



Published in final edited form as:

J Adolesc Health. 2021 February ; 68(2): 324–330. doi:10.1016/j.jadohealth.2020.06.012.

Frequency of text messaging and adolescents' mental health symptoms across four years of high school

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Abstract

Purpose: To examine the concurrent and longitudinal associations between adolescents' text messaging frequency and mental health symptoms across four years of high school.

Methods: 203 adolescents (aged 14 to 18 years) consented and were provided smartphones across four years of high school. Using billing records, daily frequencies of text messaging were created for each year. Adolescents reported on their mental health symptoms (internalizing, externalizing, social problems, and inattention) each summer.

Results: Multilevel analyses tested the between- and within- person associations between texting and mental health symptoms. Between-person analyses revealed an association only between externalizing symptoms and texting. Girls who texted more (versus less) frequently reported more externalizing and inattention symptoms, whereas there were no significant associations for boys. There were no significant within-person concurrent associations between texting and symptoms. Autoregressive latent cross-lagged model with structured residuals testing the longitudinal, bidirectional associations also did not find significant relations across four years of adolescence.

Conclusions: Across analyses, few robust associations emerged. Adolescent girls who text messaged more frequently reported greater externalizing and inattention symptoms. Contrasting the popular narrative that smartphones *cause* depression, this study did not find any consistent within-person or longitudinal associations between texting and mental health symptoms across adolescence. Research on the content, rather than quantity, of texts and device use is necessary to understand the potential effects on development.

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Conflict of Interest: The authors have no conflicts of interest relevant to this article to disclose.

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Keywords

mobile phones; mental health; adolescence; longitudinal; text messaging; internalizing; externalizing symptoms

“Have smartphones destroyed a generation?” inquire popular media headlines [1]. Overall, screen time has been correlated with small declines in adolescents’ psychological adjustment [2, 3]. However, much of this past research on adolescents’ technology use and wellbeing has relied heavily on cross-sectional, self-report surveys of screen time and wellbeing, which cannot address specific types of device usage or directionality of the linkages [4, 5]. Longitudinal studies also show mixed findings, with time spent on devices predicting future internalizing [6], externalizing [7], and inattention [8] symptoms, as well as no changes in mental health problems [9]. Few studies have examined whether adolescents’ text messaging behaviors are linked to their wellbeing, even though smartphone usage and text messaging are widely popular among adolescents [10]. This study examines the concurrent and longitudinal associations between adolescents’ rates of text messaging as assessed by billing records, and their mental health symptoms: internalizing, social problems, externalizing, and inattention.

Theories and Previous Research Linking Text Messaging Rates and Mental Health

Although theories rarely make specific predictions about text messaging, general theories of new media provide hypotheses for how digital technology use may be related to adolescents’ mental health. We review these broader theories and relevant studies that examine how the frequency of text messaging may be correlated with wellbeing. First, co-construction theory posits that adolescents’ online and offline environments are strongly linked [11]. Adolescents play an active role in their development; they can use technology as a tool to engage with peers and explore new information. Online activities can provide a marker for offline behaviors, vulnerabilities, and strengths, such that those who are already experiencing mental health symptoms may demonstrate these symptoms in their text messaging behaviors.

Related to text messaging, co-construction theory might predict that adolescents text message conversations may mirror offline conversations. Adolescents with greater internalizing symptoms may text message more frequently [12]. Perhaps, adolescents who are experiencing internalizing symptoms may use text messaging to ruminate about their own or others’ problems. However, greater text messaging may also relate to more support seeking. A daily diary study found that daily rates of text messaging were associated with fewer same-day internalizing symptoms [7]. Adolescents who engage in antisocial or aggressive behaviors offline may also participate in related conversations online. Adolescents who text more frequently than others report more externalizing behaviors [13]. A daily diary study also found that text messaging rates were linked to greater same-day externalizing symptoms [7], but another daily diary study did not find any consistent daily associations between the number of texts sent and mental health symptoms [14].

Second, the displacement hypothesis proposes that technology use displaces face-to-face interactions [15]. Here, adolescents spend time using devices instead of spending time engaging socially with others in-person, which can lead them to feel more isolated and depressed. Teens who text message more frequently may be more likely to be disrupted by their phones and text conversations at night, which may create or exacerbate sleep problems [16], internalizing and externalizing symptoms [17]. In a one-year long study, greater time spent using a mobile device was linked to increased future internalizing symptoms [18]. In a longitudinal study of text messaging, perpetually high rates of texting predicted greater depressive and social problems over time [12].

Third, the social compensation hypothesis, suggests that individuals may compensate for their lack of social skills by spending more time online [19]. This hypothesis suggests that adolescents who are already struggling with mental health difficulties (either internalizing or externalizing) may use digital technologies to communicate with others and offset their poor offline skills, which may lead to fewer symptoms over time. For example, adolescents with social anxiety who engaged in more online digital communication (via instant messaging) versus more time spent for entertainment reported fewer internalizing symptoms over time [20]. In relation to externalizing symptoms, text messaging rates have been associated with positive changes in conduct problems and aggression over time [7, 12]. Perhaps adolescents who have social problems related to aggressive or antisocial behaviors may also seek out similar peers online. Conversations about risk behavior may normalize these activities, leading to increasing externalizing behaviors over time, as has been shown when examining the frequency of risky texts sent and received from peers [21, 22].

Taken together, theories and past research suggest multiple (and sometimes conflicting) possible concurrent, longitudinal, and bidirectional links between text messaging and mental health problems. Longitudinal research is needed that parses between-person, within-person, and directional associations. Between-person associations compare groups of individuals (i.e., teens who text more versus less), within-person associations compare individuals across time points (i.e., texting more in one year versus another year), and directional associations compare individuals to future time points (i.e., texting more in one year predicts future mental health). Although sometimes related, these different types of associations can have different or even orthogonal patterns of results [23]. The theories suggest possible differences in how the frequency of text messaging may relate to internalizing versus externalizing symptoms concurrently and over time. Thus, multi-year longitudinal research with multiple symptom scales is essential to understand fully how text messaging relates to adolescents' mental health.

The Present Study

This study builds on previous investigations of digital technology use and wellbeing in several ways. First, this research utilizes billing records to create objective estimates of text messaging rates. Mobile phone use and text messaging are often measured using general, self-reported items and these measures may be poor estimates of actual behaviors [24, 25]. Moreover, using both self-reported wellbeing and technology use measures can introduce shared method bias, which may inflate associations. One study found small correlations

between objective and self-reported problematic smartphone use, with self-reports having stronger associations with wellbeing [26]. Second, this study uses the well-validated Youth Self Report scales of the Child Behavior Checklist [27] to assess adolescents' internalizing, social problem, externalizing, and inattention symptoms. For this typically developing sample, number of symptoms were examined instead of the presence or absence of clinical syndromes. Third, this study uses a four-year longitudinal design to assess associations between adolescents' text messaging rates and mental health symptoms and a technique designed to separate between- and within-individual variation. Most studies use cross-sectional designs, which cannot disentangle between- and within-individual variation [4], or two assessment longitudinal studies, which cannot adequately test directional associations [28].

The present study examines four research questions. First, do adolescents who text more have more mental health symptoms (between-person associations)? Second, when adolescents text more in one year than they do on average, do they also report more symptoms that year (within-person associations)? Third, when adolescents text more, do they later report greater symptoms and vice versa (directional and bidirectional associations)? Fourth, are there differential associations for boys and girls (gender differences)? This fourth question is exploratory and aims to address the suggestion that technology use may be especially harmful for girls [29]. Although not yet tested in relation to text messaging, girls may be more likely to engage in ruminative or comparative online conversations and may show stronger associations between digital technology usage and internalizing symptoms compared to boys [22, 29].

Methods

Participants and Procedure

Participants ($N=203$) were a group of ethnically diverse adolescents from the southwestern United States (52% male; 53% White/Caucasian, 23% Black/African-American, 17% Hispanic/Latinx, 6% Other). Participants were recruited from a longitudinal study started in 2003, which included a sample of typically developing youth from 14 local elementary schools (for more detailed study information see [30, 31]). Before starting 9th grade in 2008 ($M_{age}=13.9$ at onset of data collection), adolescents and their parents agreed to allow researchers to monitor their text messaging across four years of high school. Researchers supplied adolescents with smartphones that had unlimited text messaging plans. Each summer during high school, adolescents received new phones and completed questionnaires about their mental health and wellbeing. The mental health scales assessed adolescents' functioning during the preceding six months. Texting frequency rates were created each year from billing records to correspond to the same six-month intervals. Adolescents were included in the analyses if any valid billing record data for their phones was available; no participants were excluded. All measures and procedures were approved by National Institutes of Health and university's institutional review board (IRB#: 07-36; for a detailed discussion of ethical considerations see [32]).

Measures

Text messaging rates.—Billing records were used to create six-month averages (March to August) of daily text messaging rates for each year from 9th to 12th grades. This ensured texting records corresponded with the period of time when participants were instructed to assess their mental health. Texting rates included both sent and received messages.

Mental health symptoms.—Each summer, adolescents completed the 112-item Youth Self-Report scale [27] to report on frequency of symptoms over the last six-months on a three-point scale (0-not true, 1-somewhat or sometimes true, and 2-very true or often true). Composites were created according to validated procedures [27]. *Internalizing symptoms* include 13 anxious-depressed (e.g., “I am afraid I might think or do something bad”), eight withdrawn-depressed (e.g., “I would rather be alone than with others”), and ten somatic (e.g., “I feel overtired without good reason”) items (yearly α 's ranged from .87 to .91). *Externalizing symptoms* are a composite of 17 aggressive (e.g., “I am mean to others”) and 15 rule-breaking (e.g., “I break rules at home, school, or elsewhere”) items (α 's: .85–.91). The YSR scale also measures adolescents' *social problem symptoms* (11 items; e.g., “I don't get along with other kids”; α 's: .72–.83) and *inattention symptoms* (nine items; e.g., “I have trouble concentrating”; α 's: .77–.80).

Analytic Plan

Descriptive statistics were calculated using STATA15 [33]. Multilevel models were estimated in MPlus8 [34] to test the between-person and concurrent within-person associations between texting and mental health symptoms. These models specified a random intercept for each individual to account for nesting across individuals, included centered variables for more interpretable coefficients, and used maximum likelihood estimation with robust standard errors to account for missing data [35]. Each mental health model was estimated separately and all multi-level models controlled for grade in high school to account for time. To examine the directional associations, autoregressive latent cross-lagged models with structured residuals were examined (for more detailed discussions see [28, 36]). This model, illustrated in Figure 1, tested the average within-person lagged effects (estimated a and b paths) over time, while controlling for concurrent within-person (estimated c paths) and between-person effects (estimated d paths). Intercepts represent texting and symptom reports for 9th grade. This model was repeated for each mental health variable. To test for gender differences, separate models were conducted by gender. To follow up, gender was added as a moderator of between and within-person associations and gender invariance tests were conducted in the longitudinal models. For each research question, a Benjamini-Hochberg correction was used to account for the false discovery rate [37]. More information about the model specification and fit can be found in our supplementary materials (Open Science Framework doi: [10.17605/OSF.IO/FD6JH](https://doi.org/10.17605/OSF.IO/FD6JH)).

Results

Table 1 provides the means and standard deviations by year in high school for adolescents' daily texting rates and mental health symptoms. A set of 4 (grade) by 2 (gender) ANOVAs tested the differences by grade, gender, and their interaction in texting and symptoms. There

were differences by grade level in texting rates ($F(3,732)=4.36, p=.005$) and inattention symptoms ($F(3,726)=3.46, p=.016$), but not in social problems ($F(3,726)=1.82, p=.14$), internalizing ($F(3,709)=1.90, p=.13$), or externalizing ($F(3,726)=0.81, p=.49$) symptoms. Pairwise comparisons showed that adolescents texted less during 9th grade than in 10th or 11th grades and experienced fewer inattention symptoms in 12th grade than in 9th grade. There were no significant gender differences or grade by gender interactions in the frequency of texting or any of the four types of mental health symptoms ($p>.06$).

Do adolescents who text more than others also have more mental health symptoms (between-person associations)?

Table 2 shows the results of the MLM models testing the between- and within-individual cross-sectional associations between the frequency of text messaging and mental health symptoms. The first set of columns show the between-person associations. After false discovery rate correction, a higher rate of texting was only associated with greater externalizing symptoms. To probe this finding further, the between-person components of the autoregressive latent cross-lagged models with structured residuals were examined (see d paths in Figure 1). The intercept of texting and externalizing symptoms were significantly correlated ($b=0.16, SE=0.017, \beta=0.21, p=.036$), indicating that adolescents who started with higher externalizing symptoms also had higher rates of texting in 9th grade.

When adolescents text more than their own average, do they also report more concurrent symptoms (within-person associations)?

The second set of columns in Table 2 show the concurrent within-individual associations between the frequency of text messaging and mental health symptoms. No significant within-person associations remained after false discovery rate correction.

When adolescents text more than their own average, do they also report more symptoms later or vice versa (directional associations)?

Autoregressive latent cross-lagged models with structured residuals were used to test the longitudinal associations between the frequency of text messaging and mental health symptoms (paths a and b in Figure 1). These models tested whether texting at one assessment point (t-1) predicted symptoms at the following assessment point (t) and vice versa. The lagged, or directional, associations between texting and all four types of symptoms are presented in Table 3. There were no significant directional associations between texting and symptoms after adjusting for between- and concurrent within-person associations (β s ranged from -0.03 to 0.09).

Are there gender differences in the associations between texting and symptoms?

Finally, gender differences were tested for the between-, within-, and directional associations between the frequency of text messaging and mental health symptoms. Table 4 shows the between- and within-person concurrent associations. For the between person associations, higher rates of texting were associated with more externalizing and inattention symptoms for girls, whereas, there were no significant between person associations for boys. Correlation coefficients among girls and boys were compared and showed no differences in the

association between texting and externalizing symptoms ($z=1.16$, $p=.124$), but girls had a significantly stronger association between texting and inattention symptoms ($z=1.73$, $p=.04$). After correction, there were no within-person associations for either boys or girls. Similarly, invariance testing of the longitudinal directional models revealed no significant differences in the lagged associations by gender ($ps>.05$).

Discussion

This study of adolescents' text messaging and mental health symptoms had four primary findings. First, this study did *not* find that adolescents who texted more frequently experienced more internalizing symptoms than those who texted less often, in contrast to studies of overall screen time [2, 3]. Perhaps this study's focus on text messaging, a form of digital communication, rather than other online activities (e.g., passively browsing social media) led to weaker links with internalizing symptoms [38]. Consistent with previous studies [7, 14], the effect size for the associations between texting and internalizing symptoms were very small (correlations between technology use and internalizing symptoms of about .06). Given this study's sample size and limited power to detect between-person effects, more significant associations may emerge among larger or more targeted samples.

Only when comparing individuals with high and low texting rates, did we find a robust, albeit small, between-person correlation between the frequency of text messaging and externalizing symptoms. Adolescents who text more frequently than others may be engaging in more externalizing behaviors, consistent with previous studies of adolescents in Scandinavia [13] and previous research in the US linking the frequency of social media use and risky behavior [21, 22]. The subtle and unsupervised nature of text messaging may make it a convenient context for youth to discuss their involvement in aggressive or antisocial behaviors with peers. Indeed, previous research has found that adolescents who sent or received more texts about antisocial topics had greater externalizing symptoms over time [39] and more frequently witnessing peers engage in socially aggressive texting may promote adolescents' own aggressive behaviors [40]. Adolescents who text message more frequently may also be considered higher status or more popular amongst their peers. Popularity has been linked to externalizing behavior [41] and social and relational aggression [42]. Thus, future research is needed to test whether perceived popularity may spuriously predict both text messaging rates and aggressive behaviors.

Second, there were no robust within-person associations between objective rates of text messaging and self-reported mental health symptoms. Specifically, after error correction, there were no concurrent, within-individual associations between texting and symptoms. Although these findings counter some previous studies linking daily digital technology use to greater externalizing symptoms [7], they are consistent other studies that fail to find concurrent daily associations between mobile phone use and mental health [14]. Perhaps the frequency of text messaging, though more specific than overall screen time, is still too broad a measure as digital communication is quite varied. Some positive exchanges (e.g., support seeking) may increase social connection or improve wellbeing, whereas other negative interactions (e.g., cybervictimization) may promote or exacerbate mental health

problems. Although most of the content of text message conversations is positive or neutral [43], even minor negative interactions may shift wellbeing [44]. To fully understand these processes, the content of digital activities and online communication must be examined in relation to wellbeing.

Third, this study did not find any directional associations between the frequency of text messaging and any of the four mental health scales across adolescence. These results counter the popular narrative that smartphone use *causes* depression or other mental health problems [1]. Furthermore, this study found few changes in mental health symptoms across adolescence, suggesting that rates of internalizing problems did not increase with age for this typically developing sample. As our study was conducted from 2008–2012, our findings contrast some previous studies that suggest a population rise in depressive symptoms since 2007 [2]. With respect to externalizing symptoms, associations between texting and externalizing symptoms were detected from the first assessment point (between-person intercepts correlated in 9th grade), rather than changing together over time (no within or bidirectional associations). Taken together, our study lends greater support to co-construction theory of technology use rather than one or more casual theories (social compensation or displacement hypotheses). Adolescents with greater problems may be engaging in more maladaptive texting habits. However, future research is needed that can eliminate other factors that may relate to both externalizing symptoms and text messaging behaviors.

Fourth, after correction, only girls showed significant links between texting rates and externalizing and inattention problems. However, only the association between texting and inattention symptoms differed significantly by gender, such that girls had a stronger association between text messaging rates and inattention symptoms compared to boys. Perhaps, text messaging offers girls a more private distraction, whereas boys may have greater license to cope with attentional problems more overtly [45]. Future research could examine boys and girls texting behaviors as they experience attentional symptoms (e.g., intensive momentary studies).

Although this study has a number of unique strengths, including its use of billing data, well-validated mental health scales, and a longitudinal design, there were also a number of limitations. First, the study used text messaging as the measure of technology usage, which does not include other online activities, such as passively browsing curated content on social media [38]. Furthermore, this study focused on the frequency, rather than content, of text messaging over time. Second, the study was conducted from 2008–2012, and digital technologies have since evolved. However, text messaging remains an important staple of adolescents' online behaviors and texting is similar to other forms of digital communication (e.g., online messaging via social media) [10]. Third, the sample size was limited, so some of the between-person analyses may not have sufficient power to detect effects. For example, this study failed to find a significant gender difference internalizing symptoms [46], likely due to a lack of power ($p=.06$, $d=.27$) and the use of a continuous rather than binary measure of internalizing symptoms. Future research is needed that examines the content of digital communication to wellbeing over time to specify the types of online conversations that may relate to positive or negative changes in adolescents' mental health [39].

This study emphasizes the importance for future theoretical and empirical work to disaggregate and specify between- versus within-person effects when considering adolescents' digital technology use and wellbeing. Our findings suggest that adolescents who are texting more frequently may also be engaging in aggressive and rule-breaking activities and girls with inattention problems may be texting at higher rates. However, our results do not show evidence that texting is the cause of these links as we found no longitudinal effects. Future research is needed on the content of adolescents' messages to more fully understand how these behaviors may interact. Parents, teachers, and practitioners may use this research in intervention efforts with youth who are aggressive, break rules, or struggling with attention problems, perhaps by discussing, setting rules, and/or monitoring adolescents' daily digital communication patterns.

Acknowledgements:

The preparation of this article was supported by two grants from the Eunice Kennedy Schriver National Institute of Child Health and Human Development: R01 HD060995 and R21 HD072165.

Abbreviations:

ANOVA analysis of variance

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Implications and Contribution:

Although there have been claims that smartphones are harming adolescents, there has been a notable lack of rigorous longitudinal research. This study uses objective measures of text messaging and well-validated symptom scales over four years and finds few concurrent or longitudinal associations between adolescents' texting and mental health.

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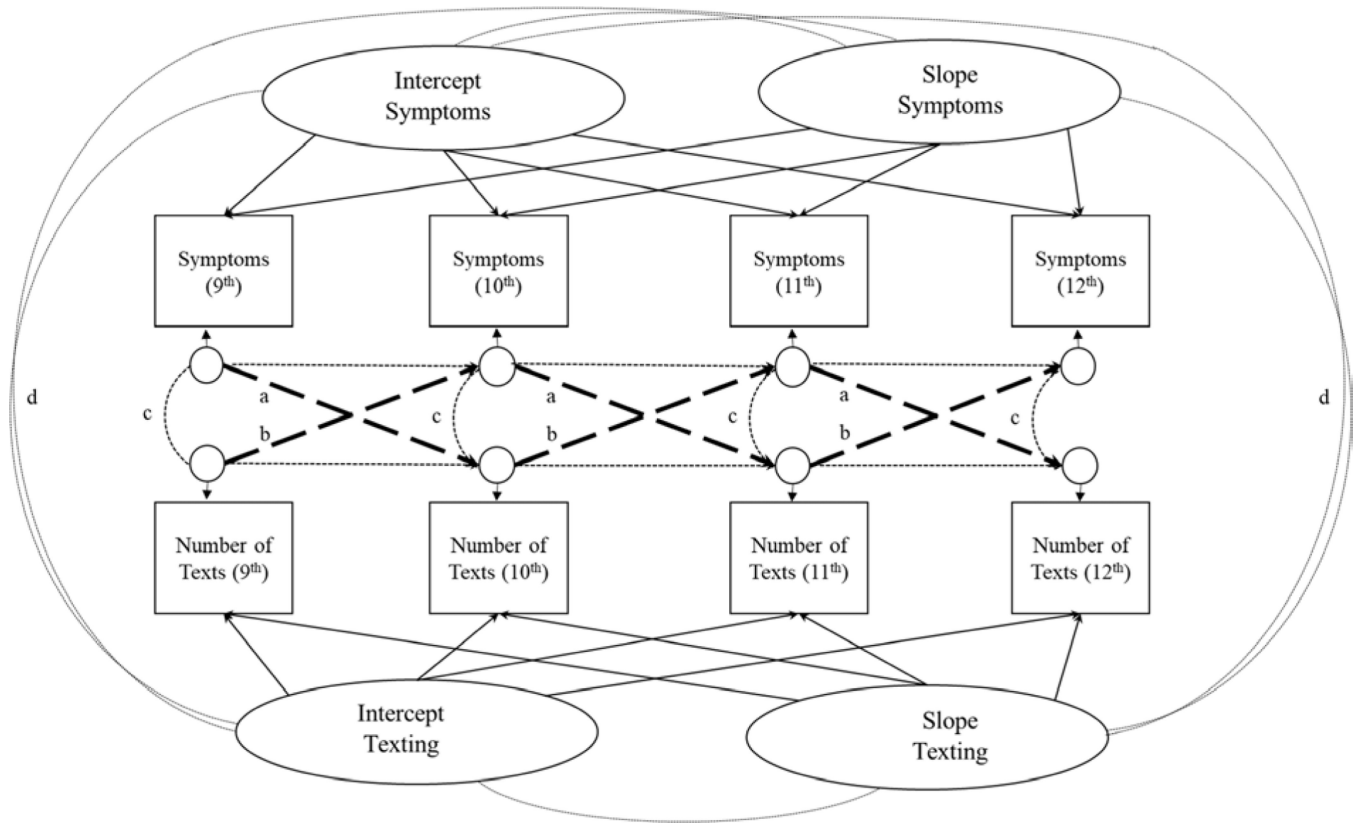


Figure 1:

Illustrates the autoregressive latent cross-lagged model with structured residuals that tests the directional associations between texting and symptoms (a and b paths) while controlling for the concurrent within-person (c paths) and between-person (d paths) associations across four years of high school (9th - 12th grades). Dotted lines indicate estimated paths; solid lines indicate fixed paths. Note that correlations among residuals and possible quadric/cubic paths were omitted for legibility.

Table 1.

Descriptive information for the text messaging and mental health variables across the full sample and split by grade level.

Variable	Range	Total	Grade in High School			
			9th	10th	11th	12th
Average Daily Texting	0.07 – 821.55	111.30	84.66 _a	126.83 _b	126.38 _b	113.26 _{ab}
		<i>M</i> 110.82	109.49	135.68	144.14	117.31
Internalizing Symptoms	0.50 – 36.25	9.89	10.60	9.99	9.86	8.58
		<i>M</i> 6.62	8.47	8.94	8.03	7.19
Social Problems	0 – 36.25	3.26	3.63	3.33	3.12	2.87
		<i>M</i> 2.58	3.21	3.64	3.07	2.88
Externalizing Symptoms	0 – 37.75	11.29	11.61	11.48	10.91	10.35
		<i>M</i> 7.36	8.60	9.62	8.55	7.23
Inattention Symptoms	0 – 13.25	5.49	6.02 _a	5.60 _{ab}	5.26 _{ab}	4.86 _b
		<i>M</i> 2.96	3.58	3.57	3.54	3.46

Note: ANOVA tests were conducted for texting and symptoms across grade in high school. Significant post-hoc comparisons ($p < .05$) are denoted with subscripts (*ab*) across rows.

Table 2.

The unstandardized and standardized coefficients, standard errors, and p -values from the multilevel models testing the concurrent between- and within- person associations between text messaging and mental health symptoms.

Mental Health Symptoms	Concurrent Associations with Texting							
	Between-Person				Within-Person			
	<i>b</i>	<i>SE</i>	β	<i>p</i>	<i>b</i>	<i>SE</i>	β	<i>p</i>
Internalizing	0.005	0.004	0.065	.216	0.007	0.004	0.060	.105
Social Problems	0.002	0.002	0.081	.153	0.003	0.001	0.063	.028
Externalizing	0.016	0.005	0.192	.001	0.006	0.003	0.057	.036
Inattention	0.003	0.002	0.076	.207	0.002	0.001	0.046	.064

Note: Separate multilevel models were conducted for each mental health variable with both between and within texting variables included together and controlled for grade level. Bolded font indicates significance after Benjamini-Hochberg false discovery rate correction.

Table 3.

The unstandardized and standardized coefficients, standard errors, and p -values of the directional or lagged associations between text messaging and mental health symptoms from the autoregressive latent cross-lagged with structured residuals models (paths a and b in Figure 1).

Mental Health Symptoms	Directional Associations							
	Symptoms (t-1) to Texting (t)				Texting (t-1) to Symptoms (t)			
	<i>b</i>	<i>SE</i>	β	<i>p</i>	<i>b</i>	<i>SE</i>	β	<i>p</i>
Internalizing	0.042	0.120	0.026	.732	0.007	0.029	0.012	.809
Social Problems	-0.005	0.111	-0.003	.962	-0.001	0.028	-0.002	.970
Externalizing	0.145	0.112	0.086	.196	0.014	0.027	0.024	.601
Inattention	0.017	0.131	0.010	.895	-0.015	0.026	-0.026	.552

Note: Separate models were conducted for each mental health variable.

Table 4.

The unstandardized and standardized coefficients, standard errors, and p -values separated by gender from the multilevel models testing the concurrent between- and within-person associations between text messaging and mental health symptoms.

Mental Health Symptoms	Concurrent Associations with Texting (Girls)							
	Between-Person				Within-Person			
	<i>b</i>	<i>SE</i>	β	<i>p</i>	<i>b</i>	<i>SE</i>	β	<i>p</i>
Internalizing	0.017	0.011	0.145	.103	0.008	0.005	0.069	.127
Social Problems	0.009	0.005	0.172	.069	0.004	0.002	0.085	.053
Externalizing	0.026	0.012	0.259	.003	0.010	0.004	0.096	.027
Inattention	0.012	0.004	0.242	.008	0.001	0.001	0.001	.972

Mental Health Symptoms	Concurrent Associations with Texting (Boys)							
	Between-Person				Within-Person			
	<i>b</i>	<i>SE</i>	β	<i>p</i>	<i>b</i>	<i>SE</i>	β	<i>p</i>
Internalizing	0.001	0.004	0.014	.723	0.006	0.007	0.049	.368
Social Problems	0.001	0.002	0.017	.703	0.002	0.002	0.037	.305
Externalizing	0.010	0.005	0.101	.033	0.003	0.004	0.024	.510
Inattention	0.001	0.002	0.001	.995	0.004	0.002	0.074	.020

Note: Separate multilevel models were conducted for each mental health variable with both between and within texting variables included together and controlled for grade level. Bolded font indicates significance after Benjamini-Hochberg false discovery rate correction.