negative effects from increased competitive pressure, which affect women more negatively than men (Niederle and Vesterlund, 2010).

Our results call for caution in the analysis and implementation of education policies. First, single-sex schooling can be a double-edged sword that can benefit one group while hurting an entirely different group of students. Further, evaluation of single-sex schooling or gender composition policies should look beyond easily observable outcomes such as academic achievements and consider effects on other outcomes such as mental health and peer relationships. Finally, considering the high rate of mental health problems among adolescents in South Korea and elsewhere (Kieling et al., 2011), more attention should be paid to students' mental health care, especially those facing intense competition at school.

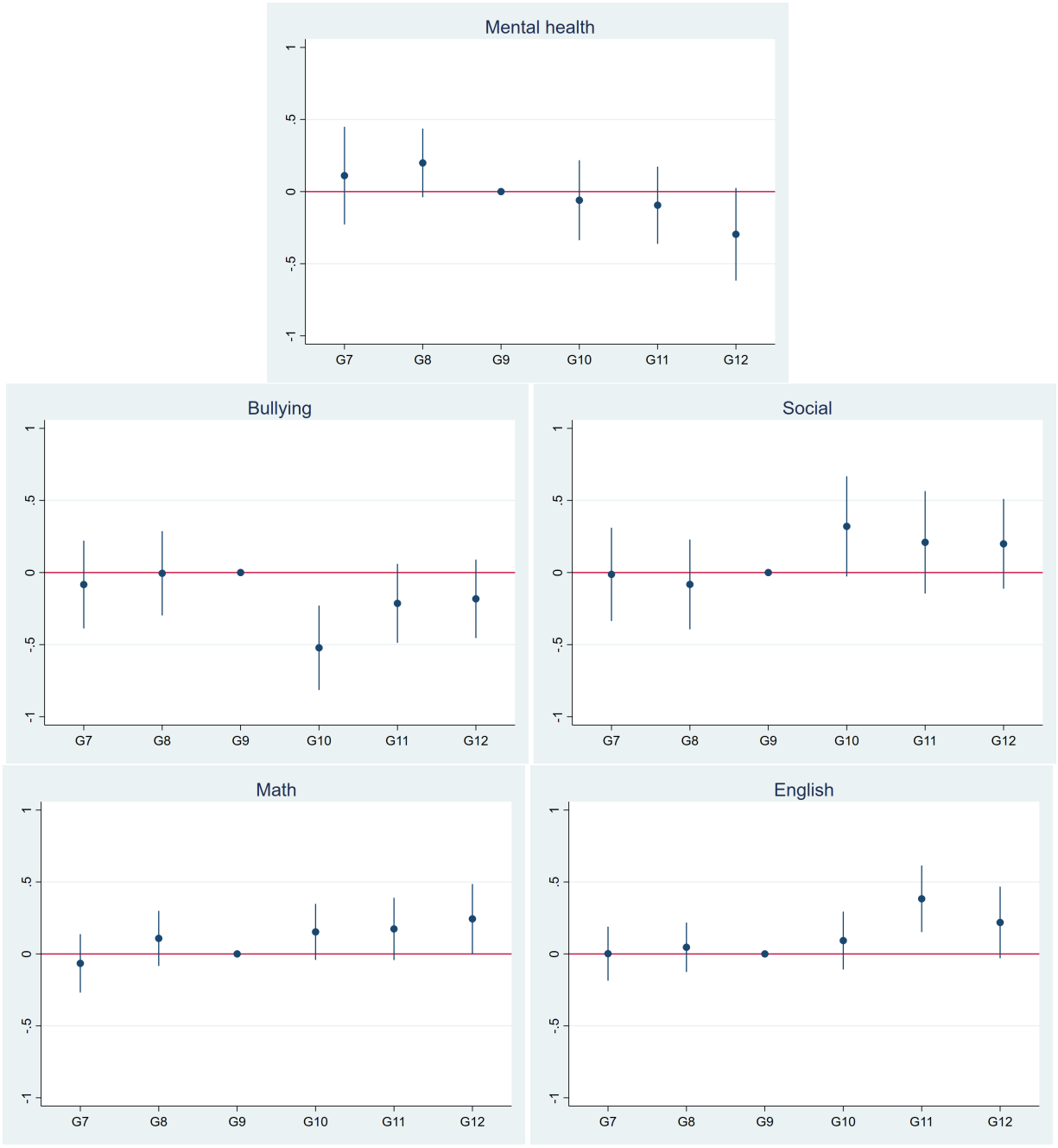

Figure 1: Effects of Single-Sex Schooling

Note: Point estimates and 95% confidence intervals for γ_t in the equation (3) measuring the difference in outcome between treatment and control groups based on the baseline period (G9) after controlling for covariates are presented.

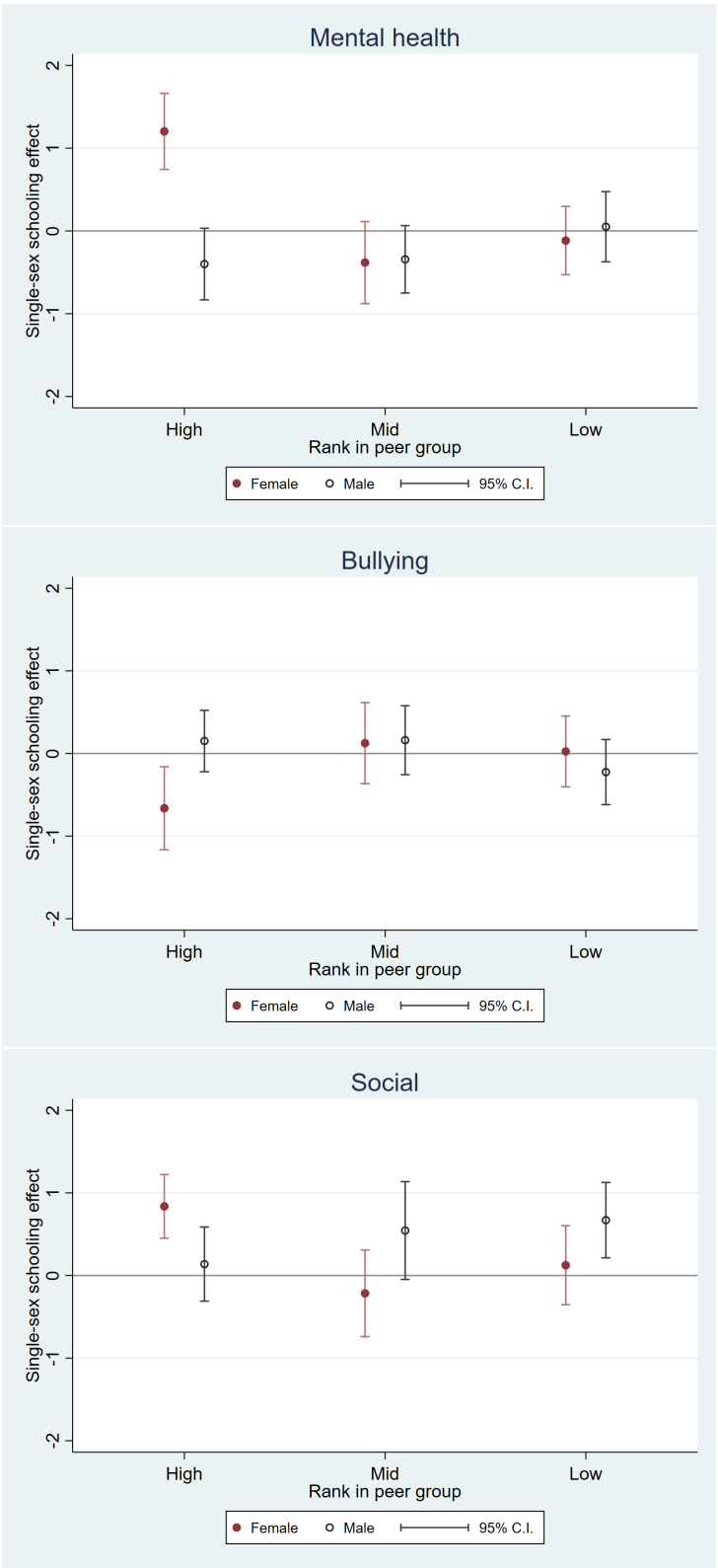

Figure 2: Effects of Single-Sex Schooling by Rank in the Peer Group

Note: Point estimates and 95% confidence intervals are presented based on Table 4.

Table 1: Summary Statistics and Balance Test

	Overall			Female			Male		
Variable	Treat	Control	p-value	Treat	Control	p-value	Treat	Control	p-value
Outcomes									
Mental health	3.68 (0.74)	3.72 (0.76)	0.811	3.78 (0.75)	3.78 (0.71)	0.873	3.60 (0.73)	3.69 (0.78)	0.945
Bullying	2.56 (0.92)	2.39 (0.97)	0.099	2.65 (0.84)	2.40 (0.91)	0.122	2.48 (0.97)	2.38 (1.01)	0.227
Social	3.78 (1.01)	3.75 (1.14)	0.953	4.00 (0.89)	3.98 (0.96)	0.835	3.60 (1.07)	3.62 (1.21)	0.978
Math	17.98 (8.50)	17.05 (8.23)	0.745	18.46 (8.07)	18.20 (7.40)	0.973	17.56 (8.86)	16.36 (8.63)	0.497
English	25.79 (9.16)	24.12 (9.43)	0.440	27.39 (8.38)	26.53 (8.70)	0.688	24.41 (9.59)	22.68 (9.56)	0.420
Socio-demographic									
Female	0.46 (0.50)	0.37 (0.48)	0.432						
Household income	5666.8 (5556.9)	5319.8 (4161.5)	0.772	5312.8 (6499.8)	5502.9 (4117.2)	0.613	5969.9 (4585.3)	5210.8 (4191.0)	0.748
Private education expenditure	406.0 (321.8)	362.9 (454.0)	0.342	396.8 (361.5)	404.2 (516.7)	0.943	413.9 (283.8)	338.3 (411.2)	0.122
School characteristics									
Middle school									
Number of students per class	30.47 (3.28)	29.74 (3.14)	0.098	30.1 (3.10)	30.07 (3.04)	0.314	30.79 (3.41)	29.54 (3.19)	0.082
Teacher tenure (year)	20.42 (5.06)	20.35 (4.71)	0.737	20.41 (5.28)	20.46 (3.96)	0.164	20.42 (4.88)	20.28 (5.11)	0.821
Single-sex school	0.05 (0.21)	0.03 (0.18)	0.485	0.00 (0.00)	0.01 (0.11)	0.344	0.09 (0.28)	0.04 (0.21)	0.379
High school									
Number of students per class	29.97 (4.00)	27.41 (4.00)	0.743	29.70 (4.26)	27.26 (3.81)	0.819	30.21 (3.75)	29.54 (3.19)	0.525
Teacher tenure (year)	20.40 (4.57)	20.00 (3.33)	0.479	19.20 (3.08)	19.84 (3.21)	0.914	21.52 (5.39)	27.53 (4.14)	0.819
Private school	0.8 (0.4)	0.17 (0.38)	0.000	0.87 (0.34)	0.13 (0.34)	0.000	0.74 (0.44)	0.20 (0.40)	0.000
Main reason for choosing high school									
Location	0.35 (0.48)	0.35 (0.48)	0.159	0.36 (0.48)	0.39 (0.49)	0.337	0.35 (0.48)	0.33 (0.47)	0.737
School environment	0.28 (0.45)	0.34 (0.47)	0.946	0.33 (0.47)	0.34 (0.48)	0.580	0.23 (0.42)	0.34 (0.47)	0.267
Aptitude and career interests	0.35 (0.48)	0.30 (0.46)	0.407	0.30 (0.46)	0.27 (0.44)	0.921	0.40 (0.49)	0.31 (0.47)	0.327
Friend	0.02 (0.14)	0.01 (0.11)	0.215	0.02 (0.12)	0.00 (0.00)	0.388	0.03 (0.16)	0.02 (0.14)	0.298
Observations	430	461		199	172		231	289	

Note: The values inside parentheses are standard deviations. Summary statistics of outcome variables, socio-demographic variables, and middle school characteristics are based on values in grades 7–9 before students enter high school. High school characteristics are based on values in grades 10–12. "Main reason" variables are measured once in grade 10. Test score ranges for math and English are 0–30 and 0–35, respectively. Household income and private education expenditure are measured in units of 1,000 KRW per month. The p-value for the differences between treatment and control groups are estimated after accounting for school region fixed effects, residential region fixed effects, and year fixed effects. For the number of students per class in high school, we additionally consider for the private school indicator for getting p-values.

Table 2: Effects of Single-Sex Schooling

	(1) Mental health	(2) Bullying	(3) Social	(4) Math	(5) English
Treat	-0.214**	-0.123	0.304**	0.152*	0.252***
	(0.106)	(0.092)	(0.120)	(0.088)	(0.096)
Baseline	0.893***	0.379***	0.307***	0.076***	0.058***
	(0.086)	(0.072)	(0.075)	(0.007)	(0.006)
Constant	-5.082***	-0.429	-2.749**	-4.569***	-5.250***
	(1.118)	(1.001)	(1.118)	(0.988)	(0.937)
N	845	845	845	845	845
R^2	0.388	0.233	0.205	0.548	0.511

Note: All outcome variables are standardized to have a mean of 0 and a standard deviation of 1. Standard errors, reported in parentheses, are clustered at the individual level. *Treat* is an indicator for single-sex high school assignments. *Baseline* is the mean value of the outcome variable for grades 7–9. Control variables are students' socio-demographic and school characteristics described in Table 1, an indicator for attending a private high school, school region fixed effects, residential region fixed effects, and year fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3: Effects of Single-Sex Schooling by Gender

	(1) Mental health	(2) Bullying	(3) Social	(4) Math	(5) English
Treat (*Effect on males*)	-0.263**	0.035	0.316**	0.216**	0.300***
	(0.124)	(0.106)	(0.141)	(0.103)	(0.110)
Treat×Female	0.118	-0.393***	-0.030	-0.159	-0.116
	(0.150)	(0.137)	(0.164)	(0.131)	(0.137)
Effect on females	-0.145	-0.357***	0.286*	0.058	0.184
	(0.138)	(0.125)	(0.150)	(0.115)	(0.125)
N	845	845	845	845	845
R^2	0.388	0.243	0.205	0.549	0.512

Note: '*Effect on females*' is the sum of the coefficients of 'Treat' and 'Treat×Female'. All outcome variables are standardized to have a mean of 0 and a standard deviation of 1. Standard errors, reported in parentheses, are clustered at the individual level. *Treat* is an indicator for single-sex high school assignments. Control variables are the average baseline value of the outcome variable (i.e., the mean value for grades 7–9), students' socio-demographic and school characteristics described in Table 1, an indicator for attending a private high school, school region fixed effects, residential region fixed effects, and year fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Effects of Single-Sex Schooling by Rank in the Peer Group

	Female			Male		
	(1)	(2)	(3)	(4)	(5)	(6)
	Mental health	Bullying	Social	Mental health	Bullying	Social
Treat (*Effect on top-ranked*)	1.203***	-0.663**	0.837***	-0.400*	0.151	0.138
	(0.234)	(0.256)	(0.197)	(0.221)	(0.190)	(0.229)
Treat×Rank_{Mid}	-1.586***	0.788**	-1.053***	0.057	0.010	0.406
	(0.332)	(0.350)	(0.300)	(0.310)	(0.279)	(0.367)
Treat×Rank_{Low}	-1.319***	0.688**	-0.712**	0.451	-0.376	0.532*
	(0.277)	(0.323)	(0.277)	(0.278)	(0.253)	(0.274)
Effect on mid-ranked	-0.382	0.125	-0.216	-0.343	0.161	0.545*
	(0.253)	(0.250)	(0.267)	(0.208)	(0.213)	(0.302)
Effect on low-ranked	-0.116	0.025	0.125	0.051	-0.225	0.670***
	(0.211)	(0.219)	(0.244)	(0.216)	(0.201)	(0.233)
N	370	370	370	475	475	475
R^2	0.522	0.287	0.302	0.421	0.310	0.259

Note: '*Effect on mid-ranked*' is the sum of the coefficients of 'Treat' and 'Treat×Rank_{Mid}, and '*Effect on low-ranked*' is the sum of the coefficients of 'Treat' and 'Treat×Rank_{Low}'. All outcome variables are standardized to have a mean of 0 and a standard deviation of 1. Standard errors, reported in parentheses, are clustered at the individual level. *Treat* is an indicator for single-sex high school assignments. *Rank* indicates a student's relative ranking in their peer group (i.e., school) in the first year of high school (grade 10) by their mean score in math before entering high school (grades 8–9). Base = 90–100%, Rank_{Mid}= 60–90%, Rank_{Low} = 0–60%. Control variables are the average baseline value of the outcome variable (i.e., the mean value for grades 7–9), students' socio-demographic and school characteristics described in Table 1, an indicator for attending a private high school, school region fixed effects, residential region fixed effects, and year fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: Effects of Single-Sex Schooling by Absolute Rank

	Female			Male		
	(1) Mental health	(2) Bullying	(3) Social	(4) Mental health	(5) Bullying	(6) Social
Treat	0.249	-0.293	0.359	-0.538**	0.082	0.277
	(0.855)	(0.313)	(0.682)	(0.235)	(0.238)	(0.391)
Treat×Rank$_{\text{Mid}}$	-0.177	0.520	-0.170	-0.031	0.235	0.218
	(0.862)	(0.398)	(0.671)	(0.341)	(0.329)	(0.498)
Treat×Rank$_{\text{Low}}$	-0.491	0.248	-0.517	0.617**	-0.461	0.491
	(0.876)	(0.338)	(0.707)	(0.295)	(0.299)	(0.452)
N	361	361	361	459	459	459
R^2	0.482	0.304	0.279	0.427	0.316	0.255

Note: All outcome variables are standardized to have a mean of 0 and a standard deviation of 1. Standard errors, reported in parentheses, are clustered at the individual level. *Treat* is an indicator for single-sex high school assignments. *Rank* indicates a student's **absolute ranking among all students in the sample** of the first year of high school (grade 10) by their mean score in math before entering high school (grades 8–9). Base = 90–100%, Rank$_{Mid}$= 60–90%, Rank$_{Low}$ = 0–60%. Control variables are the average baseline value of the outcome variable (i.e., the mean value for grades 7–9), students' socio-demographic and school characteristics described in Table 1, school region fixed effects, residential region fixed effects, and year fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Falsification Tests

	Female		Male	
	(1) Household income	(2) Private tutoring expenses	(3) Household income	(4) Private tutoring expenses
Treat	0.125	0.119	0.181	0.218
	(0.126)	(0.181)	(0.137)	(0.228)
Treat×Rank_{Mid}	-0.114	0.034	-0.396	-0.019
	(0.308)	(0.201)	(0.253)	(0.374)
Treat×Rank_{Low}	0.093	-0.274	0.160	-0.247
	(0.144)	(0.194)	(0.413)	(0.394)
N	370	370	475	475
R^2	0.680	0.848	0.601	0.622

Note: The outcome variable is standardized to have a mean of 0 and a standard deviation of 1. Private tutoring expenses are the average monthly amount spent on math and English tutoring services. Standard errors, reported in parentheses, are clustered at the individual level. *Treat* is an indicator for single-sex high school assignments. *Rank* indicates a student's relative ranking in their peer group (i.e., school) in the first year of high school (grade 10) by their mean score in math before entering high school (grades 8–9). Base = 90–100%, Rank_{Mid}= 60–90%, Rank_{Low} = 0–60%. Control variables are the average baseline value of the outcome variable (i.e., the mean value for grades 7–9), students' socio-demographic (except for the household income), and school characteristics described in Table 1, an indicator for attending a private high school, school region fixed effects, residential region fixed effects, and year fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: Effects of Single-Sex Schooling Using Difference-in-Differences

	(1) Mental health	(2) Bullying	(3) Social	(4) Math	(5) English
Average Treatment Effect					
Treat×After	-0.250**	-0.206**	0.199*	0.153*	0.192**
	(0.098)	(0.098)	(0.116)	(0.086)	(0.091)
Treat	-0.007	0.027	0.008	-0.005	-0.012
	(0.028)	(0.032)	(0.034)	(0.026)	(0.027)
After	-0.239***	-0.902***	-0.008	-0.846***	-0.989***
	(0.087)	(0.095)	(0.101)	(0.081)	(0.073)
N	1736	1736	1736	1736	1736
R^2	0.521	0.435	0.313	0.665	0.669
Gender Differences					
Treat×After (*Effect on males*)	-0.265**	-0.069	0.188	0.179*	0.200*
	(0.120)	(0.123)	(0.142)	(0.105)	(0.115)
Treat×After×Female	0.072	-0.339**	0.020	-0.067	-0.034
	(0.165)	(0.159)	(0.177)	(0.139)	(0.147)
Effect on females	-0.193	-0.408***	0.207	0.112	0.166
	(0.135)	(0.130)	(0.149)	(0.115)	(0.119)
N	1736	1736	1736	1736	1736
R^2	0.523	0.437	0.313	0.665	0.669

Note: '*Effect on females*' is the sum of the coefficients of 'Treat×After' and 'Treat×After×Female'. All outcome variables are standardized to have a mean of 0 and a standard deviation of 1. Standard errors, reported in parentheses, are clustered at the individual level. *Treat* and *After* are indicators for single-sex high school assignments and high school years, respectively. Control variables are the average baseline value of the outcome variable (i.e., the mean value for grades 7–9), students' socio-demographic and school characteristics described in Table 1, an indicator for attending a private high school, school region fixed effects, residential region fixed effects, and year fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: Effects of Single-Sex Schooling by Rank in the Peer Group Using Difference-in-Differences

	Female			Male		
	(1)	(2)	(3)	(4)	(5)	(6)
	Mental health	Bullying	Social	Mental health	Bullying	Social
Treat×After (*Effect on top-ranked*)	1.077***	-0.666**	0.638***	-0.381	0.145	0.016
	(0.213)	(0.268)	(0.209)	(0.237)	(0.231)	(0.263)
Treat×After×Rank_{Mid}	-1.379***	0.386	-0.920***	-0.054	-0.110	0.543
	(0.305)	(0.350)	(0.287)	(0.308)	(0.344)	(0.425)
Treat×After×Rank_{Low}	-1.278***	0.496	-0.515	0.357	-0.427	0.369
	(0.306)	(0.330)	(0.340)	(0.304)	(0.305)	(0.320)
Effect on mid-ranked	-0.259	-0.255	-0.317	-0.494**	0.082	0.591
	(0.219)	(0.235)	(0.195)	(0.193)	(0.252)	(0.359)
Effect on low-ranked	-0.295	-0.160	0.067	0.062	-0.258	0.405*
	(0.225)	(0.192)	(0.244)	(0.197)	(0.211)	(0.207)
N	741	741	741	995	995	995
R^2	0.591	0.462	0.396	0.523	0.456	0.311

Note: '*Effect on mid-ranked* (*Effect on low-ranked*)' is the sum of the coefficients of 'Treat×After' and 'Treat×After×Rank_{Mid} (Treat×After×Rank_{Low})'. All outcome variables are standardized to have a mean of 0 and a standard deviation of 1. Standard errors, reported in parentheses, are clustered at the individual level. *Treat* and *After* are indicators for single-sex high school assignments and high school years, respectively. *Rank* indicates a student's relative ranking in their peer group (i.e., school) in the first year of high school (grade 10) by their mean score in math before entering high school (grades 8–9). Base = 90–100%, Rank_{Mid}= 60–90%, Rank_{Low} = 0–60%. Control variables are the average baseline value of the outcome variable (i.e., the mean value for grades 7–9), students' socio-demographic and school characteristics described in Table 1, an indicator for attending a private high school, school region fixed effects, residential region fixed effects, and year fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

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Appendix

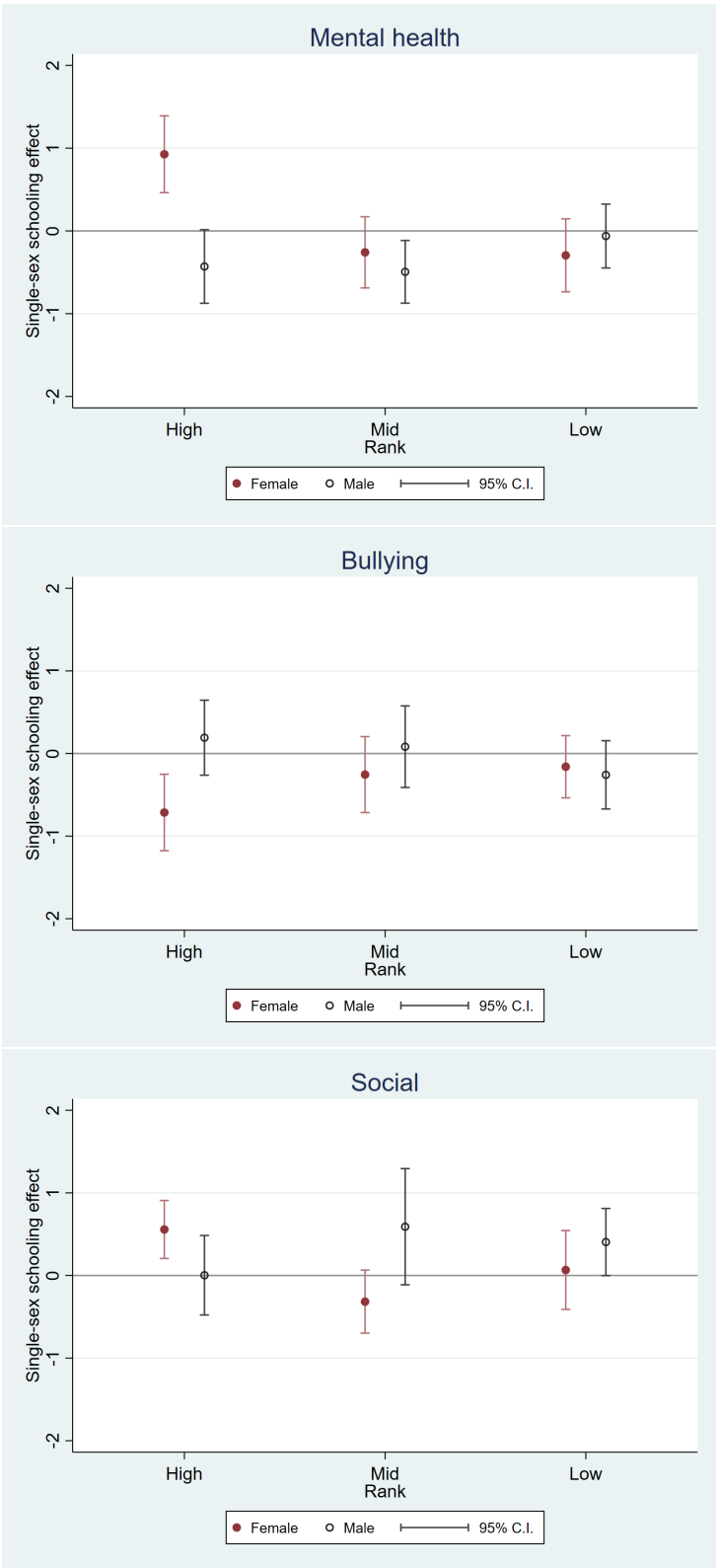

Figure A1: Effects of Single-Sex Schooling by Rank in the Peer Group, Using Difference-in-Differences

Note: Point estimates and 95% confidence intervals are presented based on Table 8.

Table A1: Summary Statistics and Balance Test (Outcomes)

	Overall			Female			Male		
Variable	Treat	Control	p-value	Treat	Control	p-value	Treat	Control	p-value
Outcomes									
Life satisfaction	3.60 (0.88)	3.56 (0.98)	0.286	3.68 (0.85)	3.66 (0.88)	0.876	3.54 (0.91)	3.49 (1.03)	0.419
Happiness	3.61 (1.00)	3.71 (0.96)	0.437	3.64 (1.02)	3.65 (0.92)	0.602	3.59 (0.98)	3.74 (0.99)	0.551
Vitality	3.68 (0.89)	3.77 (0.91)	0.348	3.82 (0.89)	3.81 (0.86)	0.939	3.56 (0.87)	3.74 (0.94)	0.436
Amusement	3.53 (0.90)	3.55 (0.94)	0.983	3.64 (0.92)	3.62 (0.87)	0.684	3.44 (0.88)	3.52 (0.99)	0.976
Laughter	3.95 (0.82)	3.97 (0.89)	0.950	4.09 (0.80)	4.09 (0.76)	0.750	3.83 (0.82)	3.90 (0.95)	0.985
Joy	3.70 (0.85)	3.76 (0.90)	0.727	3.78 (0.85)	3.84 (0.85)	0.297	3.62 (0.85)	3.71 (0.93)	0.971
Self-esteem: worth	3.83 (0.86)	3.91 (0.86)	0.287	3.88 (0.85)	3.91 (0.84)	0.324	3.77 (0.87)	3.91 (0.87)	0.354
Self-esteem: satisfaction	3.81 (0.85)	3.83 (0.94)	0.981	3.79 (0.87)	3.77 (0.95)	0.685	3.83 (0.83)	3.86 (0.94)	0.599
Self-esteem: positiveness	3.84 (0.84)	3.92 (0.89)	0.275	3.86 (0.88)	3.93 (0.90)	0.113	3.82 (0.81)	3.91 (0.89)	0.580
Resilience: causal analysis	3.53 (0.85)	3.64 (0.86)	0.526	3.47 (0.85)	3.61 (0.77)	0.318	3.59 (0.84)	3.66 (0.91)	0.971
Resilience: emotional regulation	3.38 (0.89)	3.51 (0.93)	0.258	3.31 (0.87)	3.29 (0.92)	0.544	3.45 (0.91)	3.64 (0.91)	0.268
Resilience: gratitude	3.80 (0.84)	3.88 (0.83)	0.704	3.88 (0.85)	3.90 (0.84)	0.767	3.73 (0.83)	3.86 (0.82)	0.946

Note: The values inside parentheses are standard deviations. Summary statistics are based on values in grades 7–9 before students enter high school. The p-value for the differences between treatment and control groups are estimated after accounting for school region fixed effects, residential region fixed effects, and year fixed effects.

Table A2: Effects of Single-Sex Schooling on Academic Achievements by Rank in the Peer Group

	Female		Male	
	(1)	(2)	(3)	(4)
	Math	English	Math	English
Treat	0.617***	-0.027	0.863***	0.583***
	(0.203)	(0.194)	(0.188)	(0.195)
Treat×Rank_{Mid}	-0.430	0.422	-0.707**	-0.155
	(0.303)	(0.280)	(0.283)	(0.310)
Treat×Rank_{Low}	-0.658**	0.210	-0.921***	-0.364
	(0.267)	(0.192)	(0.223)	(0.252)
N	370	370	475	475
R^2	0.687	0.603	0.589	0.564

Note: All outcome variables are standardized to have a mean of 0 and a standard deviation of 1. Standard errors, reported in parentheses, are clustered at the individual level. *Treat* is an indicator for single-sex high school assignments. *Rank* indicates a student's relative ranking in their peer group (i.e., school) in the first year of high school (grade 10) by their mean score in math before entering high school (grades 8–9). Base = 90–100%, Rank_{Mid}= 60–90%, Rank_{Low} = 0–60%. Control variables are the average baseline value of the outcome variable (i.e., the mean value for grades 7–9), students' socio-demographic and school characteristics described in Table 1, an indicator for attending a private high school, school region fixed effects, residential region fixed effects, and year fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A3: Effects of Single-Sex Schooling, Controlling Only for Region and Year Fixed Effects

	(1) Mental health	(2) Bullying	(3) Social	(4) Math	(5) English
Treat	-0.246**	-0.051	0.078	0.117	0.242**
	(0.115)	(0.084)	(0.107)	(0.114)	(0.113)
Constant	-0.369	-0.840	-0.475	-0.206	-0.302
	(0.519)	(0.512)	(0.514)	(0.770)	(0.785)
N	845	845	845	845	845
R^2	0.106	0.141	0.078	0.163	0.189

Note: All outcome variables are standardized to have a mean of 0 and a standard deviation of 1. Standard errors, reported in parentheses, are clustered at the individual level. *Treat* is an indicator for single-sex high school assignments. Control variables are school region fixed effects, residential region fixed effects, and year fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A4: Effects of Single-Sex Schooling by Rank in the Peer Group, Controlling Only for Region and Year Fixed Effects

	Female			Male		
	(1) Mental health	(2) Bullying	(3) Social	(4) Mental health	(5) Bullying	(6) Social
Treat	0.461	-0.572**	0.670**	-0.386	0.074	-0.087
	(0.402)	(0.226)	(0.261)	(0.320)	(0.212)	(0.264)
Treat×Rank$_{\text{Mid}}$	-0.926*	0.367	-0.801***	0.015	0.102	0.034
	(0.476)	(0.286)	(0.306)	(0.368)	(0.255)	(0.333)
Treat×Rank$_{\text{Low}}$	-0.641	0.375	-0.545	0.327	0.078	0.328
	(0.469)	(0.273)	(0.355)	(0.377)	(0.277)	(0.312)
N	370	370	370	475	475	475
R^2	0.217	0.265	0.232	0.198	0.228	0.145

Note: All outcome variables are standardized to have a mean of 0 and a standard deviation of 1. Standard errors, reported in parentheses, are clustered at the individual level. *Treat* is an indicator for single-sex high school assignments. *Rank* indicates a student's relative ranking in their peer group (i.e., school) in the first year of high school (grade 10) by their mean score in math before entering high school (grades 8–9). Base = 90–100%, Rank$_{Mid}$= 60–90%, Rank$_{Low}$ = 0–60%. Control variables are school region fixed effects, residential region fixed effects, and year fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A5: Effects of Single-Sex Schooling, Using Public High School Sample

	(1) Mental health	(2) Bullying	(3) Social	(4) Math	(5) English
Treat	-0.073	-0.174	0.352**	3.280***	4.253***
	(0.182)	(0.140)	(0.146)	(1.125)	(1.223)
Baseline	0.869***	0.370***	0.276***	0.589***	0.583***
	(0.086)	(0.076)	(0.071)	(0.069)	(0.061)
Constant	-4.861***	0.581	-1.244	-17.565*	-19.251**
	(1.195)	(0.982)	(1.166)	(9.295)	(9.484)
N	443	443	443	443	443
R^2	0.411	0.307	0.243	0.533	0.554

Note: All outcome variables are standardized to have a mean of 0 and a standard deviation of 1. Standard errors, reported in parentheses, are clustered at the individual level. *Treat* is an indicator for single-sex high school assignments. Control variables are the average baseline value of the outcome variable (i.e., the mean value for grades 7–9), students' socio-demographic and school characteristics described in Table 1, total scores, school region fixed effects, residential region fixed effects, and year fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A6: Effects of Single-Sex Schooling by Rank in the Peer Group, Using Public High School Sample

	Female			Male		
	(1) Mental health	(2) Bullying	(3) Social	(4) Mental health	(5) Bullying	(6) Social
Treat	1.365***	-0.225	1.566***	-0.090	0.074	0.047
	(0.420)	(0.380)	(0.541)	(0.227)	(0.214)	(0.251)
Treat×Rank$_{\text{Mid}}$	-1.652**	0.081	-1.551***	-0.365	-0.119	0.461
	(0.654)	(0.469)	(0.571)	(0.413)	(0.454)	(0.448)
Treat×Rank$_{\text{Low}}$	-1.465***	0.242	-0.633	0.326	-0.189	0.526
	(0.380)	(0.366)	(0.493)	(0.331)	(0.305)	(0.345)
N	177	177	177	266	266	266
R^2	0.550	0.398	0.351	0.457	0.351	0.292

Note: All outcome variables are standardized to have a mean of 0 and a standard deviation of 1. Standard errors, reported in parentheses, are clustered at the individual level. *Treat* is an indicator for single-sex high school assignments. *Rank* indicates a student's relative ranking in their peer group (i.e., school) in the first year of high school (grade 10) by their mean score in math before entering high school (grades 8–9). Base = 90–100%, Rank$_{Mid}$= 60–90%, Rank$_{Low}$ = 0–60%. Control variables are the average baseline value of the outcome variable (i.e., the mean value for grades 7–9), students' socio-demographic and school characteristics described in Table 1, school region fixed effects, residential region fixed effects, and year fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A7: Robustness Test: Individual Mental Health Measures

	(1) Life satisfaction	(2) Happiness	(3) Vitality	(4) Amusement	(5) Laughter	(6) Joy
Female						
Treat	0.552	0.863***	1.063***	1.031***	1.451***	1.397***
	(0.353)	(0.256)	(0.226)	(0.294)	(0.285)	(0.304)
Treat×Rank$_{\text{Mid}}$	-1.023**	-1.099***	-1.483***	-1.366***	-1.544***	-1.674***
	(0.459)	(0.351)	(0.351)	(0.456)	(0.427)	(0.411)
Treat×Rank$_{\text{Low}}$	-0.576	-0.906***	-1.126***	-0.931***	-1.748***	-1.428***
	(0.411)	(0.296)	(0.289)	(0.336)	(0.411)	(0.315)
N	370	370	370	370	369	370
R^2	0.405	0.485	0.401	0.436	0.393	0.426
Male						
Treat	-0.551**	-0.584**	-0.162	-0.423	-0.003	-0.066
	(0.216)	(0.230)	(0.230)	(0.262)	(0.213)	(0.200)
Treat×Rank$_{\text{Mid}}$	0.526	-0.344	-0.251	0.313	-0.098	-0.222
	(0.343)	(0.310)	(0.341)	(0.370)	(0.307)	(0.290)
Treat×Rank$_{\text{Low}}$	0.894***	0.531*	0.138	0.570*	-0.087	0.086
	(0.291)	(0.283)	(0.272)	(0.313)	(0.301)	(0.272)
N	474	475	474	475	475	475
R^2	0.249	0.408	0.384	0.266	0.395	0.324

Note: All outcome variables are standardized to have a mean of 0 and a standard deviation of 1. Standard errors, reported in parentheses, are clustered at the individual level. *Treat* is an indicator for single-sex high school assignments. *Rank* indicates a student's relative ranking in their peer group (i.e., school) in the first year of high school (grade 10) by their mean score in math before entering high school (grades 8–9). Base = 90–100%, Rank$_{Mid}$= 60–90%, Rank$_{Low}$ = 0–60%. Control variables are the average baseline value of the outcome variable (i.e., the mean value for grades 7–9), students' socio-demographic and school characteristics described in Table 1, an indicator for attending a private high school, school region fixed effects, residential region fixed effects, and year fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A8: Robustness Test: Alternative Mental Health Measures

	Self-esteem			Resilience		
	(1) Worth	(2) Satisfaction	(3) Positiveness	(4) Causal analysis	(5) Emotional regulation	(6) Gratitude
Female						
Treat	1.096***	0.702***	0.648*	0.587**	0.275	0.439
	(0.297)	(0.249)	(0.349)	(0.285)	(0.311)	(0.280)
Treat×Rank_{Mid}	-1.738***	-1.671***	-1.404***	-0.299	-1.106**	-0.538
	(0.427)	(0.374)	(0.455)	(0.447)	(0.502)	(0.416)
Treat×Rank_{Low}	-1.234***	-0.951***	-0.683*	0.021	-0.235	-0.748***
	(0.424)	(0.337)	(0.387)	(0.321)	(0.332)	(0.277)
N	370	370	370	370	369	369
R^2	0.338	0.391	0.328	0.297	0.300	0.221
Male						
Treat	0.031	-0.155	-0.130	-0.238	0.104	-0.319
	(0.200)	(0.219)	(0.321)	(0.206)	(0.279)	(0.239)
Treat×Rank_{Mid}	-0.003	-0.380	-0.203	0.314	-0.327	0.149
	(0.324)	(0.294)	(0.336)	(0.312)	(0.423)	(0.341)
Treat×Rank_{Low}	0.075	0.362	-0.037	0.373	-0.063	0.472
	(0.275)	(0.247)	(0.336)	(0.261)	(0.393)	(0.359)
N	475	475	475	475	475	475
R^2	0.316	0.314	0.289	0.369	0.261	0.298

Note: All outcome variables are standardized to have a mean of 0 and a standard deviation of 1. Standard errors, reported in parentheses, are clustered at the individual level. *Treat* is an indicator for single-sex high school assignments. *Rank* indicates a student's relative ranking in their peer group (i.e., school) in the first year of high school (grade 10) by their mean score in math before entering high school (grades 8–9). Base = 90–100%, Rank_{Mid}= 60–90%, Rank_{Low} = 0–60%. Control variables are the average baseline value of the outcome variable (i.e., the mean value for grades 7–9), students' socio-demographic and school characteristics described in Table 1, an indicator for attending a private high school, school region fixed effects, residential region fixed effects, and year fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A9: Robustness Test: Alternative Peer Relationship Measures

	Female		Male	
	(1) Friendship	(2) Friend-time	(3) Friendship	(4) Friend-time
Treat	0.694**	0.236	-0.134	-0.144
	(0.308)	(0.332)	(0.190)	(0.275)
Treat×Rank$_{\text{Mid}}$	-1.393***	-1.217***	-0.274	0.020
	(0.437)	(0.429)	(0.332)	(0.331)
Treat×Rank$_{\text{Low}}$	-0.812**	-0.930**	-0.139	0.496
	(0.346)	(0.390)	(0.347)	(0.350)
N	369	370	475	475
R^2	0.311	0.268	0.322	0.321

Note: All outcome variables are standardized to have a mean of 0 and a standard deviation of 1. Standard errors, reported in parentheses, are clustered at the individual level. *Treat* is an indicator for single-sex high school assignments. *Rank* indicates a student's relative ranking in their peer group (i.e., school) in the first year of high school (grade 10) by their mean score in math before entering high school (grades 8–9). Base = 90–100%, Rank$_{Mid}$= 60–90%, Rank$_{Low}$ = 0–60%. Control variables are the average baseline value of the outcome variable (i.e., the mean value for grades 7–9), students' socio-demographic and school characteristics described in Table 1, an indicator for attending a private high school, school region fixed effects, residential region fixed effects, and year fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A10: Robustness Test: Other Competition Measures and Levels

	Female			Male		
	(1) Mental health	(2) Bullying	(3) Social	(4) Mental health	(5) Bullying	(6) Social
Treat	0.996***	-1.038**	0.598*	-0.394	0.140	0.596**
	(0.378)	(0.414)	(0.336)	(0.256)	(0.235)	(0.242)
Treat×Rank_{Mid}	-0.960**	0.887**	-0.376	0.314	-0.231	-0.014
	(0.467)	(0.437)	(0.393)	(0.290)	(0.274)	(0.269)
Treat×Rank_{Low}	-1.535***	1.266***	-0.270	0.371	-0.168	0.119
	(0.426)	(0.467)	(0.304)	(0.383)	(0.300)	(0.430)
N	361	361	361	459	459	459
R^2	0.486	0.305	0.283	0.428	0.325	0.274

Note: All outcome variables are standardized to have a mean of 0 and a standard deviation of 1. Standard errors, reported in parentheses, are clustered at the individual level. *Treat* is an indicator for single-sex high school assignments. *Rank* indicates a student's relative ranking in their peer group (i.e., school) in the first year of high school (grade 10) by their **mean score in math and English one year before entering high school (grade 9). Base = 95-100%, Rank_{Mid}= 50-95%, Rank_{Low} = 0-50%.** Control variables are the average baseline value of the outcome variable (i.e., the mean value for grades 7–9), students' socio-demographic and school characteristics described in Table 1, an indicator for attending a private high school, school region fixed effects, residential region fixed effects, and year fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.