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Social media use and depressive symptoms among United States adolescents

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Abstract

Purpose—Depression is increasingly common among US adolescents; the extent to which social media exposure contributes to this increase remains controversial.

Methods—We used Monitoring the Future data from 8th and 10th grade students (n=74,472), 2009–2017, to assess the relationship between daily social media use and depressive symptoms. Self-reported depressive symptom score (range: 4–20) was assessed continuously using a log-transformed outcome and at varying cutscores with logistic regression analyses. First, these outcomes were examined overall, comparing adolescents using social media daily to adolescents who were not. We then estimated predicted depressive symptom scores using 26 predictors in order to establish underlying depression risk. We partitioned students into depression risk quintiles to control for confounding due to underlying depression risk and examine heterogeneity in the association between social media use and depressive symptoms. Sensitivity analyses were used to test the robustness of results with different configurations of the predicted score model, and overall associations were examined in two-year groups to identify differences in effects.

Results—For girls, in adjusted risk-stratified analysis, daily social media use was not associated with high (vs low) depressive symptoms. For boys, results were inconsistent, suggesting a

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protective effect of daily social media use at some cutscores. Results were consistent across sensitivity analyses, and any potential harmful effects appear to be limited to 2009–2010, limiting the evidence supporting social media as a current risk factor for depressive symptoms.

Conclusions—Among US adolescents, daily social media use is not a strong or consistent risk factor for depressive symptoms.

Keywords

Adolescent Development; Depression; Epidemiology

Introduction

After almost 50 years of stability [1], recent evidence has indicated unprecedented increases in adolescent depression [2], depressive symptoms [3], and suicidal behavior [4], particularly among girls. There has been widespread speculation that increasing use of smartphones and social media has contributed to these trends. Proponents of this hypothesis note that adolescents are increasingly isolated from face-to-face interaction [5–7], experience cyber-bullying [8], and face challeges to self-esteem and self-worth through curated online images of peers [9]. These negative effects of social media affect girls more than boys [10], plausibly explaining why trends in mental health problems have been more prominent among girls and underscoring the need to examine potential gender-specific effects. On the other hand, social media is often a positive outlet [11], and its use may have positive effects on adolescent self-esteem [12]. Social networking sites help as a resource for self-affirmation [13], and provide a space for content that is positive or humorous, particularly valuable to adolescents who are depressed [14]. Many young people seek out support and advice on social media, particularly those with moderate to severe depressive symptoms, twice as likely to use social media for these emotional resources compared to peers [15]. Thus, the relationship between social media and mental health remains unresolved.

Several nationally-representative [16,17] studies and other large samples [18,19] have documented a small association between amount of digital technology use, including social media, and depressive symptoms. Other survey studies [20] and detailed time-use diary studies [21] have reported no relationship between social media and depression symptoms. Orben & Przybylski (2019) found that the specification of variables capturing digital technology use, adolescent well-being, and confounders could potentially result in myriad effect sizes, with the most likely association being exceedingly small and explaining only a small portion of well-being variance [22]. These divergent findings may be partially due to not accounting for underlying mental health risk, which might influence patterns of social media through reverse causation, and residual confounding. Adolescence marks a period of social changes that may affect health and behavior in a manner related to depression and social media use, such as school attitudes and performance, peer relationships, and family environment. Not accounting for these factors may bias estimates of the effect of social media use on risk of depression.

Typically, multi-variable regression modeling is used to control for confounding. However, parameter estimates can become unstable as the number of covariates increases [23]. Alternatively, outcome risk scores may be used to avoid this issue. Outcome risk scores are the predicted probability of having the outcome, conditional on a set of well-established predictors, in this case depression [24]. This provides an estimate of a given adolescent's underlying depression risk. Using these predicted scores, adolescents with similar predicted depression risks can be compared with one another. This limits the extent to which it could be argued that it is underlying depression risk influencing social media use, rather than the causal direction of interest where social media impacts depressive symptoms. While self-reported symptoms give a direct snapshot of adolescent mental health now, outcome risk scores help to articulate underlying mental health risk, control confounding strongly, and provide an unbiased and transparent estimate of the relationship between social media use and depressive symptoms. Such analyses are particularly important in the conext of social media and depression.

Whether social media use puts teens at risk for depressive symptoms is a critical policy-relevant question, and evidence thus far has been mixed. We draw on nationally-representative data, collected from 2009 through 2017, of US 8th and 10th grade students to examine the association between social media use and depressive symptoms among adolescents. These analyses contribute new knowledge by using outcome risk scores to examine underlying risk for depression, and stratifying adolescents based on this risk. These analyses introduce strong methods to address confounding in a large, nationally-representative sample. This, in conjunction with the ability to account for heterogeneity over time and multiple sensitivity analyses, allows for the rigorous examination of this important and controversial potential risk factor for adolescent depressive symptoms.

Methods

The 2009 through 2017 Monitoring the Future (MTF) surveys included an annually conducted nationally-representative cross-sectional survey of school-attending adolescents [25]. These data are de-identified and publicly available. Schools were selected under a multi-stage random sampling design and are invited to participate for two years. Schools that declined participation were replaced with schools with similar geographic location, size, and urbanicity. The overall school participation rates (including replacements of schools that decline to participate) ranged from 91% to 99% for all study years. Student response rates have ranged from 85.0% to 87.3%, and averaged 86.5%, with no systematic trend. Almost all non-response was due to absenteeism; less than 1% of students refused to participate. Self-administered questionnaires were given to students. The Institutional Review Boards of University of Michigan and Columbia University approved the study protocol and analytic aims, respectively. Parents were informed of the study and provided the option to decline participation on their child's behalf. The final analytic sample included 74,472 respondents.

Students filled out a "core" questionnaire, and then were randomized to a "subform" with unique content. We restricted analysis to the subforms in which key study variables overlapped. There were subforms with both social media and depressive symptom questions for 8th and 10th grade students. The years 2009 through 2017 were selected as these were the

years where both social media and depressive symptom items were available and overlapped on subforms.

Social media use was assessed with the following question: “How often do you do each of the following? Visit social networking Web sites like Facebook, Twitter, Instagram, etc.” For 8th and 10th grade students, social networking items included examples of Myspace and Facebook from 2008 to 2011, and only Facebook from 2012 onward. Response options ranged from “Almost every day” to “Never”, with intermediate options of “At least once a week”, “Once or twice a month” and “A few times a year”. We controlled for survey year in all analyses, accounting for changes in question wording. We dichotomized social media use as daily versus non-daily use. The number of adolescents in these intermediate categories of social media use is quite small relative to those using social media daily, which contributed to our decision to collapse the groups outside of daily social media use. This dichotomization was hypothesis-driven: given how increasingly prevalent and important social media is becoming in adolescents’ lives, the dichotomization of social media use into daily versus non-daily aimed to capture two distinct patterns. Either social media is engrained into an adolescent’s daily life and activities as a personally important means of socializing, or not. Knowing how quickly social media use is increasing among adolescents, daily use has become the norm. Our binary variable, then, distinguishes between adolescents who operate within that norm, and those who do not, regardless of the specific frequency of their non-daily use.

Four items were used to measure depressive symptoms, 1 (Disagree) to 5 (Agree) after the stem question “How much do you agree or disagree with each of the following statements”: “Life often seems meaningless”, “The future often seems hopeless”, “It feels good to be alive”, and “I enjoy life as much as anyone”. The latter two questions were reverse coded for analysis. These items are derived from the Bentler Medical and Psychological Functioning Inventory’s depression scale [26] which exhibits strong reliability (.72) in adolescent samples [27].These items have been used to assess depressive symptoms in previous studies of these data [28,29], and have good reliability in this analytic sample (Cronbach’s alpha range: 0.77 (2009, grade 8) to 0.85 (2017, grade 10)). Scores were summed to create a total score. Respondents missing data on one of the four items (2.3%) were imputed with the mean value of the other three; respondents missing data on two or more of the four items (11.7 %) were excluded from the analysis. Scores ranged from 4 to 20 with a mean of 7.67 (SD=3.86) and a median of 7.0, indicating that the mean and median scores were close to the “disagree somewhat” response (2 on the response scale).

Depressive symptom scores were highly right-skewed, did not meet normality assumptions for linear models, and alternative models including negative binomial, cumulative and generalized multinomial did not achieve sufficient model fit and convergence for reliable estimation. Given this, we log-transformed scores to assess the association between social media and continuous depressive symptoms and created dichotomies of depressive symptoms to assess associations with “high”, relative to other adolescents, depressive symptoms. Given that there is no empirically validated clinical cutscore, we used a range of potential cutscores, including > 9 symptom score (25.0% of boys; 30.6% of girls), >10 (20.3% of boys; 25.3% of girls), >12 (9.0% of boys; 14.6% of girls), and >15 (3.7% of boys;

6.4% of girls). These correspond to approximately the 75th, 90th, and 95th percentiles, with >9 and >10 serving as the closest cutscores on either side of the 75th percentile.

Predicted probability of high depressive symptoms.

We created an outcome prediction model that estimated the probability that an adolescent had high depressive symptoms, dichotomized at >10 (i.e., 75th percentile).

To build the model predicting high depressive symptoms, we considered 97 items from the MTF surveys known to be associated with depressive symptoms. Of these, 26 items with moderate to high correlations (>0.10) were retained (see Appendix Table A1 for all items). Each individual's predicted probability of meeting the depressive symptom cutpoint was estimated using logistic regression, which demonstrated adequate prediction (McFadden's adjusted pseudo-R^2=0.55)[30] and excellent accuracy in predicting observed high-depressive symptom status (AUC=0.95). We then categorized the predicted probabilities of depression into five groups, based on ascending risk of high depressive symptoms. The thresholds for each category were created using established covariate balancing methods. Within each risk group, none of the covariate means differed between those with and without the outcome. These methods constitute a broader strategy of risk stratification, allowing for more efficient control of observed confounders than regression-based approaches [31,32], and are a better alternative to propensity score estimation when covariates are not highly correlated with the exposure [33]. Prediction models and covariate balancing [34] were implemented in R version 3.5.1. Unadjusted and adjusted mean differences in prediction model covariates are provided in Figure 1.

We included a range of covariates in the depression risk stratification models, adjusting for central sources of confounding including race/ethnicity, grade, parental educational attainment, urbanicity, academic performance, year, and subform of the MTF questionnaire assigned to the student (Appendix Tables A2, A3). The model distinguished between groups with different underlying risks of depressive symptoms. For instance, when self-reported depressive symptom score is dichotomized at the lowest cutscore used (>9 symptom score), 10.8% of girls and 9.0% of boys with the lowest depression risk exhibit high depressive symptoms, and 97.7% of girls and 98.1% of boys with the highest depression risk exhibit high depressive symptoms.

We replicated the predicted depression score at a cutscore at the 90th percentile as a sensitivity analysis, to represent very high levels of depressive symptoms. We also conducted a separate sensitivity analysis at the original dichotomization of >10 but removing potential symptoms of depression from the predictive model, specifically self-esteem, self-derogation, and daily social media use, to ensure that the inclusion of these items did not restrict the range of outcomes and bias results toward the null.

Statistical analysis.—After estimating predicted depression risk scores, we conducted regression analysis to determine the association between daily social media use and depressive symptoms: a) adjusted and unstratified by depression risk category, and b) adjusted and stratified by depression risk category. For dichotomous outcomes we used logistic regression. For the analysis of depressive symptom score as a continuous outcome,

we used linear regression after log transformation. We also examined the interaction of social media use and year, to examine whether the effects of social media use have changed as it has become more prevalent in this population.

Results

Figure 2 shows the trend from 2009 to 2017 in daily social media use among 8th and 10th grade students. The prevalence of daily social media use increased from 61.0% to 89.0% among girls, and from 45.8% to 75.3% among boys.

When considering potential confounders, associations were inconsistent in both direction and magnitude. Among girls (Table 1), when considering depressive symptoms continuously, there was a positive association between daily social media use and an increase in mean symptoms (β=0.018, 95% CI: 0.004, 0.031) after controlling for potential confounders, but when stratified by depression risk, the association persisted only in the lowest depression risk category (β=0.020, 95% CI: 0.008, 0.032). When examined by cutscore, there were no overall associations between daily social media use and depressive symptoms, and only one (protective) association between daily social media use and depressive symptoms score >10 among those with a middle-low depression risk (OR=0.81, 95% CI: 0.66–0.99). Tests of interaction between predicted risk score and daily social media were null for all cutscores.

Among boys (Table 2), while there was evidence of an overall protective effect of daily social media use on depressive symptoms for two out of four symptom cutscores, these associations were largely attenuated within strata of depression risk. Boys in the second lowest depression risk stratum were at increased risk for depressive symptoms >9 (OR=1.23, 95% CI: 1.02, 1.49), the broadest category of depressive symptoms considered. Similarly, boys with moderate depression risk were at an increased risk of depressive symptoms >12 (OR=1.42, 95% CI: 1.13, 1.78). Boys in the lowest depression risk category, however, were at decreased risk for depressive symptoms >12 (OR=0.77, 95% CI: 0.62, 0.96); there was also evidence of a decrease in risk at the highest depression risk category, but small sample size resulted in wider confidence intervals. There was no association between social media use and depressive symptoms when depressive symptoms were considered continuously after controlling for potential confounders, across any risk category. Tests for interaction between daily social media use and depression risk were largely null, and the exception was variation in odds ratios at a cutscore score of >12 (chi-square for interaction: 13.01, $p<0.01$).

As a sensitivity analysis, we replicated the predicted depression risk score at the 90th percentile. Given the small number of adolescents at high levels of depressive symptoms at this cutscore, models did not converge for many estimates. However, at lower levels of predicted depression risk, model estimates were in the same direction and general magnitude of model estimates when predicted depression risk was at the 75th percentile.

As a separate sensitivity analysis, we utilized a predicted risk score based on a model without possible symptoms of depression. The association between daily use of social media and depressive symptoms for any binary depressive outcome was null within every category

of predicted risk score for both boys and girls. Among girls, when depressive symptom score was considered continuously within predicted risk categories, daily social media use was associated with increased depressive symptoms among girls in the lowest predicted risk category only (β=0.019, 95% CI: 0.006, 0.031),

Finally, we examined the interaction between year and daily social media use. We examined year as both a continuous and a categorical variable in two-year groups up to 2017, and then 2017 as a single year. Among girls, when depressive symptom score was considered continuously, daily social media use was associated with increased depressive symptoms in 2009–2010 (β=0.027, 95% CI: 0.009, 0.045), but not in other years. Thus, there was no evidence of a consistent association across years; one statistically significant association across all years tested is indicative of an inconsistent and weak signal.

Discussion

The extent to which social media use is a risk factor for depressive symptoms among teens is a critical question in the literature, with past results being equivocal. We found that among adolescents in the United States, daily social media use is not a consistent risk factor for depressive symptoms. The most consistent association observed across main and sensitivity analyses indicated that girls who had the *lowest* risk for depression had increased depressive symptoms with daily social media use, though this was only seen in the log-transformed continuous depressive symptom score outcome, not the binary outcomes. However, it should be noted that girls in this group typically had almost no other risk factors for depressive symptoms. Among boys, daily social media use was not consistently related to increased depressive symptoms. These results run contrary to the popular narrative that social media is significantly harmful to adolescent mental health.

Findings are consistent with a growing body of evidence demonstrating that social media use is not a risk factor for adolescent depressive symptoms. These results stand in contrast to descriptive analyses, including those previously reported from these data [7]. Our results suggest that, in the face of other known risk factors for adolescent depression, the risk conferred by social media use is not meaningful. Among adolescents with the lowest risk of high depressive symptoms, daily social media use was associated with depression risk, although a low number of adolescents were affected given the rarity of developing high depressive symptoms in this group.

Among boys, there were more associations, albeit small, with social media inversely related to depression. Girls online appear to be more likely than boys to experience negative emotions, given gender-based harassment and bullying [35], as well as greater salience of social networks that online engagement can facilitate, creating further isolation during periods of conflict with friends [36]. The suggestion of increased risk for girls, but not boys, is consistent with gender differences in coping and stressor response in relation to depression. Gender differences in response styles may become evident during adolescence and girls are more likely to use ruminative coping and response styles [37], that include repetitive or frequent negative thinking, and internal versus external attribution of negative experiences [38], which can increase the risk of depressive symptoms.

The present study is strengthened by the use of US nationally-representative data, which increases generalizability of the findings. Stratifying by year allowed for examination of potential trends in these associations. The analytic approach accounted for potential bias due to unmeasured confounding. Some of the differences in the results of various studies using MTF data may have arisen from improper application of methods that rely on an assumption of normality to non-normal depressive symptom scores, or failure to account for selection and confounding. We found that depressive symptom scores did not meet basic standards for distribution normality, and thus did not include estimates of explained variance, as has been provided elsewhere [16,22].

Nonetheless, several limitations are notable. Daily social media use does not capture the diverse ways in which adolescents use social media, which may be both positive [11,13,15] and negative [5,6,9] depending on the social context. We only were able to assess 8th and 10th grade students, and results may vary among older or younger respondents or youth who are not in school. We potentially underestimated effects of social media on depressive symptoms, as depression is linked to adolescent absenteeism and these students are not represented here [39]. Differences between these absent and present students are uncertain. It is worthwhile to recognize that the role and nature of social media vary over time, though in our sensitivity analyses, any harmful effects were in 2009–2010, so this recognition of heterogeneity over time supported our conclusions that currently social media is not a strong risk factor for depressive symptoms. Depressive symptoms are not diagnostic and therefore of uncertain clinical importance. We also lacked information on whether adolescents had received treatment for mental health problems. However, trends in depressive symptoms were consistent with other national sources with information on depressive episodes and suicide-related behavior [2,4], underscoring that these measures correlate with other meaningful indicators of adolescent mental health. Further, a minority of individuals with depression receive treatment [40], suggesting that treatment is unlikely to have a large impact on the symptom scores in our sample. A strength of our depressive symptom measure is the identical wording and placement of questions across the years of data collection. Given the cross-sectional nature of these data, we were unable to establish temporality needed to rule out reverse causation, and estimate incident depression symptoms. Given that the magnitude of model estimates was very low, this is unlikely to be a large concern. Still, many strengths from this study, like the large sample size, nationally-representative sampling, and use of outcome risk scores and stratification to control confounding due to underlying mental health risk, should be applied to future studies with longitudinal designs and more nuanced social media items to strengthen results.

Conclusion

Technologies emerge in each generation that change how adolescents interact, including most recently smartphones and social media. Assessing the potential impact of new technologies on adolescent mental health is a critical part of understanding how these tools are used, and in communicating clinical messages to adolescents and parents with a solid empirical foundation. At present, there is not compelling evidence to suggest that social media use meaningfully increases adolescents' risk of depressive symptoms.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Disclosure

Study sponsors had no role in the study design, collection, analysis, or interpretation of data, the writing of the report, or the decision to publish the manuscript.

All authors contributed to the initial draft.

Kreski, Platt, Rutherford, Odgers, and Olfson have nothing to disclose.

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Dr. Keyes has testified as an expert witness in litigation against opioid manufacturers and other defendants.

Abbreviations:

MTF	Monitoring the Future

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Implications and Contribution

By using risk stratification and stronger control of confounding, these rigorous analyses thoroughly examine the association between social media and depressive symptoms in a nationally-representative sample of adolescents, finding that contrary to the popular narrative, daily social media use is not a strong or consistent risk factor for depressive symptoms.

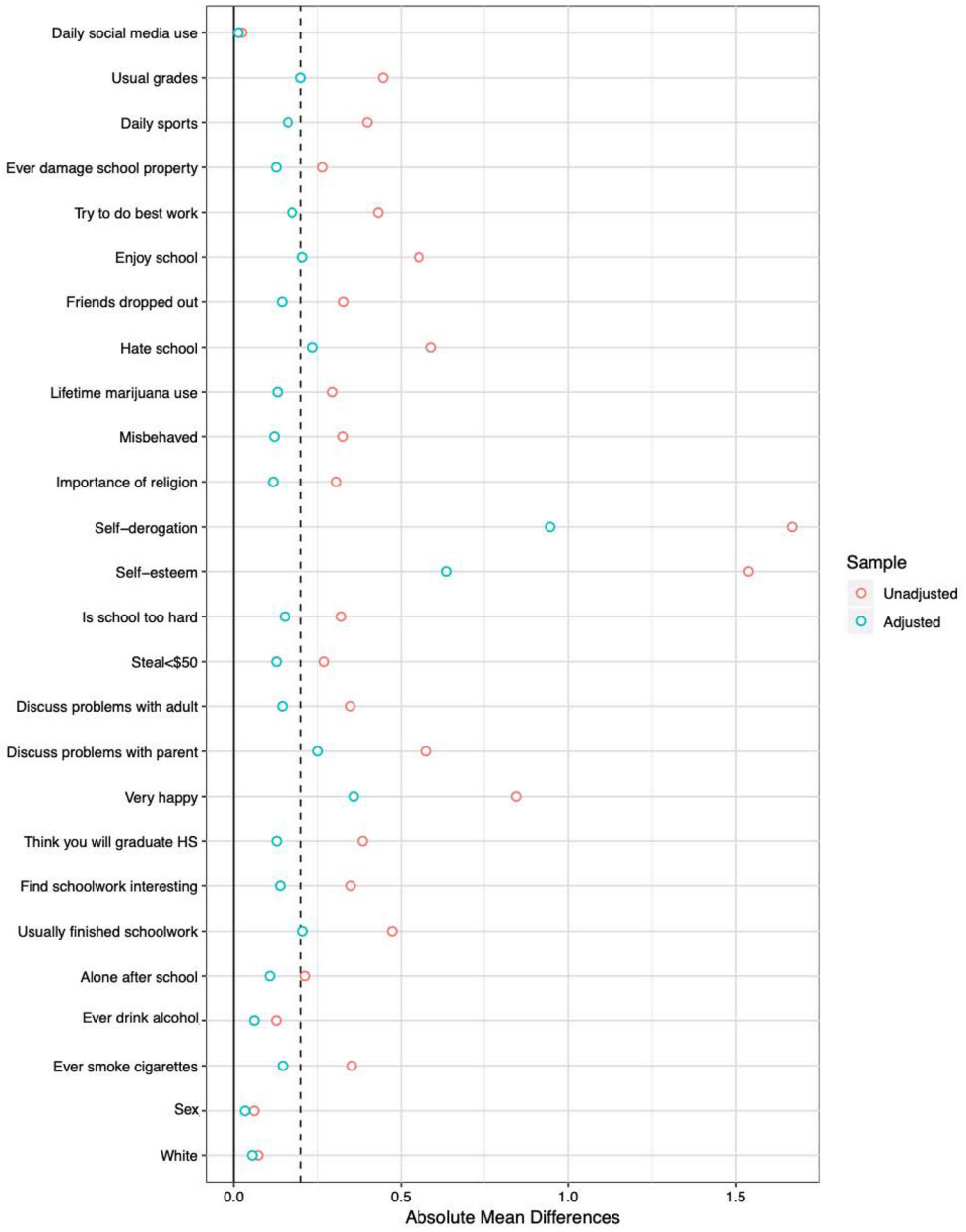

Figure 1:

Covariate Balancing Across Five Subsets– This visualizes the covariates that fed into covariate balancing and the extent to which they vary between groups

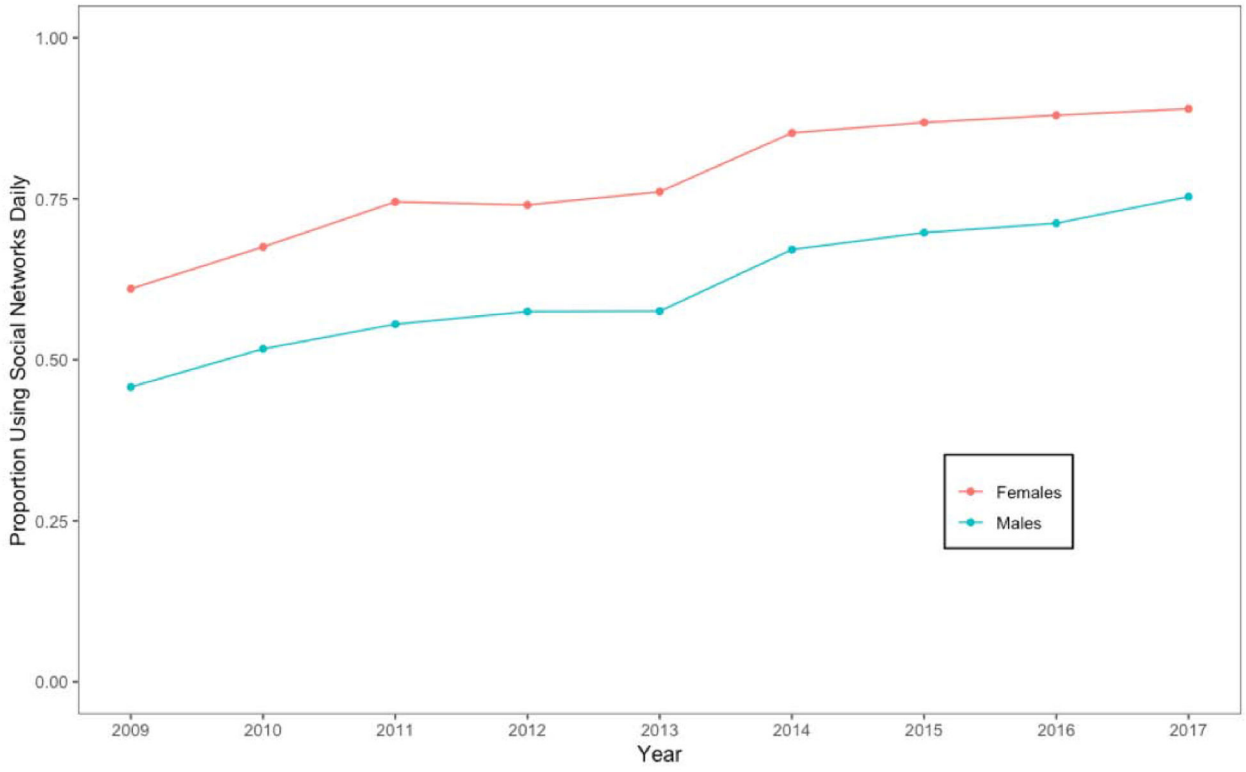

Figure 2:

Daily use of social network sites over time, by sex, 8th and 10th grade - This plots trends by sex in the proportion of students using social media daily

Table 1.

Association between daily social media exposure and depressive symptoms[a] among girls, stratified by risk for depressive symptoms based on existing risk factors, 2009–2017[b]

Association between daily social media and depressive symptoms at different cutscore of Depression Score (Odds Ratio, 95% CI)						
	Depression risk					
Cutscore	**Low**	**Middle-low**	**Moderate**	**Middle-high**	**High**	**Overall**
Score > 9	1.07 (0.97, 1.18)	0.85 (0.68, 1.06)	0.88 (0.65, 1.17)	1.04 (0.73, 1.49)	0.64 (0.29, 1.44)	1.03 (0.97, 1.09)
Score > 10	1.06 (0.94, 1.20)	0.81 (0.66, 0.99)	0.89 (0.69, 1.14)	1.09 (0.80, 1.47)	0.74 (0.39, 1.38)	1.01 (0.95, 1.08)
Score > 12	0.99 (0.78, 1.24)	0.83 (0.65, 1.07)	1.00 (0.79, 1.26)	1.13 (0.90, 1.41)	0.94 (0.64, 1.38)	1.02 (0.94, 1.10)
Score > 15	--[c]	1.02 (0.53, 1.93)	1.40 (0.86, 2.27)	0.79 (0.61, 1.03)	1.12 (0.88, 1.43)	1.07 (0.96, 1.21)
Linear Estimates for log transformed depressive symptoms (Beta, 95% CI)						
	0.020 (0.008, 0.032)	−0.029 (−0.057, −0.002)	−0.016 (−0.046, 0.014)	−0.010 (−0.021, 0.042)	0.003 (−0.025, 0.032)	0.018 (0.004, 0.031)

[a] Adjusted for Race/Ethnicity, Grade, Urbanicity, Parental Education, Academic Performance, Year, and Form

[b] Chi-square values from joint tests of interaction effects between predicted risk score category and daily social media use for each depression score cutscore: Score >9: 4.9794, p=0.2894; Score >10: 7.5326, p=0.1103; Score >12: 2.9149, p=0.5722; Score >15: 8.3081, p=0.0809; Continuous depression score: 15.49, p=0.0038

[c] Model did not converge

Table 2.

Association between daily social media exposure and depressive symptoms[a] among boys, stratified by risk for depressive symptoms based on existing risk factors, 2009–2017[b]

Association between daily social media and depressive symptoms at different cutscores of Depression Score (Odds Ratio, 95% CI)						
	Depression risk					
Cutscore	**Low**	**Middle-low**	**Moderate**	**Middle-high**	**High**	**Overall**
Score > 9	1.02 (0.93, 1.11)	1.23 (1.02, 1.49)	1.24 (0.94, 1.64)	0.77 (0.52, 1.12)	0.54 (0.18, 1.62)	0.97 (0.92, 1.02)
Score > 10	1.02 (0.91, 1.15)	1.09 (0.92, 1.30)	1.10 (0.88, 1.39)	0.89 (0.65, 1.21)	0.68 (0.29, 1.60)	0.95 (0.90, 1.01)
Score > 12	0.77 (0.62, 0.96)	1.02 (0.82, 1.28)	1.42 (1.13, 1.78)	1.06 (0.84, 1.33)	0.66 (0.39, 1.12)	0.92 (0.84, 0.99)
Score > 15	0.88 (0.51, 1.53)	0.76 (0.42, 1.38)	1.00 (0.59, 1.69)	1.02 (0.74, 1.39)	0.92 (0.69, 1.24)	0.86 (0.76, 0.98)
Linear Estimates for log transformed depressive symptoms (Beta, 95% CI)						
	0.004 (−0.006, 0.015)	0.018 (−0.007, 0.043)	0.018 (−0.006, 0.042)	−0.003 (−0.031, 0.025)	−0.012 (−0.040, 0.017)	−0.005 (−0.017, 0.007)

[a] Adjusted for Race/Ethnicity, Grade, Urbanicity, Parental Education, Academic Performance, Year, and Form

[b] Chi-square values from joint tests of interaction effects between predicted risk score category and daily social media use for each depression score cutscore: Score >9: 5.3296, p=0.2551; Score >10: 1.7221, p=0.7867; Score >12: 13.0142, p=0.0112; Score >15: 1.101, p=0.8941; Continuous depression score: 2.82, p=0.589

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