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Peer gender and mental health*

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ABSTRACT

Adolescent mental health is key for later well-being. Yet, causal evidence on environmental drivers of adolescent mental health is scant. We study how an important classroom feature—the gender composition in compulsory-school—affects mental health. We use Swedish administrative data (N = 576,285) to link variation in gender composition across classrooms within cohorts to mental health. We find that a higher share of female peers in a classroom increases the incidence of mental health diagnoses, particularly among boys. The effect persists into adulthood. Peer composition is thus an important and persistent driver of mental health.

1. Introduction

Mental health problems among adolescents are common, particularly among boys, and have large long-run negative implications.[1] Individuals with bad mental health have lower income, non-cognitive skills, educational attainment, and invest less in their children (Currie and Stabile, 2006; Lundborg et al., 2014; Baranov et al., 2020).[2] To better understand human

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[1] According to the Center for Disease Control, suicide is currently the second most prominent cause of death for men under the age of 20 (Heron, 2016).

[2] Papers examining the negative impacts of mental health problems early in life include Currie and Stabile (2006), Currie et al. (2010), Salm and Schunk (2012), De Neve and Oswald (2012), Lundborg et al. (2014). For papers discussing the effects of bad mental health across different stages in life on productivity, see, e.g., Currie and Stabile (2006), Lundborg et al. (2014), Borowiecki (2017), Prinz et al. (2018), Bu¨tikofer et al. (2020), Ridley et al. (2020). Individuals with mental health issues are also more likely to commit crimes (Blattman et al., 2017). One reason for the strong impacts of mental health on economic outcomes may be the intimate link between mental health, economic preferences, and beliefs (Haushofer and Fehr, 2014; De Quidt and Haushofer, 2019; Meier, 2019).

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capital accumulation and to devise policy interventions, it is crucial to know whether and to what extent the environment in adolescence affects mental health (Cunha et al., 2010; Heckman et al., 2013; Bütikofer et al., 2020).

Children spend much of their time with their peers at school. Psychological research suggests an intimate link between peer relationships and mental health: Roughly half of the children with conduct disorders have problems with peers (Parker et al., 2015). Gender composition is a key feature of peer environment and an important correlate of school wellbeing and motivation (Belfi et al., 2012; Pahlke et al., 2014). Gender composition creates constraints for socialization and friendship formation, affects self-image, and shapes conflict.[3] Because of the dearth of large-scale diagnostic data and the difficulties of conducting randomized trials, however, findings examining the link between the school environment and mental health remain largely correlational.

In this paper, we study causal impact of the gender composition in the primary school classroom on mental health. We use a unique and barely exploited link between classroom peer composition and mental health diagnoses based on administrative data of 576,285 students. A key advantage of the data is that, in addition to knowing which cohort a student was in, we know the classroom for each student within their cohort. Our identification strategy thus relies on both idiosyncratic variation of the classroom share of female peers across classrooms within cohorts and cohort variation.

We find that students in classrooms with more girls have more mental health diagnoses. A 10 percentage point increase in the share of female peers, which corresponds to 2–3 classmates, increases the likelihood of a mental health diagnosis by 2.2%. Boys drive this effect: for them, a similar increase in the share of girls in the classroom leads to a 4.5% increase in the likelihood of receiving a mental health diagnosis. A higher share of female peers also substantially increases the risk of self-harm among boys. The mental health effect is not only substantial, it also persists into early adulthood.

The extensive administrative data allows us to conduct a series of balancing and robustness checks. We observe balance for parental characteristics, including mental health, education, and income. Importantly, student mental health before class formation also does not predict the share of females in the classroom. Moreover, student gender does not predict the share of female peers, classroom fixed effects do not predict student gender (Chetty et al., 2011; Balestra et al., 2020), and the distribution of the share of female peers looks as if randomly assigned. We also do placebo checks which show i) no impact of previous or following cohorts on mental health and ii) no impact on mental health diagnoses related solely to biological origins. Finally, the coefficient estimates are equivalent when we drop students who move during the sample period.

An advantage of the data is that we can exploit cohort and classroom variation. We also document sizable and statistically significant effects when we rely only on cohort variation.

Theory and evidence highlights the classroom as the relevant peer environment (Lazear, 2001; Chetty et al., 2011), but data limitations have traditionally hindered the use of classroom-level variation. Exceptions include Ammermüller and Pischke (2009); Burke and Sass (2013); Balestra et al. (2020), who use naturally occurring classroom assignment to estimate the effects of peers like we do (Chetty et al., 2011; Anelli and Peri, 2019; Bietenbeck, 2020 use randomized assignment to classrooms). Given the theoretical arguments and the empirical evidence highlighting classrooms as the relevant peer environment, our focus lies on this variation.

We discuss and explore potential mechanisms by combining insights from previous literature with analyses of our data. In the first step, we document an increase of diagnoses related to peer problems. A marked increase in conduct disorders and substance abuse-related disorders drives the impact on mental health. Both diagnostic types are intimately linked to peer relationships (see, e.g., Lundborg, 2006; Parker et al., 2015; Ackermann et al., 2019), suggesting personal relationships as a relevant factor for explaining the effects of peer gender composition.

Second, we discuss an obvious potential explanation for the link between peer relationships and mental health: Boys have smaller potential friend networks than girls in classes with more girls. Same-gender friendships in adolescence are much more common than opposite-gender friendships (see, e.g., Hill 2015), and having more friends benefits mental health (see, e.g., Parker and Asher, 1987; Bond et al., 2007; Ho, 2016). Finding many friends is particularly relevant for boys, as they tend to have larger same-gender networks than girls (Benenson et al., 1997; Rose and Rudolph, 2006; Anelli and Peri, 2019). Moreover, boys have closer relationships to boys than to girls (Hill, 2015). Consistent with these findings highlighting the relevance of friendship network for boys, Anelli and Peri (2019) show that boys who went to school with more boys are more likely to choose the same college major, but the same does not hold true for girls. We also document that boys with more boys in their primary school classroom are more likely to attend the same high-school track as their primary school classmates. Moreover, the effect is more pronounced for boys than for girls, implying that boys' friendship networks are relatively more dependent on the classroom gender composition. Accordingly, boys seem to have a tougher time finding close friends in classes with more female peers, with plausibly detrimental consequences for mental health.

Third, we examine educational attainment, average peer ability, as well as mental health and class rank (Elsner and Isphording, 2018; Kiessling and Norris, 2020). The average grade in the rest of the class, average mental health, or class rank cannot explain the results. However, consistent with the impact on mental health, we observe lower educational attainment of boys in classes with more females. The difference in own educational attainment accounts for roughly a third to half of the relationship between class composition and mental health.

[3] Cillessen and Mayeux (2004), Sullivan et al. (2006), Belfi et al. (2012) detail links between peer relationships and mental health diagnoses (see also, Viner et al. 2012). A large literature examines how gender composition affects classroom dynamics and identity for formation, see, e.g., Simmons and Rosenberg (1975), Benenson et al. (1997), Rose and Rudolph (2006), Dijkstra et al. (2007), Faris and Felmlee (2011), Kornienko et al. (2016).

Fourth, we explore the role of bullying, which is a key factor in shaping peer relationships (Ammermu¨ller, 2012; Eriksen et al., 2014; Klomek et al., 2015; Rees et al., 2020). Economic research has documented that boys and girls report less fighting with more girls in the cohort, according to Lavy and Schlosser (2011).[4] Our evidence is consistent with these findings: More girls in the classroom reduce the incidence of physical injury and have no effect on assaults. Accordingly, physical bullying can not explain the higher incidence of mental health diagnoses when there are more females in the classroom. While physical bullying seems lower, we discuss that psychological bullying might matter as females engage more in relational aggression (Lagerspetz et al., 1988; Björkqvist et al., 1992, Crick and Grotpeter, 1995; Card et al., 2008; Smith et al., 2010). Psychological bullying also has a disproportionate effect on boys (Crick and Grotpeter, 1996; Goldstein et al., 2008; Williams et al., 2009). Taken together, while physical bullying does not seem to explain the peer effects, psychological bullying might offer a potential explanation.

Fifth, we discuss the potential of an increase in discovery rates. This could be occurring, for instance, because of additional teacher or student attention to potential mental health problems. While this could be one part of the explanation for the general finding, and likely explains our findings for some diagnostic sub-categories, several results are at odds with it being the sole explanation. For instance, we find that boys are more likely to harm themselves in classes with more girls.

To summarize, the discussion of mechanisms indicates that (i) diagnostic categories with intimate links to peer relationships drive the main results, suggesting peer relationships as the key driver of the results; (ii) boys prefer larger friendship networks than girls, which is difficult to attain in classrooms with more girls, providing a plausible explanation for lower mental health; (iii) educational attainment in classes with more females is lower for boys, explaining part of the co-variation between classroom composition and mental health; and (iv) psychological bullying might play a role.

We add to three strands of literature. First, we add to a growing economic literature on early determinants of mental health (see, e.g., Black et al., 2016, 2018) Persson and Rossin-Slater (2018). document the role of family environment for mental health: In-utero exposure to negative family events has lasting negative effects on children's mental health. Studying the impact of economic shocks, Adhvaryu et al. (2019) document lower adult mental health after negative agricultural shocks in early life, and Baird et al. (2013) report better adolescent mental health after cash transfers. Moreover, Fruehwirth et al. (2019) find that more religious students tend to have fewer mental health problems and Singhal (2019) shows that children exposed to war have more. In sum, the literature indicates that early economic and family circumstances can have lasting effects on mental health.[5] We add evidence that school environment is also a persistent driver of mental health.

Second, we complement the literature on the impact of peers on educational and labor market outcomes (see, e.g., Chetty et al., 2011; Eisenkopf et al., 2015; Feld and Zölitz, 2017; Carrell et al., 2018; Balestra et al., 2020, 2021; Bietenbeck, 2020; Golsteyn et al., 2021; Thiemann, 2020). Several papers examine the impact of the gender composition of school peers on educational attainment.

(Lavy and Schlosser, 2011; Park et al., 2012; Black et al., 2013; Eisenkopf et al., 2015; Giardili, 2020) and educational choices (Black et al., 2013; Anelli and Peri, 2019; Brenøe and Z¨olitz, 2020).[6] Focusing on long-run labor market outcomes, Getik and Meier (2020) study the impact of more female peers on gender wage inequality at age 30. They document that more females in the classroom reduce wage inequality because females select into less gender-stereotypical occupations. Taken together, previous literature has examined the impact of the school environment on educational and labor market outcomes, but evidence on the impact on mental health is scant.

Third, our paper complements the literature studying peer effects on risky behaviors by providing evidence on how peer gender composition shapes substance use (see, e.g., Kremer and Levy, 2008; Cawley and Ruhm, 2011; Card and Giuliano, 2013; Elsner and Isphording, 2018). Previous papers demonstrate how peer consumption of alcohol and cigarettes affects substance use. Among other effects, peers who take drugs may induce others to consume drugs as well or may act as gatekeepers (Lundborg, 2006; Clark and Lohéac, 2007; Meier et al., 2020). Adding to this literature, we find an increase in diagnoses of substance-related disorders among boys with more girls in the classroom.

The paper is structured as follows: Section 2 describes the Swedish schooling system, mental health care provision, and the data. Section 3 discusses the empirical strategy and the main identifying assumption. It also provides evidence on

[4] Giardili (2020) reports a lower incidence of bullying in single-sex classes consisting only of boys and Lee, 2014 estimate a non-statistically significant reduction in bullying in single-sex classes.

[5] Two concurrent working papers use survey data from AddHealth to estimate the impact of cohort composition in middle and high school on answers to survey items from the Center for Epidemiological Studies Depression Scale (CES-D) Giulietti, Vlassopoulos and Zenou (2020). find that going to school with a higher share of peers with low well-being is linked to lower reported well-being Kiessling and Norris (2020). show that students' ability rank within a cohort is linked to well-being: a higher ability rank relates to higher reported well-being. In related studies, Eisenberg et al. (2013) finds small, if any, impact of peer mental health on own mental health in college students, and Bu¨tikofer et al. (2020) show that students admitted to more selective high schools have less mental health problems. We provide complementary evidence on the impact of the primary school environment in early adolescence and focus on the peer gender composition. Further differences to Giulietti et al. (2020); Kiessling and Norris (2020) include the use of diagnostic data from comprehensive administrative registers, including data *before* school start, classroomlevel composition (in addition to cohort-level), and the population-wide coverage of students (AddHealth covers roughly 20,000 students).

[6] Black et al. (2013) document lower educational attainment for boys with more girls in the cohort, while Lavy and Schlosser (2011) document higher attainment for boys and girls with more girls in the cohort. The latter finding is consistent with some findings exploiting random assignment to single-sex schooling (Park et al., 2012; Giardili, 2020). Regarding educational choices, Brenøe and Z¨olitz (2020) find that female high-school students who joined the math track are more likely to make gendercongruent choices when exposed to more boys Anelli and Peri (2019). find no impact, and Giardili (2020) finds that female students in single-sex schools make less gender-congruent choices.

balancing and placebo checks. Section 4 and Section 5 show the main results on early and later mental health. Section 6 discusses mechanisms, and Section 7 concludes.

2. Institutional background and data

2.1. Compulsory education in Sweden

All children in Sweden have to complete nine school years with a standardized curriculum across schools and classes. Students are generally assigned to the nearest primary school (grundskolan). After students enter primary school in the year when they turn seven, they usually pass through three stages: grades 1–3 (low), grades 4–6 (middle), and grades 7–9 (high).[7] At the beginning of each of these stages, students are assigned to classes, in which they remain for the duration of the stage.[8] Importantly, students are not reshuffled into different classes after grade 7 (around age 13), in which they remain until the end of primary schooling.

Based on the institutional context, it is likely that the share of female peers is arbitrary: Parents are not allowed to influence class assignment of their children by legal means (Öquist and Wikström, 2006). It is also consistent with the mandate for educational facilities, and by implication for school principals, to provide equal access and uniform standards for students.[9] A battery of balance and robustness checks detailed below corroborate these legal prescriptions, suggesting that gender composition in classrooms is indeed largely arbitrary.

Note that for the late stages of primary schooling we examine, teachers typically specialize in particular subjects in their educational training. They are normally assigned their teaching load based on the subjects they are qualified to teach rather than based on specific classrooms or cohorts.[10] Accordingly, teachers generally do not select classrooms, but subjects which are then taught across classrooms.

In the last year of primary school, students can apply to proceed to a high school within their municipality. To do so, students need to attain a passing grade in a sufficient number of courses in primary school. Around 90% of students in our sample subsequently proceed to and complete high school. When entering high school, students are naturally assigned to new classes.

2.2. Swedish mental health care

Children and adolescents with mental health issues typically first have to contact the so-called first-line psychiatric care (första linjens psykiatrivrd) and can then be referred to specialists. In most regions, local primary care (vårdcentral) is responsible for first-line care and thus the treatment of more common mental issues, such as mood disorders (Heurgren, 2019).

Psychiatrists treat the vast share of these cases in outpatient consultation. Children aged 17 and below who need more attention are referred to a special branch known as child and adolescent psychiatry (barn- och ungdompsykiatri, BUP), which provides inpatient and specialist outpatient treatment. Some of the wards also operate emergency rooms where both children and adults can be admitted in acute cases. Regular inpatient treatment occurs in open clinics, where patients usually pre-book a stay.

Our analysis relies on the nationwide register data covering all inpatient and outpatient mental health diagnoses of all Swedes from 2001 to 2012. The outpatient data covers all mental health diagnoses from the first-line psychiatric care and the child and adolescent psychiatry. Due to the standardized admission to care through outpatient referrals, the outpatient data covers over 92% of all mental health diagnoses.

2.3. Data and descriptive statistics

We use administrative data on classroom composition linked to all outpatient and inpatient mental health diagnoses for the years 2004 and 2012. We link the data using an anonymized version of the unique personal identifier of each Swedish resident. The reason for this time horizon is that classroom composition is only available from 2004 onward, and diagnostic data only from 2001 to 2012 at the time when the analysis was conducted. We further link the data on student classroom and mental health to information about students' family background. The final dataset covers 576,285 students from 26,278 classes in 855 schools over the course of 12 years.

We use data from administrative registers on schooling (National Exams Register, Nationella prov ˚arskurs 9) to construct the main independent variable, the leave-one-out share of female peers in the classroom. The share corresponds to the classroom composition in grade 7 (around age 13) which remains for the last three years of primary schooling.

[7] Around 6% to 12% of students in our sample attend charter schools (frist˚aende skolor), which apply additional criteria for admission. Moreover, instead of the absolute distance, some municipalities apply a measure known as relative distance (relativ n¨arhet). This metric involves comparing the relative distance between a school and the next best alternative across students. See, for example, the explanation by the schooling authority for Stockholm.

[8] Note that schools have some discretion over which stages to offer and when to reshuffle. However, there is no reshuffling after grade 7 and students remain in the same school.

[9] Swedish Primary School Regulation (Grundskolef¨orordning), SFS:1994:1194, 4 kap 4§.

[10] For more information, see the report by the Higher Education Authority (H¨ogskolverket).

The data comprises the population of Swedish compulsory-school students who took their national exams, and hence graduated, between 2004 and 2012. We know the class in which each student was; the classroom indicator comes from the group in which a student took the national exams. To ensure that it corresponds to their class, we cross-reference the indicator for each of the three exams in the register.[11] We then use this information to compute the leave-one-out share of female peers for each class of all schools that can be observed throughout.[12] Note that, according to Skolverket (the Swedish school authority), approximately 25% of students do not change the classroom after entering school. This means students may well be exposed to the same peers from the beginning of primary school.

We use data from administrative registers on mental health diagnoses (Inpatient and Outpatient Register) to construct the main dependent variable, an indicator capturing whether a student was diagnosed with a mental health issue in the last three years of primary school (the results are equivalent when we use only diagnostic codes observed in the last year of primary school, see Table D.3). The last reshuffling of classrooms takes place at the start of these three years in grade 7, which corresponds to ages 13 to 14 for most students.[13] So, we define an indicator which is 100 if any diagnostic code was observed between grades 7 to 9. In most cases, this will be the first diagnosis we observe for a student.[14]

We identify mental health diagnoses using ICD-10 codes for each patient. The indicator is 100 if any of the ICD-10 codes between F00 and F99 is present, and it is 0 otherwise.[15] The diagnostic database allows us to understand whether and when a diagnosis occurred, but, unfortunately, does not contain detailed information on healthcare utilization or prescription drug use. We also present results for specific diagnoses (see Table 3) and for the inpatient and outpatient data separately (see Table D.1).

Table A.1 presents the summary statistics of the data. The mean class size is around 23 students while there are, on average, around 5 classes per cohort. The mean share of female peers is 49%, with most of the observations between 40 and 60% share of females (see Fig. A.1). Regarding mental health, we observe that roughly 4.5% of students have a diagnosed mental health issue. The most prominent cluster of diagnoses (with a prevalence of 1.5%) are hyperactivity and conduct disorders, including disorders of social functioning. For parents, mood-related diagnoses, covering such illnesses as depression, are most prevalent with 4.2% of parents having such a diagnosis.[16]

3. Empirical strategy and plausibility checks

3.1. Specification and identifying assumptions

We estimate the following main specification separately for boys and for girls:

$$Y_{ic} = \beta_1 \times ShareFemPeers_{ic} + \alpha_{schoolxcohort} + X_i\gamma + E_{ic}$$

In the equation above, Y_{ic} is an indicator for a mental health diagnosis for student i in classroom c during the last three years of primary school. The key explanatory variable is

$ShareFemPeers_{ic}$, the proportion of female students in a given classroom. It is defined as, $\frac{ngirls_c - gender_i}{Size_c}$, where $ngirls_c$ is the number of girls in a given classroom, $size_c$ is the classroom size, and $gender_i$ is the student's gender (1 = female). The estimate for β_1 gives the effect of gender peer composition. $\alpha_{schoolxcohort}$ represent one fixed effect for each school and cohort interaction. The specification therefore exploits within-school–cohort variation coming from differences in gender composition across classrooms. X_i denotes individual and school-level controls. The individual controls are log family income, dummies for parental education (indicators for high-school degree, vocational degree, college degree, stem degree), and an indicator for any parental mental health diagnosis before school start.[17] The included school-level controls are classroom size, cohort size, and the number of schools in a given municipality. When we show

[11] For roughly 7% of students the class indicator is missing and we drop the corresponding observations. We treat groups of students larger than 35 as having a missing class indicator. This class size is implausibly large in the Swedish context and suggest inaccurate class indicators. Note that whether the classroom indicator is missing does not correlate with student gender and the distributions of the share of female peers across classrooms looks similar in schools with and without missing classrooms. When including schools we do not observe over the whole sample period and all classes with more than 35 students, the estimates from the specification including school-by-cohort fixed effects and controls (the specification in column 7 of Table 1) are $\beta = 1.08$, $se = 0.29$, for all genders, $\beta = 1.78$, $se = 0.38$, for only boys, and $\beta = 0.37$, $se = 0.41$, for only females. The results are therefore equivalent to the results with the sample restrictions.

[12] Following Brenøe and Z̈olitz (2020), we exclude students whose class contained less than ten students (roughly 2% of the sample). These seemingly very small classes are likely coming from misreporting of classroom information and/or are because the corresponding students attend non-regular education, such as special education classes.

[13] Potential minor remaining changes in composition because students move schools cannot explain our results, see Table D.3 where we drop all movers during primary school and the year just before school start.

[14] In Table B.2, we show that mental health diagnoses before primary school are independent of the later share of female peers and that controlling for mental health up to and including grade 6 leads to similar results.

[15] The 0 and 100 binary designation allows us to interpret the estimates as a percentage change. The ICD-10 codes indicating mental health issues contain 10 classifications: organic disorders (F00 - F09); mental and behavioural disorders due to psychoactive use (F10 - F19); schizophrenia, schizotypal and delusional disorders (F20 - F29); mood disorders (F30 - F39); neurotic, stress-related and somatoform disorders (F40 - F49); behavioural syndromes associated with physiological disturbances and physical factors (F50 - F59); disorders of adult personality and behaviour (F60 - F69); mental retardation (F70 - F79); disorders of psychological development (F80 - F89); behavioural and emotional disorders with onset in adolescence (F90 - F98).

[16] This is in line with depression being the most frequently reported mental health diagnosis, please see the following WHO factsheet.

results for the pooled sample of boys and girls, we interact all fixed effects and controls with gender for comparability with the split-sample estimates. We cluster the standard errors on the school level, allowing for correlation in classroom makeup within school.

The main threats for a causal interpretation of the estimates from the above specification come from potential sorting of students. Here, the institutional context ensures that there is little selection apart from geographic location and age into schools and cohorts. The empirical strategy addresses this selection and even school-cohort specific selection since it exploits idiosyncratic variation in classroom composition conditional on *school* × *cohort* fixed effects. Based on theory (Lazear, 2001) and recent evidence (Ammermüller and Pischke, 2009; Chetty et al., 2011; Burke and Sass, 2013; Anelli and Peri, 2019; Balestra et al., 2020; Bietenbeck, 2020), we expect the classroom environment to be the relevant peer environment. Previous literature has pointed out that peer composition across cohorts, conditional on including one set of school and a separate set of cohort fixed effects, is already as good as randomly assigned (Hoxby, 2000; Black et al., 2013; Helene et al., 2015). Many peer effects papers therefore exploit the within-school, across-cohort variation in peer composition.[18] We show that the results are qualitatively equivalent when we use these less restrictive specifications (see Table D.2). In the main specification, we choose the most restrictive specification: We take dynamic selection into account by controlling for *school* × *cohort* fixed effects, which fully accounts for potential changes in sorting to schools over time.

Given the above specification, the main identifying assumption is that no omitted variable satisfies the following conditions: (i) time-variant and class-specific, (ii) not captured by cohort × school fixed effects, (iii) associated with mental health diagnoses and gender-peer composition, (iv) not captured by a large set of individual controls based on administrative data. The existence of such a factor seems highly unlikely given that parents are not allowed to influence the choice of class by legal means (Öquist and Wikström, 2006). Still, to assess the likelihood of such a factor existing, we examine the relationship between high-quality and detailed observable characteristics from administrative registers and genderpeer composition in the classroom. We also examine whether student mental health before school predicts the share of female peers. Taken together, the results from these and further checks, which we detail below, support the main identifying assumption.

3.2. Balance and placebo checks

The school × cohort fixed effects address static and potential dynamic selection at the school-cohort level. We now check whether remaining variation in the classroom gender-peer share is likely arbitrary in our sample. Here is a summary of what we find:

1. Across 154 bivariate regressions, we find no indication that family characteristics, including parental mental health, income, and education, systematically predict gender peer share.
2. Student mental health before school start does not predict the share of female peers.
3. The residualized share of females is normally distributed.
4. The distribution of the residualized share of females is similar to the simulated residualized share of females where we randomly assign students to classes.
5. Student gender does not predict the share of female peers.
6. Classroom fixed effects do not jointly predict student gender.
7. Including classroom fixed effects does not markedly affect the coefficient size of estimated gender differences.
8. Gender peer share in previous and following classes does not affect mental health.
9. There is no increase in mental illnesses which are exclusively biologically driven.

3.3. Balance checks

Family characteristics. We provide a series of balance checks for high-quality background variables on parental and family characteristics from administrative registers measured before the child starts (primary) school. The 22 variables include, among others, family income, parental education, and parental mental health diagnoses. For each variable, we examine whether there is a correlation with the share of female peers in the classroom across 7 specifications. If there were many such correlations, this would indicate that parents may be able to select to specific classrooms within school–cohorts. We show the results of the resulting 154 bivariate regressions in Table B.1. In the absence of systematic sorting, one would expect to have approximately 10%, 5%, and 1% of the coefficients to be significant at each corresponding level. Out of 22 variables, there are only 2 statistically significant coefficient estimates at the 10% level in the most restrictive specification. We conclude that the fraction of statistically significant coefficients is not higher than could be expected by chance.

Prior mental health. We further check whether students with mental health diagnoses *before* starting (primary) school are more likely to end up in classes with a higher share of females. The data offers a unique possibility for such a check.

[17] We only observe parental mental health before school start for cohorts finishing school after 2009. Parents of students of earlier cohorts receive an indicator for missing mental health data. When using parental mental health as a control variable, we include a dummy for each value of the categorical variable capturing no mental health diagnosis, any mental health diagnosis, or a missing mental health diagnosis.

[18] To account for potential dynamic selection across cohorts into schools, some recent contributions have include school-specific time trends to analyze deviations from peer composition conditional on dynamic trends (Brenøe and Z¨olitz, 2020).

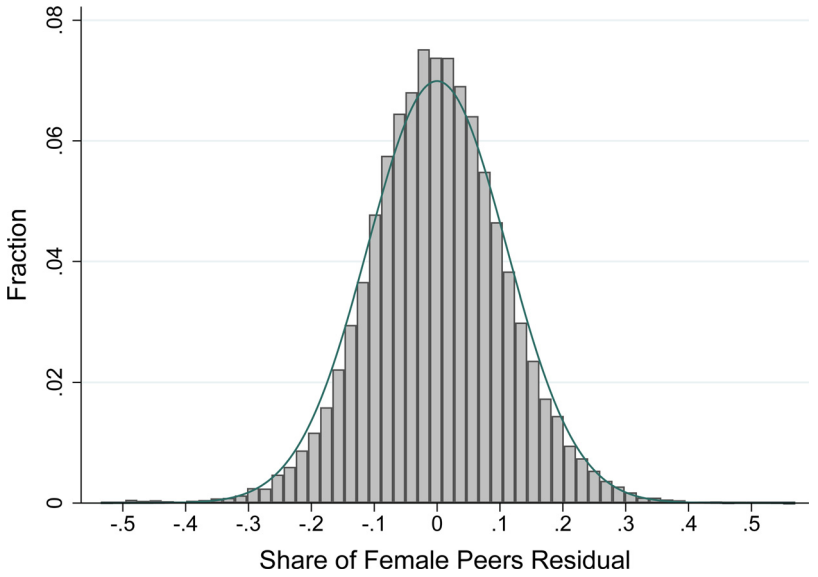

Fig. 1. Variation of the share of female peers across classrooms within school–cohorts effects. The overlaid curve shows a normal distribution with the same mean and variance.

Usually, prior measurement of later outcome variables are not observable in peer effects studies before students are exposed to peers. To examine whether there is selection into classrooms based on pre-existing mental health issues, we regress the indicator capturing a diagnosis before school starts on the share of later female peers.[19] Note that this check also directly tests for the potential role of preexisting differences in mental health of boys and girls.[20]

We do not find any indication that students with worse recorded mental health before starting school are more likely to end up in classes with a higher share of female peers, see Table B.2. None of the coefficients are statistically significant, and they are a fraction of the magnitude of the effect estimates of the impact of the share of female peers on later mental health. The coefficient signs, if anything, indicate better mental health among students ending up in classes with a high share of female peers.

In addition, considering any occurrence before the last stage of primary school (up to and including grade 6), we also control for 8 different mental health conditions for students and parents as indicated in Table 3, as well as for physical injuries and assault of students. While these specifications absorb part of the treatment effects, due to the persistence in classrooms over time, it is reassuring to see that our main results remain similar (see Table B.3). Again, the results indicate that selection on mental health is unlikely to drive our results.

Distribution and simulated distribution of the share of females. In a next plausibility check of as-good-as-random assignment to classrooms, we examine the variation of the gender peer share that we exploit. If gender-peer share was as good as randomly assigned, we would expect that the corresponding distribution of peer shares would look normally distributed, conditional on school × cohort fixed effects. Fig. 1 suggests that the corresponding distribution is well-behaved and follows a normal distribution, suggesting that gender peer share may indeed be arbitrary.

We further test whether peer-gender variation within schools is consistent with random assignment by comparing the distribution of the share of female peers to a simulated distribution of the share of female peers based on randomly assigning students to classrooms. To this end, we do Monte Carlo simulations in which we assign students randomly to classes within their school-cohorts. We take the number and size of classes from the actual data. In the spirit of Bietenbeck (2020), we then regress the share of female peers on school × cohort fixed effects in the simulated data and collect the residuals. We plot the residuals from the simulations alongside the residuals from the actual data in Fig. B.1. The distributions look very similar, a result consistent with as-good-as-random assignment of the share of female peers.

Gender and the share of female peers. In addition, we also examine whether a student's own gender correlates with the proportion of females in their class, following the methodology proposed by Guryan et al. (2009). To examine the correlations, we use seven specifications analogous to the main results table (Table 1). Across specifications, we control for the

[19] We examine diagnoses received prior to entering school rather than diagnoses before the last stage of primary school because we do not have information the share of female peers in earlier stages. Therefore, we do not know with certainty the classroom composition before the last stage of primary school. According to the Skolverket (the Swedish school authority), approximately 25% of students do not change the classroom after entering school. A substantial share of students is thus treated from when they enter school, which is why we examine diagnoses before school start.

[20] If pre-existing differences played a role, it would likely bias the results in the opposite direction that we observe. Females have more mental health issues, which indicates that we should see a higher incidence of mental health issues among females in classes with more females. However, we observe the opposite.

Table 1
Gender composition and mental health.

	Mental Health Diagnosis [0,100]						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
All Genders (Avg: 4.67)	1.04***	0.96***	1.05***	1.02***	1.10***	0.97***	1.06***
	(0.30)	(0.30)	(0.29)	(0.29)	(0.29)	(0.35)	(0.35)
Males (Avg: 4.21)	1.47***	1.59***	1.69***	1.70***	1.77***	1.82***	1.92***
	(0.38)	(0.38)	(0.37)	(0.38)	(0.37)	(0.46)	(0.45)
Females (Avg: 5.16)	0.41	0.31	0.38	0.34	0.40	0.08	0.17
	(0.40)	(0.41)	(0.40)	(0.41)	(0.41)	(0.48)	(0.48)
School FE	–	X	X	X	X	–	–
Cohort FE	–	–	X	X	X	–	–
School Trends	–	–	–	X	X	–	–
Controls	–	–	–	–	X	–	X
School × Cohort FE	–	–	–	–	–	X	X
Observations	576,285	576,285	576,285	576,285	576,285	576,285	576,285
Schools	855	855	855	855	855	855	855
R-squared	0.00	0.01	0.01	0.02	0.02	0.04	0.04

Note: The table shows the estimated relationship between the incidence of mental health diagnoses and the share of female peers in the classroom. The first row shows the results for the sample with both genders (All Genders). In this specification, we interact all fixed effects and controls with gender. The next two rows show coefficient estimates from separate estimations based on samples including either only males or only females. The number of observations and the corresponding *R*-squared come from the sample including both genders. Controls include parental education, income, and mental health as well as class size, cohort size, and the number of schools in the municipality. Standard errors (in parentheses) are based on clustering at the school level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

school × cohort-level leave-one-out class mean of the share of females to account for the mechanical relationship between peer and own gender following Guryan et al. (2009). That is, we control for the share of female peers in the other classes of a student's school–cohort. There is no statistically significant correlation between own gender and the share of female peers, see Table B.4.

Gender and classrooms. Following Chetty et al. (2011); Balestra et al. (2020), we regress student gender on class fixed effects. The class fixed effects should be jointly insignificant if assignment to classroom is random regarding student gender (Chetty et al., 2011), which is what we find. We proceed as follows: In the first step, we regress student gender on the school × cohort fixed effects and controls as indicated and we then retrieve the residuals from this regression. In the second step, we regress the residuals obtained in the prior regression on classroom fixed effects. We then do a joint *F*-test to determine whether those fixed effects are jointly significant. Across three different specifications the *F*statistics suggest no predictory power of classroom fixed effects for student gender: $F = 0.727$ without controls, $F = 0.724$ with school-level controls, and $F = 0.722$ with school-level and individual-level controls. All *F*-statistics are well below critical values required for statistical significance.

Stability of gender differences to classroom fixed effects. We conduct a final check, where we include classroom fixed effects to better understand the potential role of selection into classrooms. Note that this check does not directly assess the robustness of the main effects, which show how the share of female peers affects the level of mental health in males and females. It is not possible to estimate these levels when we include classroom fixed effects. However, it is possible to estimate how the share of females shapes the difference between males and females conditional on classroom fixed effects.

Examining the stability of the gender difference to the inclusion of classroom fixed effects is informative: If including classroom fixed effects changes the estimated effect of the gender peer share on the gender difference in mental health, this may indicate potential selection. However, if the estimated impact on gender difference remains similar when we include classroom fixed effects, it is unlikely that selection into classrooms has large effects on levels of mental health in males and females. The argument is that if we observe stable gender differences across specifications, it is unlikely that selection into classrooms is a key driver of the main results. Table B.5 in the Appendix shows that gender differences are stable even when including classroom fixed effects, which provides another piece of evidence that classroom selection does likely not drive the results.

3.4. Placebo checks

Previous and subsequent cohorts. We also do the following placebo checks to further assess the plausibility of the identification strategy. First, we examine whether the share of female peers in the previous or the subsequent cohort affects mental health diagnoses Table B.6. shows that the corresponding regression coefficients are not significantly different from zero. The check indicates that any effect of current class or cohort composition reflects idiosyncratic variation coming from the current cohort rather than from the previous or past cohort.

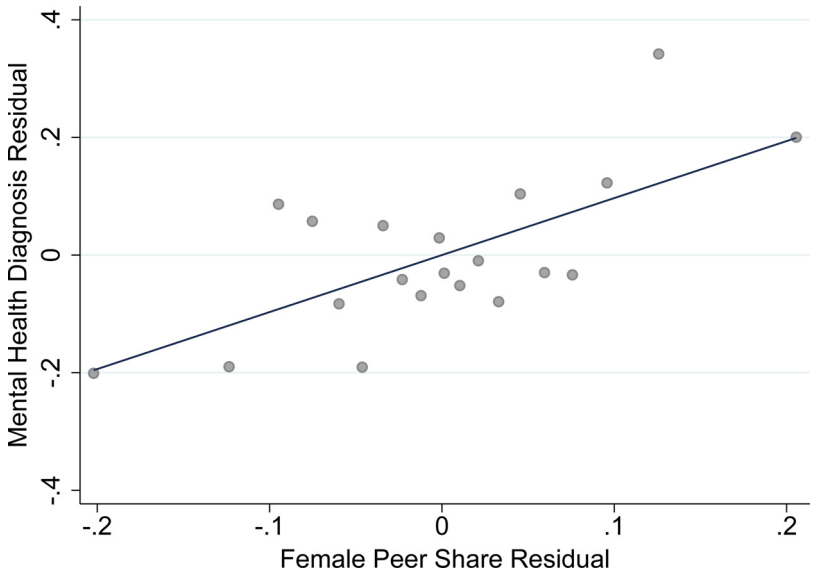

Fig. 2. The figure shows the relationships between the residual of mental health diagnoses and the residual share of female peers in the classroom ($N = 576{,}285$). The residuals stem from regressions of the respective variables on cohort-by-school fixed effects. The dots show the binned averages across 20 quantiles. The line shows the linear fit from OLS regressions using all data with $\beta = 0.97$, $se = 0.35$. The figure shows the relationship for the entire population, whereas it is also estimated separately for boys and girls in Table 1.

Diagnoses with biological origins. We next examine mental health issues that are exclusively biologically driven: organic disorders and mental retardation. Both have biological origins often determined at birth (Wittchen, 2001; Costeff et al., 2008). We present the estimates for these subcategories in Table B.7. There are no statistically significant effects of peer composition on mental health diagnoses purely determined by biology.

4. Peer gender and mental health

Fig. 2 and Table 1 show the main estimates for the impact of the gender peer composition on mental health. Table 1, row 1, shows the effect estimates for the pooled sample, row 2 shows the estimates for only males, and row 3 the estimates for only females. Across different specifications, the results indicate that a higher share of female peers leads to a higher prevalence of mental health diagnoses. As the results in row 2 suggest, boys drive this effect (see Fig. C.1 for the scatter plots showing the results for only males and only females).

The effects are precisely estimated overall, and for boys, and are substantial in size. The coefficient estimates for all genders indicates a 1.06 ($se = 0.35$) percentage point increase in mental health diagnoses when changing from an all male to an all female classroom. Accordingly, the likelihood of mental health diagnosis increases by 2.2% with an addition of 2–3 girl classmates ($sd = 0.09$) when compared to the average prevalence of mental health issues of 4.7%.[21] Adding just one female student to an average-sized classroom corresponds to a 1.1% increase in mental health diagnoses. When adding 5 female students, the effect size translates into a 5.5% increase. For boys, a similar increase in the share of girls corresponds to a 4.5% increase in the likelihood of receiving a mental health diagnosis. Note also that the differences between boys and girls are statistically significant (see Table B.5).

These are large increases when compared to the transmission of mental health between parent and children: Having one parent with a mental health diagnosis increases the likelihood of receiving a mental health diagnosis at this age by roughly 4 percentage points ($se = 0.001$). Therefore, the effect of a 10 percentage point increase in the share of female peers on mental health diagnosis is 2.7% as large as the relationship between parental and child mental health. The effect is also large when compared to the link between parental education and child mental health, corresponding to roughly 15% of the association between the two variables. Taken together, the coefficient estimates suggest an important role of peer gender composition in shaping mental health.

The coefficient estimates are stable across different specifications. Column (1) shows the results of OLS regressions without any adjustments or controls. Adding school and cohort fixed effects in columns (2) and (3) yields similar results. To partly address potential selection into school–cohorts across time, column (4) includes school specific linear time trends.

Column (5) then adds individual- and school-level controls. Both additions do not decrease the size of the coefficient estimates. Columns (6) and (7) present our main specifications including school × cohort fixed effects in column (6) as

[21] When not interacting fixed effects with gender, the magnitude of the effect for both genders in specification (7) of Table 1 is around 1.8% ($\beta = 0.79$, $se = 0.34$).

well as controls in column (7). The last two specifications address potential selection across time to school-cohorts. Again, the coefficient estimates are similar to and statistically indistinguishable from the coefficient estimates in less restrictive specifications. The coefficient stability to the inclusion of fixed effects and controls suggests any potential bias because of remaining unobservables is likely small (Oster, 2019).

4.1. Robustness checks and further results

Inpatient and outpatient diagnoses. The outpatient registry covers the vast majority of diagnoses (approximately 92%). This makes sense as most patients with mental health issues enter the system through outpatient referral or get outpatient care after an inpatient stay. In the main specification, we examine the effects on mental health diagnoses using data from the outpatient and the inpatient registers. However, we also separately examine the effect of the share of female peers on inpatient and outpatient diagnoses.

Table D.1 in the Appendix shows the results for the combined inpatient and outpatient data in row 1 (corresponding to the main results), only outpatient data in row 2, as well as only inpatient data in row 3. The results show that outpatient diagnoses are the key driver of the results, including inpatient diagnoses does not strongly affect the results. The coefficient estimates are also positive and large across the board for inpatient diagnoses but less precisely estimated.

Exploiting within-school across-cohort variation. In additional specifications, we exploit only cohort variation rather than classroom variation. We show the results exploiting within-school, across-cohort variation in Table D.2. The overall estimates go in the same direction as the main estimates and are statistically significant. Because of more imprecision in measuring the share of female peers, however, the results are less precisely estimated. Again, as before, the effects for girls are smaller than the effects for boys. Taken together, the additional results confirm that peers affect mental health.

Movers. Individuals who stay in the same neighbourhood do not have an institutional reason to change schools. However, could people who move from one municipality to another drive the result? To examine this concern, we split the sample into those who move across municipalities and those who do not. We define non-movers as students who lived in the same municipality throughout the entire nine-year period of primary schooling as well as the year before the start of primary school. Just under 80% of students do not move across municipalities and therefore likely remain in the same school. The coefficient estimates across the groups do not differ substantially (see Table D.3). This suggests that the results are likely not driven by students changing schools.

Definition of mental health diagnosis. The main outcome variable captures any mental health diagnosis of a student during the last three years of primary schooling. In this check, we examine whether the results are similar when we only examine diagnostic codes observed in the last year of school (see Table D.3). We do not observe significant changes in the direction and the magnitude of the coefficients relative to the alternative definition of a diagnosis. This check suggests that the results are not sensitive to how we define the cut-off for a diagnosis during primary school.[22]

Outliers. One potential concern is that the results might be driven primarily by the tails of the distribution. To examine the possibility of outliers driving the results, we estimate the main specification without the top and bottom 5% of classrooms with the highest share of female peers. In our data, these cut-offs roughly correspond classrooms having a two-to-one gender ratio. Dropping extreme observations results in qualitatively equivalent coefficient estimates (see Table D.3).

5. Persistent effects on mental health

Do the effects on mental health persist? We examine whether peer environment affects student mental health also in early adulthood. To address that, we first show the results of following students up to 13 years after entering primary school, or age 19, when they typically complete high school. We then consider effects in an even longer horizon by following them for additional three years after high-school age.[23] The definition of a mental health diagnosis in both cases is equivalent to the one used for our main results, but pertinent to the corresponding time frame.

High-school years Table 2. shows the effects of compulsory-school gender composition on the likelihood of a mental health diagnosis within three years after completing primary schooling. The specifications therefore test for the persistence of effects even after students switched to a different class in high-school, or to a job. Similarly to the main results, we document robust and large effects of gender composition on longer-run mental health. Boys drive the effect, and, as before, we observe positive but less precisely estimated coefficients for girls.

The estimate in column (7) indicates that a 10 percentage point increase in the share of girls (2–3 peers) in primary school results in an approximately 2.6% increase in the likelihood of a later mental health issue when compared to the incidence of mental health issues at this age of 7.7%. For boys, a 10 percentage point increase in the share of female peers corresponds to a 4% increase in the likelihood of a diagnosis. These relative increases are in the ballpark of the relative

[22] It also suggests that intermittent changes in classroom composition do not play a large role if they occur.

[23] We follow both students who transition to a different high-school class and students who leave school after primary school for up to three years after graduation. In the sample, over 90% of students transition to high-school. Because we examine how students fare up to 3 years after they left primary school, we only have observations for students completing primary school before 2010. The reason for the sample reduction is that students who completed compulsory-school after 2010 are not observable for the whole duration of high school. We show the compulsory-school or more short-run effects for this sample in Table D.4.

Table 2
Gender composition in primary school and later mental health.

	Mental Health Diagnosis [0,100]						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
All Genders (Avg: 7.72)	1.45***	1.36***	1.34***	1.43***	1.55***	1.78***	1.99***
	(0.46)	(0.45)	(0.44)	(0.46)	(0.45)	(0.52)	(0.51)
Males (Avg: 6.4)	1.68***	2.03***	2.02***	2.15***	2.21***	2.41***	2.58***
	(0.54)	(0.53)	(0.52)	(0.54)	(0.54)	(0.62)	(0.61)
Females (Avg: 9.1)	0.68	0.68	0.64	0.78	0.93	1.14	1.36*
	(0.65)	(0.66)	(0.65)	(0.67)	(0.67)	(0.76)	(0.75)
School FE	–	X	X	X	X	–	–
Cohort FE	–	–	X	X	X	–	–
School Trends	–	–	–	X	X	–	–
Controls	–	–	–	–	X	–	X
School × Cohort FE	–	–	–	–	–	X	X
Observations	414,716	414,716	414,716	414,716	414,716	414,716	414,716
Schools	890	890	890	890	890	890	890
R-squared	0.01	0.02	0.02	0.02	0.02	0.04	0.04

Note: The table shows the estimated relationship between the incidence of mental health diagnoses up to 3 years after the end of primary schooling (or approximately age 19, depending on the birth month) and the share of female peers in classroom in primary schooling. The number of observations is lower here since we need to observe students for three more years. Therefore, we only have observations for students completing primary school before 2010. The first row shows the results for the sample with both genders (All Genders). In this specification, we interact all fixed effects and controls with gender. The next two rows show coefficient estimates from separate estimations based on samples including either only males or only females. The number of observations and the corresponding *R*-squared come from the sample including both genders. Controls include parental education, income, and mental health as well as class size, cohort size, and the number of schools in the municipality. Standard errors (in parentheses) are based on clustering at the school level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

increases of mental health issues during primary school. The coefficient estimates are larger in absolute size, which could be because of the higher baseline prevalence or because peer influences take time to manifest. For instance, problems may emerge during primary school but may only be diagnosed later on. Taken together, the results show persistent and sizable impacts of gender peer composition on mental health.

Post high-school years: Ages 19 to 22. The results just above show that mental health is impacted up to the end of high-school, or age 19. We also examine even longer-run outcomes, following primary school students until age 22, well after the end of high school. Table C.1 shows the corresponding results, with the dependent variable being 100 if a student received a mental health diagnosis 3–6 years after completing compulsory schooling or between ages 19 to 22, and 0 otherwise. The results are in line with the main results of the paper. The effects are substantial and statistically significant for boys, while we do not observe pronounced effects for girls. The relative magnitude of the effects is comparable to the one in the main results, relative to the incidence of mental health issues at this age. This result shows that the mental health effects are lasting beyond school.

6. Mechanisms

6.1. Types of diagnoses and self-harm

Diagnosis Type. We examine specific diagnoses in Table 3. The table shows which of 8 diagnostic types drive the main results. We use the main specification including school-by-cohort fixed effects, as well as controls (specification 7 from Table 1) for the estimations.

Based on evidence from psychological and economic literature, it is plausible that peers influence substance abuse incidence and self-harm (Sullivan et al. 2006, Clark and Lohéac 2007, Kremer and Levy 2008, Lundborg et al. 2014, Cawley and Ruhm 2011, Elsner and Isphording 2018, Rees et al., 2020). We could also expect the incidence of diagnoses related to incontinence, habit disorders, and anorexia-related behaviors to be malleable by peers (see, e.g., Rey et al. 1995). The latter diagnoses are part of the "Hyperactivity and Conduct Disorder" category. The hyperactivity and conduct disorders category captures diagnoses related to disturbances of attention or conduct disorders such as disorders of social functioning, and emotional disorders with onset specific to adolescence. Hyperkinektic disorders, such as ADHD, are also in this category. Previous evidence in psychology also mentions the possibility that environmental factors can contribute to the timing of onset or abatement of symptoms of hyperkinectic disorders such as ADHD (Livingstone et al., 2016).[24]

We see that diagnoses related to substance abuse are more common among boys when they are surrounded by more girls. We observe that a 10 percentage point increase in the female peer share increases the likelihood of a substance-abuse

Table 3
Gender composition and diagnosis type.

Diagnosis:	All (1)	Males (2)	Females (3)
Hyperactivity and Conduct Disorder	0.59***	1.21***	−0.05
	(0.19)	(0.30)	(0.22)
Substance-Related Disorder	0.21	0.53***	−0.14
	(0.16)	(0.21)	(0.24)
Depression and Mood Disorder	0.26**	0.21	0.33
	(0.13)	(0.15)	(0.23)
Eating and Sleeping Disorder	−0.02	0.06	−0.10
	(0.11)	(0.07)	(0.21)
Neurotic and Stress Disorder	0.13	0.07	0.20
	(0.15)	(0.17)	(0.25)
Learning and Socialization Disorder	0.17*	0.33**	0.01
	(0.10)	(0.16)	(0.11)
Schizotypal Disorders	0.05*	0.01	0.09**
	(0.03)	(0.03)	(0.04)
Adult Personality Disorder	0.03	−0.01	0.07
	(0.03)	(0.03)	(0.05)

Note: The table shows the estimated relationships between specific diagnosis types and the share of female peers in the classroom conditional on school-by-cohort fixed effects and controls. Column (1) shows the results for the sample with both genders (All). In this specification, we interact all fixed effects with gender. The next two columns show coefficient estimates from separate estimations based on samples including either only males or only females. The dependent variable in each row refers to a specific diagnostic category of ICD-10 codes F00 - F99. The names of some of the categories in the table have been adjusted for easier reference of non-psychological/psychiatric readership. Hyperactivity and Conduct Disorders corresponds to the WHO category Behavioural and emotional disorders with onset usually occurring in childhood and adolescence (F90 - F98); Substance-Related disorders to Mental and behavioural disorders due to psychoactive substance use (F10 - F19); Eating and Sleeping Disorders to Behavioural syndromes associated with physiological disturbances and physical factors (F50 - F59); Learning and Socialization Disorders to Disorders of psychological development. (F80 - F89). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

related diagnosis by 2 percent relative to the average prevalence. Thus, it seems that substance abuse related diagnoses in part drive the effect for boys.

We also find that a similar increase in the share of female peers increases the incidence of hyperactivity and conduct disorders in boys by 0.12 percentage points. Compared to the average prevalence of 2%, this corresponds to a 6% relative increase of hyperactivity and conduct disorders for boys.[25] So, two broad diagnostic categories which are susceptible to the peer environment show substantial increases in the incidence of diagnoses.

When examining the diagnostic categories in more detail in Table E.1, we see that part of the effect we observe in the "Hyperactivity and Conduct Disorder" category is driven by an increase in hyperkinektic disorders such as ADHD. Although the onset and abatement of ADHD can be environmentally driven (Livingstone et al., 2016), part of this effect is likely because of increased discovery rates, a mechanism we discuss in more detail below. However, even when we drop the diagnostic code capturing hyperkinektic disorders from the category, we still observe an increase in the rest of the diagnoses by 6.5% ($p < 0.01$). The reason is that we observe an increase in diagnoses related to incontinence, habit disorders, and anorexia-related behaviors.

The overall pattern of results for boys matches priors based on psychological research: Peer environment mainly affects diagnostic categories intimately linked to peer relationships (Parker et al., 2015; Ackermann et al., 2019).

We also observe that a 10 percentage points increase in the share of girls increases the incidence of learning and socialization disorder-related diagnoses by 0.03 percentage points Table E.1. suggests that this impact comes from the sub-category covering pervasive developmental disorders, which include autism and asperger. These diagnoses have (almost) exclusively genetic origins, so for this diagnostic category it is likely that discovery rates among boys increase.

For girls, the positive coefficients on depression and mood disorders, neurotic and stress disorders, learning and socialization disorders, as well as schizotypal disorders, seem to provide an explanation for an estimated positive impact on overall mental health diagnoses. In addition, we see some indication that depression and mood disorders are more common with a higher share of female peers.

Self-harm. In addition to typical diagnostic codes capturing mental health problems, we estimate the effect of the share of female peers on the incidence of self-harm. The incidence of intentional self-harm is much lower than the incidence of mental health issues, so the results have to be interpreted with caution.[26] We consider this check useful to examine whether the higher incidence of mental health diagnoses also reflects actions related to self-harm. The results in Table E.2 suggest

[24] While these disorders do have a genetic component, a substantial part of the variation of up to over 50% in prevalence across individuals can be traced to environmental factors in late childhood and adolescence (Rhee and Waldman, 2002; Burt, 2009; Livingstone et al., 2016; Wesseldijk et al., 2018; Fairchild et al., 2019).

[25] Table A.1 shows the average incidence across categories.

[26] To examine the effects on intentional self-harm we use the ICD-10 codes X60 to X84. Naturally, there is a statistically significant relationship between mental health diagnoses and intentional self-harm ($\beta = 0.45$, $se = 0.02$).

that it is not only the diagnostic incidence of mental health problems that increases among boys, but also the likelihood of actions related to self-harm.

The impact of the gender composition on self-harm in boys is positive, relatively large, and statistically significant across the board. A 10 percentage point increase in the share of girls leads to a more than 8% increase in the incidence of intentional self-harm. The magnitude of the effects is stable across specifications. The point estimates for girls are negative, but not statistically significant and decrease with more restrictive specifications. The results are broadly consistent with the mental health findings that show statistically significant effects of female peers on boys and imprecisely estimated effects on girls.

Based on the results in Tables 3, E.1, and E.2, the most affected diagnoses among boys are: intentional self-harm; substance abuse; other hyperactivity and conduct-related disorders such as incontinence, habit disorders (e.g., hair plucking), and anorexia-related disorders; hyperkinectic disorders; and pervasive developmental disorders. The symptom incidence of at least the first three diagnostic categories are likely to be closely tied to peer environment.

6.2. Friendship constraints and educational attainment

Friendship constraints. A straightforward explanation for the impact on diagnoses linked to peer relationships is friendship formation. Having fewer same-gender peers in the classroom limits the number of potential friends.[27] Anelli and Peri (2019) present evidence consistent with this argument: Boys who went to school with more boys tend to be more likely to choose the same college major, but the same does not hold true for girls.

We find corroborating evidence for this channel in our data. We test whether peer gender composition has a relationship with the number of cohort-mates that one retains in their specific track in high school. The results are shown in Table E.4. Having more peers of one's own gender leads to a higher likelihood to having more students in the cohort of ones' high-school track who were in the same primary school class. This suggests that gender composition of the peer group at that stage plays a role in friendship network formation. Consistent with Anelli and Peri (2019), we find that the effects are larger for boys. An impact on friendship networks could partially explain why we find more pronounced mental health effects for boys.

Educational Attainment, Classroom Ability, Relative Rank, and Classroom Mental Health. One further possible mechanism could be that peer gender composition affects compulsory-school grades, which, in turn, affect mental health. We see that boys perform worse in classes with more girls and girls perform better (see Table E.5). For boys, the coefficient is −0.25 and the standard error 0.03. Also, boys are substantially more affected than girls. The results suggest that educational attainment may be partly responsible for the mental health effects.

We also examine below how much coefficients change when we account for grade levels or grade ranks. Since grades are endogenous, the following results have to interpreted with caution. They indicate the residual variation in mental health that can be explained by the classroom gender composition conditional on the variation explained by grade levels and ranks. Ultimately, it is not possible to fully establish whether grades are a direct outcome of gender composition, a mechanism for mental health outcomes, or the consequence of worse mental health. However, the results indicate how sensitive the relationship of gender composition with mental health is when we account for variation driven by grades.

Doing naive accounting of the variation by simply controlling for compulsory grades reduces the effects of peer composition on mental health by up to 50% (see Table E.6). Thus, there seems to be an important link between the two, but the link between mental health and educational attainment does not fully explain the link between gender peer composition and mental health.

We also test the possibility that average ability approximated by grades in the classroom explains the effects in Table E.7. Controlling for average grades in the rest of the classroom does not explain the effects. Neither does controlling for average mental health in the classroom.

Previous literature has shown that the ability rank of students affects their mental health and risky behaviors (Elsner and Isphording, 2018; Kiessling and Norris, 2020). If ability was correlated with the gender composition, this could affect the interpretation of our results. In Table E.8, we show estimates when controlling for the grade level of the student and for the grade rank of a student in the classroom. The results remain similar. Note that these results need to be interpreted with caution since both grade rank and level were determined concurrently. Note also that parental ability as proxied by education and income does not correlate with gender composition. While ability rank is clearly an important driver of mental health generally, it does not seem to be the primary driver of the effects we find. Taken together, key peer characteristics other than gender are likely not responsible for the results.

6.3. Bullying

A key reason for why mental health diagnoses related to peer relationships could increase is bullying. Bullying has large negative consequences for mental health (Klomek et al., 2015; Rees et al., 2020), and it reduces educational attainment

[27] Same-gender friendships are considerably more common than opposite-gender friendships in adolescence (see, e.g., Hill 2015). Naturally, having friends is critical for well-being (see, e.g., Parker and Asher 1987, Bond et al. 2007, Ho 2016). Large friendship networks are particularly important for boys (Benenson et al., 1997; Rose and Rudolph, 2006).

(Ammermu¨ller, 2012; Eriksen et al., 2014). Differential levels of physical and psychological bullying in classes with more females could therefore provide an explanation for the results.

Physical Bullying. Using survey data, Lavy and Schlosser (2011) find that a higher proportion of girls in the classroom is related to less fighting. Lee et al., (2014) and Giardili (2020) also observe that single-sex schools are associated with fewer self-reported bullying incidents for both sexes. Thus, the previously documented impact cannot explain our results. The reason is that if bullying decreases in classrooms with more girls, we would expect a *decrease* rather than an *increase* in mental health problems.

We examine the role of bullying in our setting. To this end, we study the impact on physical assault and injuries. Table E.9 shows the corresponding results.[28] We do not find a statistically significant impact on assault. This may be because of a very low incidence of assault in the data. In contrast, we estimate a statistically significant and substantial reduction in physical injuries for boys and girls. The latter result is in line with previous evidence. More girls in the class seem to, if anything, reduce physical harm. This reduction in physical harm is at odds with the documented mental health effects.

Psychological Bullying. A large literature suggest that boys and girls engage in different types of aggression (Lagerspetz et al., 1988; Björkqvist et al., 1992; Crick and Grotpeter, 1995; Card et al., 2008; Smith et al., 2010). A key finding of the literature is that conventional measurements of aggression tend to overlook indirect forms of aggression usually aimed at undermining reputation.

The indirect form of aggression, also called relational aggression, seems to be more commonly used by girls (Lagerspetz et al., 1988; Björkqvist, Lagerspetz and Kaukiainen, 1992; Crick and Grotpeter, 1995; Card et al., 2008; Smith et al., 2010). Like direct aggression, relational aggression is linked to a worse school environment (Goldstein et al., 2008) and peer difficulties (Cillessen and Mayeux, 2004). It is also related to higher anxiety levels (Loukas et al., 2005), loneliness and depression (Crick and Grotpeter, 1995), increased drug use (Sullivan et al., 2006), and has intimate links to mental health (Ackermann et al., 2019). Intriguingly, boys seem to be more affected by psychological bullying (Crick and Grotpeter, 1996; Goldstein et al., 2008; Williams et al., 2009).

Previous literature thus suggests that having more girls in the class increases the incidence of psychological bullying with likely negative consequences for mental health, particularly among boys. Psychological bullying could therefore explain part of the documented relationship between peers and mental health.

6.4. Increased discovery rates

One potential explanation for our findings could be that gender composition affects the discovery of mental health problems. For instance, it may be that girls are more observant and therefore mental health problems are discovered more quickly. For some diagnostic subcategories, such as hyperkinectic disorders and pervasive developmental disorders, increase discovery rates are a likely explanation.

However, based on an overall look at the results, it seems unlikely that changing discovery rates are the sole explanation for our findings. First, the impact on self-harm among boys suggests an actual increase in mental health problems. Second, girls and boys are affected differently. If discovery rates are higher with more girls, the incidence in diagnoses among girls should also increase.

Third, if discovery rates were higher, the coefficient estimates would likely not be positive for inpatient diagnoses as problems are discovered earlier in classes with more females. In turn, the overall estimated impact using inpatient and outpatient diagnoses jointly may be lower than when just using outpatient diagnoses. However, the point estimates for inpatient diagnoses are positive, and the overall estimated impact is similar when comparing the outpatient results to the combined results for inpatient and outpatient data.[29]

Fourth, we also find that the number of different unique diagnoses increases slightly only for boys, which seems less consistent with teacher discovery that are likely based on one very salient diagnosis (see Table E.3). Fifth, we do not observe heterogeneity depending on the socioeconomic status of the parents (see Section 6.6). If reporting were an issue, it seems likely that the impact on mental health diagnoses would vary by parental characteristics. For instance, if there is underreporting among children from low socioeconomic status backgrounds, there should be a relative increase in mental health diagnoses when there are more girls in class. Similarly, children of parents with mental health issues may have higher discovery rates, but we do not see statistically significant differences across children of neurodiverse and non-neurodiverse parents.

Finally, even when controlling for mental health status up to and including grade 6, the coefficient estimates remain intact. It seems likely that teachers would discover severe mental health issues with some probability already in earlier years. In addition, we observe that the impact of gender composition on mental health last even beyond high-school years. While we cannot rule out higher discovery rates as an important factor for our findings, some of our results are at odds with higher discovery rates as the sole explanation.

[28] Roughly 0.22% of students in our sample experience physical assault and roughly 22% any kind of physical injury.

[29] Note that this argument depends on the nature of those marginal cases. It is also possible also that marginal and early detected cases are less likely to require inpatient treatment.

6.5. Impacts across the distribution of the share of female peers and potential implications for policy

Table D.5 shows the impact of the share of female peers for boys and girls across quintiles. The effect on boys is most pronounced for when the share of girls is higher than 50%, when the classrooms are female-dominated.

For a policy maker only interested in minimizing mental health consequences of the peer environment, a potential implication from these results is to balance classrooms. The results from examining the impact of different quintiles of the peer distribution suggests it as a potential way to minimize negative mental health effects. Such policy implication, however, is based on assuming that the policy maker is only concerned with mental health implications.

In practice, however, the effects of the peer environment are multidimensional. For instance, Table E.5 shows that girls benefit in terms of grades from having more girls around them. So, it is important to keep in mind that changing the peer environment will likely affect multiple outcomes.

Considering only grades and mental health, one further option for policy-makers might be to offer certain courses as single-gender courses to alleviate concerns about friendship constraints and mental health for boys in female-dominated classes, while at the same time benefiting girls' grades.

6.6. Further mechanisms

The role of parents. We discuss further mechanisms which could contribute to the observed effects. Table E.10 shows heterogeneity in effects for students by parental characteristics. We estimate a large level difference relative to the baseline effect for students who have a parent with a mental health diagnosis when compared to those without. Having at least one parent with a mental health diagnosis substantially amplifies the effect of having many female peers in the classroom, but the coefficient estimate is not statistically significant. The coefficient estimates for parental education background and income level are small and statistically imprecisely estimated. Accordingly, parents do not seem to play an important role in how children's mental health reacts to classroom composition.

Teacher–student relationships. There are other environment-related mechanisms that could be responsible for the results. For instance, having more females in the cohort is linked to better teacher-student relationships (Lavy and Schlosser, 2011; Giardili, 2020).[30] However, previous results do not correspond to the mental health effects we observe. Based on these results, we would expect that more girls improve mental health among girls and, potentially, boys.[31] Yet, another potential explanation for our findings could be that teachers in female-dominated classes have a much better relationship with female students and that male students feel left out. If this pattern does not occur to the same extend in male-dominated classrooms, boys may suffer relatively more from being around more girls than vice versa .

7. Conclusion

Previous research has demonstrated the importance of early mental health for adult mental health and economic well-being (Currie and Stabile, 2006; Currie et al., 2010; Salm and Schunk, 2012; De Neve and Oswald, 2012; Lundborg et al., 2014). But what drives adolescent mental health? We show that the classroom composition—as captured by the gender composition—has a large and persistent effect on mental health.

To this end, we use a unique data set which combines classroom gender composition and mental health diagnoses. We find that a higher share of female peers increases the likelihood of mental health problems, particularly among boys. These effects are large and persist into adulthood. The results highlight that peer relationships are crucial in shaping well-being.

We find that the mental health diagnoses which are affected are the ones with close ties to peer relationships according to psychological and economic research. The likelihood of diagnoses related to conduct disorders and substance abuse increase. We further examine potential reasons for peer relationship by discussing friendship constraints, educational attainment, and bullying. We conclude that boys having stronger constraints on friendship networks, lower educational attainment of boys, and a higher incidence of psychological bullying in classrooms with more females might offer explanations for the decrease in mental health.

The results indicate that compulsory-school environment has a substantial causal impact on mental health and therefore reinforce calls for early life policy interventions. It is likely that interventions geared at improving mental health early on during primary school could have a disproportionate positive impact on later life well-being. Based on our results, one intervention could be focusing more strongly on achieving classroom balance in gender composition.

Declarations of Competing Interest

None.

[30] Note that selection of teachers on school–cohort level should not affect our estimates as we consider within-school variation.

[31] Another concern may be that teachers refer students to psychiatric services. As far as we are aware, there is no standardized process in place for teacher referrals.

Supplementary materials

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jebo.2022.03.014.

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