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Relations of Adolescent Knowledge of COVID-19, Social Media Engagement, and Experiences During Quarantine/Lockdown with Well-Being

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Abstract
This study investigated the relations of adolescent COVID-19 knowledge, quarantine/lockdown experiences, and social media use with indices of their psychosocial adjustment. The sample consisted of 215 adolescents from throughout the United States, with adolescents ranging from ages 14 to 17. Better knowledge of COVID-19 was related to lower loneliness, stress, anxiety, depression, and fear of missing out (FoMO). Higher parent-reported restrictions during quarantine were associated with these difficulties as well. Further, the lowest anxiety was reported for adolescents with good COVID-19 knowledge who also checked social media relatively less frequently. The findings point to the importance of accurate information about COVID-19 for adolescents and the impact of quarantine/lockdown experiences on their perceived emotional and social adjustment.

Keywords COVID-19 · Adolescence · Social media engagement · Quarantine

Highlights
- Accurate knowledge about COVID-19 was related to better adolescent well-being (e.g., lower internalizing problems).
- Greater perceived interference from quarantine/lockdowns was associated with lower reported well-being.
- Anxiety was highest among adolescents with lower COVID-19 knowledge who were relatively more engaged with social media.

The novel coronavirus (COVID-19) is a contagious infection that is transmitted through respiratory droplets (CDC, 2020). Since the report of the first case in December 2019 and introduction of its pandemic state in March 2020 (WHO, 2020a, b), this disease has affected lives in numerous ways. To restrict and decrease viral spread, health experts and authorities proposed and implemented measures such as hand washing and social distancing. Social distancing, or physical distancing, resulted in unprecedented impacts on social interactions and mental health, including increased levels of psychological distress, social difficulties, depression, and

anxiety (e.g., Li et al., 2020; Shamblaw et al., 2021; Tasso et al., 2021). During a tumultuous and unpredictable time, such as in the initial months of the COVID-19 pandemic, accurate information may serve a protective function in terms of providing reasonable and actionable steps to reduce health risk and related stress. Further, for present-day adolescents, social media may be a source of such information but can also provide inaccurate data and behavioral recommendations (Caceres et al., 2022). In light of these issues, the primary aim of the present study was to investigate the associations of accurate COVID-19 knowledge and experiences during quarantine with social media engagement and psychosocial adjustment in a sample of adolescents from the United States.

Social Media, Information Seeking, and Well-Being

When there is an outbreak of an infectious disease, individuals' preventive actions play an important role in control

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or spread of the disease. Evidence from previous notable diseases such as SARS, Ebola, or H1N1 influenza showed that media can affect perceptions of diseases and cause behavioral change and thus influence the transmission pattern of infectious diseases (Kim et al., 2019). A study by Liu (2020) showed that seeking information about COVID-19 through digital media encouraged people to practice preventive behaviors. Additionally, this exposure to accurate health messaging may then have positive consequences for psychological well-being. Although any digital media can have such an influence, it seems important to be aware of the role of social media specifically, as digital innovations have improved the availability and popularity of these platforms, making them an important and accessible means of seeking news and information (Mitchell et al., 2016). Further, as described below, social media can serve as a source of information, including misinformation; thus, the associations among social media engagement, COVID-19 knowledge, and adolescent well-being was a consideration of this study.

Beyond social media as a conduit of correct or incorrect information, it also appears to have a mixed association with adolescent well-being during a pandemic. On the one hand, these platforms allow individuals to stay connected with friends and families (Spies Shapiro & Margolin, 2014), particularly during restrictions on social activities (Mano, 2020). On the other hand, social media engagement is associated with internalizing symptoms for adolescents, particularly for those who experience fear of missing out (FoMO; Barry et al., 2017). To compensate for FoMO, adolescents might increase their use of social media and thus create a cycle of further use of social media and heightened FoMO (Oberst et al., 2017). FoMO is also connected to excessive or problematic social media use (Blackwell et al., 2017; Elhai et al., 2020). Based on these findings, it is possible that restrictions on social activities during COVID-19 may have increased social media engagement, as well as FoMO and other indicators of maladjustment in adolescents.

Nevertheless, these results point to disparate mental health sequelae of social media use and the need to consider other factors, such as the degree to which social media use is problematic or occurs in the course of other important daily activities (e.g., immediately before/after sleep, academics, direct interactions with others) rather than solely basic parameters of social media use. Further, social media engagement may be particularly connected to maladjustment for those who do not obtain accurate information about news events, such as the COVID-19 pandemic. This latter issue was of interest in this study, with social media activity for those with lower COVID-19 knowledge expected to relate to greater internalizing problems (e.g., depression, anxiety, stress, loneliness, FoMO).

Potential Impact of COVID-19 and Quarantine

It is well established that experiencing stressful life events is a particularly important risk factor for youth depression and anxiety (Fox et al., 2010). As a result of COVID-19 and stay-at-home restrictions, being in lockdown/quarantine is a significant event that many adolescents have now experienced and that could be associated with stress and other forms of maladjustment. Studies on previous epidemics (e.g., Influenza A virus subtype H1N1, Severe Acute Respiratory Syndrome [SARS], Avian influenza) suggest substantial psychological impact (e.g., post-traumatic stress disorder, anxiety, depression, sleep problems) in quarantined individuals, with factors such as length of quarantine/isolation, inadequate information, stigma, fear of becoming infected, financial problems, and boredom identified as possible factors (Brooks et al., 2020). Emerging research with adults reflects similar issues during the ongoing COVID-19 pandemic (Shamblaw et al., 2021; Tasso et al., 2021).

For adolescents, stay-at-home orders/quarantine might have a significant effect on mental health and social development, given their need for interpersonal connectedness, especially with peers (e.g., Lansford et al., 2014). However, the effects of lockdowns/quarantine on adolescents are unclear with some initial research even showing less depression and loneliness in teens during the COVID-19 pandemic (Twenge et al., 2020). Other research has indicated that with the significant increase in adolescent social media use during the COVID-19 pandemic, depressive symptoms have also increased, whereas loneliness has remained relatively unaffected (Ellis et al., 2020). An adolescent's mindset regarding quarantine may have played a role in their adjustment to COVID-19 as well. That is, not only would a higher intensity/longer duration of quarantine be expected to relate to lower well-being, but perceptions of greater interference (e.g., regarding social life, academics) from quarantine may be particularly relevant for maladjustment. However, accurate knowledge of health risks may be an important mitigating factor in the association between quarantine and mental health. More specifically, understanding the potential protective health benefits of social distancing and quarantine might lower the stress and loneliness that might otherwise be expected for adolescents who are restricted from typical in-person activities.

As noted above, the present study investigated the association of adolescents' accurate knowledge of COVID-19 with social media engagement and well-being. Further, because social isolation, often referred to as "lockdown" or "quarantine," was a common experience in the United States in the wake of the first surge of COVID-19 cases in the Spring of 2020, we also considered such experiences for

adolescents in relation to their perceived well-being (e.g., stress, depression, loneliness). This study was aimed at extending knowledge of the mental health sequelae of COVID-19 and more specifically, to investigate the association between accurate COVID-19 knowledge and experiences during quarantine with social media engagement and mental health in a sample of adolescents from the United States. Given the pervasiveness of ongoing issues surrounding the COVID-19 pandemic in the United States, this study has clear public health implications.

Research Questions and Hypotheses

The primary research question was *whether knowledge about COVID-19 is associated with adolescent adjustment (i.e., loneliness, stress, anxiety, depression and FoMO;* Research Question 1). Because some evidence suggests health benefits of information obtained through social media (Liu, 2020) but also the potential of exposure to misinformation on social media pertaining to COVID-19 (Su, 2021), we did not make a specific directional prediction about the relation between COVID-19 knowledge and social media engagement. Thus, an additional question addressed in this study was *whether accurate COVID-19 knowledge is associated with adolescent social media engagement (e.g., frequency of checking social media; social media use during daily activities;* Research Question 2).

It was hypothesized that greater restrictions and perceptions of interference (e.g., less connection to others) due to quarantine would be related to adjustment difficulties (Hypothesis 1). It was also hypothesized that COVID-19 knowledge would moderate the relation between social media engagement and well-being, such that the connection between social media use and maladjustment would be stronger for adolescents with lower COVID-19 knowledge (Hypothesis 2) pointing to potential consequences of exposure to misinformation for some adolescents. Lastly, it was hypothesized that accurate knowledge of COVID-19 would moderate the expected relation between level of quarantine restrictions and adjustment (i.e., stress, anxiety, depression, loneliness, FoMO) such that higher knowledge would attenuate the association between greater quarantine restrictions and maladjustment (Hypothesis 3).

Method

Participants

The sample consisted of 215 adolescents ages 14 to 17 years ($M = 15.63$, SD = 1.13) from across the continental

United States. Of the adolescents, 110 (51.2%) identified as male, 103 as female, and 2 preferred not to answer. The majority of adolescent participants identified as White/Caucasian (79.1%), with 6.5% identifying as Black/African American, and the remainder identifying as a member of another racial/ethnic group(s) or as multi-racial. Of the parent respondents, 56.3% identified as being female. The median parent-reported 2019 family income for the sample was $50,000–100,000, consistent with the U.S. median family income at that time (https://www.census.gov/library/publications/2020/demo/p60-270.html).

Based on parent report, nearly half (48.8%) of participants lived in the Eastern Time Zone, whereas 32.6, 5.1, and 13.5% resided in the Central, Mountain, and Pacific time zones, respectively. In regards to community size, 15.8% were from communities of less than 10,000 people, 19.1% were from communities of 10,001–50,000, 16.3% were from communities of 50,001–100,000, 17.7% were from communities of 100,001 to 250,000 people, 17.2% reported living in cities of 250,001 to 1 million residents, and 14.1 resided in cities of more than 1 million residents. Nearly all participants (94.9%) reportedly had their last day of in-person school instruction prior to April 1, 2020, suggesting relative uniformity in social distancing policies at that stage of the pandemic.

Measures

Adolescent report

COVID-19 Knowledge Questionnaire (see Appendix) A questionnaire composed of 18 *True/False* items about COVID-19 was designed for this study using available information from the Centers for Disease Control (CDC) and World Health Organization (WHO) at the time of data collection. The questions covered basic facts about COVID-19 (e.g., symptoms, at-risk population, transmission and seriousness of the disease, preventive measures), common myths about COVID-19, as well as information sources (e.g., reliability of sources of information, social media). Scores on this measure were the total number of items answered correctly. For all items across the entire sample, there were only 4 missing item responses. These non-answers were treated as incorrect responses for purposes of analyses. The internal consistency of scores on this measure was $\alpha = 0.74$ in the present study.

Social media engagement Based on a measure used in previous adolescent research (Barry et al., 2017), participants were asked the number of social media accounts they had and about the frequency of checking their social media accounts, using a 7-point response scale from *Never* to *More than 10 times/day*. These items have been associated

with indicators of adolescent well-being such as anxiety and depression (Barry et al., 2017), as well as adolescent-reported experiences on social media (i.e., aggression, victimization; Barry et al., 2019). We also asked adolescents whether they use social media for certain purposes in a dichotomous (yes/no) format. In this sample, most participants (62.3%) reported that they do not use social media to get news. As an additional indicator of social media engagement, participants reported whether they use social media during certain daily activities (e.g., during meals, in the 15 min before going to sleep, during class) on 6 items, which were combined to form a composite of social media use during daily activities. The internal consistency of scores on this 6-item scale of social media use during daily activities was $\alpha = 0.83$.

Impact of quarantine To assess the impact of quarantine (i.e., mandated lockdowns) during the Spring and early Summer of 2020, adolescents responded to 9 items developed for this study that dealt with perceived enhancement from the quarantine experience (e.g., "For me, being in quarantine has improved my relationships with others") or perceived interference from being in quarantine (e.g., "For me, being in quarantine has interfered with my academic performance") on a 5-point scale from *Strongly disagree* to *Strongly agree*. The content of items was intended to focus on important aspects of adolescents' daily lives (i.e., relationships, academics, sleep, appetite). Three items focused on enhancement, with scores on this scale having moderate internal consistency $\alpha = 0.70$. The remaining six items addressed perceived interference from quarantine with scores on this scale demonstrating good internal consistency, $\alpha = 0.83$. A confirmatory factor analysis showed modest fit of a model that separated the measure into a perceived interference and a perceived enhancement scale (see Supplementary Analysis). Nevertheless, these scales were considered separately to allow for perceptions that quarantine may have both enhanced and interfered with these domains. Indeed, these scores had a small, positive intercorrelation, $r = 0.15$, $p = 0.03$.

Depression Anxiety Stress Scale (DASS; Lovibond & Lovibond, 1995) The DASS is a widely used 21-item self-report assessment of depressive and anxiety symptoms, as well as general distress, in the past week. Item responses (e.g., "I felt sad and depressed") are made on a 4-point scale from *Did not apply to me* to *Applied to me very much*. The Depression, Anxiety, and Stress subscales, consisting of 7 items each, were analyzed separately. This 3-factor model and the construct validity of the 21-item version of the DASS have been supported in previous work with adolescents (Szabó, 2010; Tully et al., 2009). The internal consistency of scores on each of the three subscales was good

(i.e., $\alpha = 0.93$ for anxiety, 0.95 for stress, 0.93 for depression) in the present sample.

UCLA Loneliness Scale-3 (UCLA-3 Russell, 1996) Loneliness (e.g., "How often do you feel alone?") was assessed via the UCLA-3, a widely used 20-item self-report inventory. Responses range from *Never* to *Often* on a 4-point scale. The UCLA-3 has previously shown good internal consistency and convergent validity with adolescents (e.g., Barry et al., 2017; Shevlin et al., 2015), although some evidence suggests lower reliability in adolescent, relative to adult, samples (Vassar & Crosby, 2008). In the present sample, the internal consistency of scores on this scale was $\alpha = 0.94$.

Fear of Missing Out Survey (FOMOS; Przybylski et al., 2013) The FOMOS is a 10-item measure that assesses the extent to which respondents are concerned with missing out on activities in their social circle (e.g., "I get anxious when I don't know what my friends are up to") on a 5-point response scale from *Not at all true of me* to *Extremely true of me*. This measure has shown good internal consistency and construct validity (e.g., correlations with loneliness, social media engagement, lower life satisfaction) in previous studies of adolescents and adults (Barry & Wong, 2020; Przybylski et al., 2013). The internal consistency of FOMOS scores in the present study was $\alpha = 0.92$.

Parent report

Parents were asked to report the level of quarantine experienced by their teen on an ordinal scale (i.e., "*No current or previous restrictions on activities;*" "*No current restrictions on activities;*" "*Some restrictions on activities;*" "*Stay-at-home order is in place*") which was coded on a 1–4 scale.

Procedure

The Institutional Review Board (IRB) of the authors' institution approved this study before data collection. Data were collected in July 2020. Survey panels were used to recruit parents and adolescents who lived in the United States and fit the age requirements for this study. We did not set any other restrictions on the location of participants hoping to get a sample of individuals from all over the continental United States. Parents first gave consent and provided demographic and quarantine information on Qualtrics, a secure online platform. Adolescents then were provided an opportunity to assent to participation and complete the adolescent measures privately, also on Qualtrics. Parents were compensated a small number of points (approximate value of 5 US dollars) that could be used for

online purchases for their participation and that of their adolescent. At the end of the study, adolescents were provided the correct answers to the COVID-19 knowledge questionnaire based on current scientific knowledge.

Analytic Plan

First, we examined the distributions of the main variables to determine their suitability for parametric tests and conducted the Shapiro-Wilk test on any variables with skewness at ±1. For variables that violated assumptions of normality, Spearman correlations were used to examine the Research Questions and test Hypothesis 1. Otherwise, parametric procedures (i.e., Pearson correlations) were used. We also analyzed the correlations between potential demographic confound variables (i.e., age, gender, family income as a proxy for SES) in relation to the five adjustment variables assessed in this study (i.e., depression, anxiety, stress, FoMO, loneliness).

Correlational analyses were used to determine the associations of adolescents' COVID-19 knowledge with indicators of adjustment (Research Question 1) and with social media engagement (Research Question 2). Hypothesis 1, concerning the relations of quarantine restrictions and perceived quarantine interference with adolescent adjustment, was also tested via correlations. Confound variables that were significantly related to adjustment variables were then controlled for in partial correlation analyses for the relations tested in the Research Questions and Hypothesis 1. The second hypothesis was tested via moderated multiple regression analyses. Specifically, adjustment variables (i.e., stress, anxiety, depression, loneliness, FoMO) were regressed onto COVID-19 knowledge and social media engagement in the initial step with a separate model analyzed for each dependent variable. Demographic variables (i.e., age, gender, family income) that were significantly related to a criterion were covaried in the regression model predicting that criterion. The interaction term for COVID-19 knowledge x social media engagement was entered into the next step. Because of the number of models analyzed, an interaction effect was only considered significant at $p < 0.01$ (see below). This family-wise error correction was also employed for the regression analyses that tested Hypothesis 3. Specifically, the adjustment variables were regressed onto COVID-19 knowledge and quarantine restrictions in the initial step of these models, with the interaction term entered into the next step. This hypothesis was tested in separate models for each of the five adjustment variables assessed in this study. Again, demographic variables were covaried if they were significantly associated with the adjustment variable being predicted in the model.

Lastly, although not part of the original analytic plan, post hoc analyses were conducted on the association of adolescent well-being with over- or under-estimation of risks from COVID-19. These analyses addressed a more specific issue than the relation of overall knowledge with well-being. For these analyses, we considered the items that reflected estimation of risk contamination/spread of COVID. More specifically, items 4, 11, and 12 (see Appendix) were scored as overestimation of risk (higher scores = higher 'true' responses to these items for which 'false' was correct). Items 5, 10, 13, 14, 15, 16, and 17 were scored as underestimation of risk (higher scores = higher 'true' responses to these items for which 'false' was correct).

Results

Descriptive statistics for the main study variables are displayed in Table 1. The variables appeared to fall along a normal distribution, with anxiety, stress, and depression being slightly positively skewed in this sample, whereas COVID-19 knowledge and frequency of checking social media were somewhat negatively skewed. On average, participants responded correctly to just over 15 of 18 items on COVID-19 knowledge, with 21.9% of the sample answering all 18 items correctly. The Shapiro-Wilk test indicated that COVID-19 knowledge, frequency of checking social media, depression, anxiety, and stress violated assumptions of non-normality; thus, non-parametric (i.e., Spearman) correlations were used for analyses involving these variables. Of note, adolescents in the present sample were reportedly engaged with social media on a consistent basis in that 98.1% of them reported having at least one social media account, and 87% of them reported checking their social media accounts at least once a day. When

Table 1 Descriptive statistics for main study variables

	M	SD	Range	Skew
COVID-19 knowledge	15.35	2.73	6–18	−1.47
Social media during daily activities	14.63	3.96	6–24	0.23
Frequency of checking social media[a]	6.43	1.40	2–8	−1.134
Quarantine level[b]	3.16	0.58	1–4	−0.47
Depression	10.99	5.46	7–28	1.37
Anxiety	10.29	4.96	7–28	1.57
Stress	11.81	5.34	7–28	1.13
Loneliness	37.25	11.81	19–74	0.28
FoMO	26.64	10.00	10–50	0.31

[a]Frequency of checking social media was reported on a scale from 1 (none/not applicable) to 8 (more than 10 times/day)

[b]Quarantine level was assesses on a scale from 1 (No current or previous restrictions on activities) to 4 (Stay-at-home order is in place)

Table 2 Correlations between main study variables

	1.	2.	3.	4.	5.	6.	7.	8.
1. COVID-19 knowledge[a]	–							
2. Social media in daily activities	−0.21**	–						
3. Frequency of checking social media[a]	0.07	0.48***	–					
4. Depression[a]	−0.33***	0.43***	0.11	–				
5. Anxiety[a]	−0.40***	0.29***	0.07	0.76***	–			
6. Stress[a]	−.30***	0.36***	0.08	0.82***	0.81***	–		
7. Loneliness	−0.27***	0.36***	0.03	0.70***	0.65***	0.65***	–	
8. FoMO	−0.29***	0.43***	0.23**	0.54***	0.53***	0.57***	0.47***	–

[a]Correlations for COVID-19 knowledge, Frequency of checking social media, Depression, Anxiety, and Stress are Spearman's rho coefficients given their non-normal distributions

**p < 0.01; ***p < 0.001

adolescents were asked about the frequency of checking news about COVID-19 specifically, 44% said that they check it at least once a day, whereas 9% said they never check any news about it.

We considered the relations of age, gender, and family income with the five adjustment variables (i.e., depression, anxiety, stress, FoMO, loneliness) to determine if these demographic variables would need to be covaried in subsequent analyses. Age was not related to any of these variables and thus was not controlled for in remaining analyses. Females scored higher than males in FoMO, $r = 0.14$, $p = 0.04$, and loneliness, $r = 0.14$, $p = 0.04$. Family income was positively associated with depression, Spearman's rho = 0.18, $p = 0.008$, anxiety, Spearman's rho = 0.27, $p < 0.001$, stress, Spearman's rho = 0.17, $p = 0.01$, and FoMO, $r = 0.40$, $p < 0.001$.

Correlations among the main study variables are shown in Table 2. In regard to Research Question 1, better knowledge of COVID-19 was related to lower loneliness, stress, anxiety, depression, and FoMO for adolescents. Pertaining to Research Question 2, accurate knowledge concerning COVID-19 was associated with lower social media use during daily activities and was weakly, positively correlated with frequency of checking social media. Self-reported frequency of checking social media was uncorrelated with the indicators of well-being assessed in this study. To provide further context concerning COVID-19 knowledge, it was negatively correlated with community population, Spearman's rho = −0.20, $p = 0.003$, positively related to frequency of seeking news about COVID-19, Spearman's rho = 0.19, $p = 0.005$, and uncorrelated with using social media to get news, Spearman's rho = 0.00, $p = 0.78$.

Correlations involving the impact of quarantine are displayed in Table 3. Consistent with Hypothesis 1, perceptions that quarantine interfered with aspects of adolescents' lives were moderately to strongly correlated with lower well-being

Table 3 Correlations involving indicators of quarantine impact

	Quarantine interference	Quarantine enhancement	Quarantine level
Depression[a]	0.60***	0.06	0.20**
Anxiety[a]	0.54***	0.19**	0.26***
Stress[a]	0.58***	0.08	0.24***
FoMO	0.57***	−0.29***	0.32***
Loneliness	0.64***	0.06	0.13
COVID knowledge[a]	−0.32***	−0.23***	−0.31***
Social media during daily activities	0.35***	0.13	−0.09
Frequency of checking social media[a]	0.10	−0.12	0.02

Higher scores on quarantine level = higher restrictions

[a]Correlations for COVID-19 knowledge and for Frequency of checking social media are Spearman's rho coefficients given their non-normal distributions

**p < 0.01; ***p < 0.001

(i.e., higher stress, anxiety, depression, loneliness, and FoMO). These perceptions were inversely related to COVID-19 knowledge. The same pattern was evident for the parent-reported level of quarantine (i.e., restrictions on activities due to COVID-19), such that more restrictions were moderately related to worse self-reported well-being. Similarly, perceptions that quarantine enhanced aspects of adolescents' lives were negatively associated with stress, depression, and FoMO, but these perceptions were positively associated with anxiety and negatively with COVID-19 knowledge.

Partial correlations involving depression, anxiety, stress, and FoMO, controlling for family income, did not change in comparison to their bivariate relations with COVID-19 knowledge, frequency of checking social media, and social

Table 4 Moderated multiple regression analyses examining interaction between social media engagement and COVID-19 knowledge in predicting adjustment

Criterion variable	Depression	Anxiety	Stress	Loneliness	FoMO
Predictor: Social media use during daily activities					
Step 1	$R^2 = 0.33$***	$R^2 = 0.40$***	$R^2 = 0.31$***	$R^2 = 0.21$***	$R^2 = 0.37$***
Gender	–	–	–	2.35 (1.17)*	0.54 (0.88)
Family income	0.41 (0.30)	0.74 (0.26)**	0.35 (0.30)	0.51 (0.71)	3.20 (0.54)***
COVID-19 knowledge	−0.78 (0.12)***	−0.93 (0.10)***	−0.78 (0.12)***	−1.19 (0.28)***	−0.77 (0.21)***
Social media use during daily activities	0.45 (0.08)***	0.24 (0.07)**	0.40 (0.08)***	0.81 (0.19)***	0.91 (0.15)***
Step 2	$\Delta R^2 = 0.01$	$\Delta R^2 = 0.01$	$\Delta R^2 = 0.01$	$\Delta R^2 = 0.00$	$\Delta R^2 = 0.00$
COVID-19 knowledge × Social media use during daily activities	−0.05 (0.03)	−0.04 (0.02)	−0.05 (0.03)	0.05 (0.07)	−0.03 (0.05)
Predictor: Frequency of checking social media					
Step 1	$R^2 = 0.22$***	$R^2 = 0.35$***	$R^2 = 0.22$***	$R^2 = 0.14$***	$R^2 = 0.28$***
Gender	–	–	–	3.29 (1.19)**	1.60 (0.91)
Family income	0.35 (0.34)	0.72 (0.28)*	0.30 (0.33)	0.39 (0.77)	2.82 (0.59)***
COVID-19 knowledge	−0.91 (0.13)***	−0.99 (0.11)***	−0.90 (0.13)***	−1.50 (0.30)***	−1.18 (0.23)***
Frequency of checking social media	0.26 (0.24)	0.03 (0.20)	0.32 (0.24)	0.01 (0.86)	1.50 (0.43)**
Step 2	$\Delta R^2 = 0.01$	$\Delta R^2 = 0.02$**	$\Delta R^2 = 0.01$	$\Delta R^2 = 0.01$	$\Delta R^2 = 0.00$
COVID-19 knowledge × Frequency of checking social media	0.11 (0.08)	0.19 (0.06)**	0.12 (0.08)	0.33 (0.18)	0.10 (0.14)

Unstandardized coefficients are shown with standard error in parentheses. Step 2 included control and main effects variables, but only interaction effects are shown for clarity

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

media use during daily activities. More specifically, all correlation coefficients changed by only 0.01–0.03 when controlling for family income. Controlling for gender, correlations for FoMO and loneliness in relation to COVID-19 knowledge, frequency of checking social media, and social media use during daily activities changed by a magnitude of only 0.00 to 0.03. Similarly, partial correlations between quarantine level, perceived interference from quarantine, FOMO, and loneliness, while controlling for gender, only changed the coefficients from 0.00 to 0.02. Controlling for family income also did not appreciably change the correlation coefficients between quarantine level and perceived interference from quarantine with adjustment. An exception was the correlation between quarantine level and FOMO, which changed from $r = 0.32$, $p < 0.001$, to $pr = 0.23$, $p = 0.001$. Thus, the correlations among the variables of interest pertaining to the Research Questions and Hypothesis 1 generally were not confounded by demographic variables.

Moderation Analyses

To test Hypothesis 2, the moderating effect of COVID-19 knowledge on the relations between social media engagement and well-being were investigated. Specifically, separate multiple regression models involving 2

predictors (i.e., social media use during daily activities; frequency of checking social media), 1 moderator (COVID-19 knowledge), and 5 criterion variables (i.e., depression, anxiety, stress, loneliness, FoMO) were analyzed (see Table 4). To help correct for family-wise error, an interaction was only considered significant at the $p < 0.01$ level of alpha. From these models, there was a significant interaction between COVID-19 knowledge and frequency of checking social media in the prediction of anxiety, $b = 0.19$, $se = 0.07$, $p = 0.005$, Model $R^2 = 0.35$, $p < 0.001$. Post hoc probing, according to the procedures outlined by Hayes (2013), was conducted to determine the nature of the interaction (see Fig. 1). As shown in Fig. 1, low COVID-19 knowledge (i.e., >1 SD below sample mean) was related to relatively high anxiety, independent of checking social media. However, better COVID-19 knowledge (i.e., ≥1 SD above sample mean) was associated with relatively less anxiety for teens who reported checking social media less often.

Finally, a series of multiple regression models were analyzed to test Hypothesis 3 (see Table 5). Specifically, there were 5 models tested with 1 predictor (i.e., quarantine level), 1 moderator (i.e., COVID-19 knowledge), and 5 well-being variables (i.e., depression, anxiety, stress, loneliness, FoMO). None of the interaction effects from these models were significant.

Fig. 1 Interaction between frequency of checking social media and COVID-19 knowledge in predicting anxiety symptoms. Low COVID-19 knowledge: $b = -0.28$, se $= 0.24$, $p = 0.25$; high COVID-19 knowledge: $b = 0.70$, se $= 0.29$, $p = 0.01$
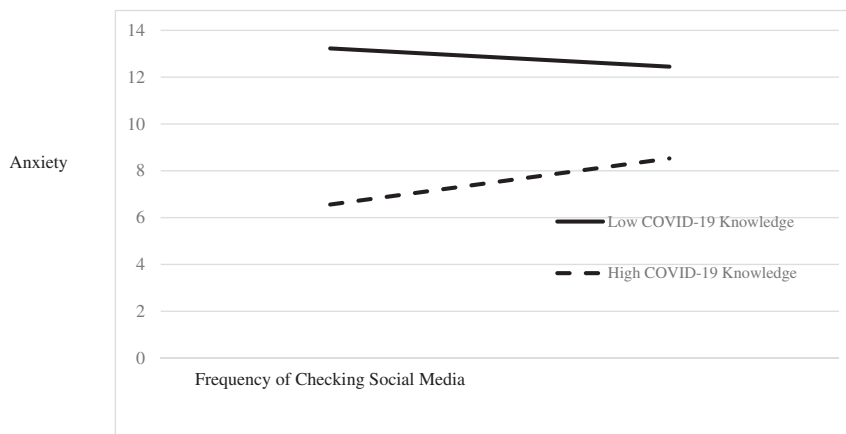
Table 5 Moderated multiple regression analyses examining interaction between quarantine level and COVID-19 knowledge in predicting adjustment

Criterion variable	Depression	Anxiety	Stress	Loneliness	FoMO
Step 1	$R^2 = 0.25$***	$R^2 = 0.38$***	$R^2 = 0.24$***	$R^2 = 0.15$***	$R^2 = 0.28$***
Gender	–	–	–	3.37 (1.16)**	2.01 (0.91)*
Family income	0.35 (0.33)	0.70 (0.27)*	0.28 (0.32)	0.53 (0.75)	2.93 (0.59)***
COVID-19 knowledge	−0.90 (0.13)***	−1.00 (0.10)***	−0.87 (0.13)***	−1.47 (0.29)***	−0.96 (0.23)***
Quarantine level	0.70 (0.61)	0.40 (0.51)	0.70 (0.60)	0.55 (1.41)	2.82 (1.11)*
Step 2	$\Delta R^2 = 0.00$	$\Delta R^2 = 0.00$	$\Delta R^2 = 0.00$	$\Delta R^2 = 0.01$	$\Delta R^2 = 0.01$
COVID-19 knowledge × Quarantine level	−0.12 (0.19)	−0.07 (0.16)	−0.12 (0.19)	−0.49 (0.45)	−0.35 (0.35)

Unstandardized coefficients are shown with standard error in parentheses. Step 2 model included control and main effects variables, but only interaction effects are shown for clarity

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Post Hoc Analyses

The correlations shown in Table 2 were repeated using scores on COVID under-estimation and over-estimation of risk instead of overall COVID knowledge. Under-estimation of risk was significantly correlated with each of the well-being variables (i.e., anxiety, depression, stress, loneliness, FOMO) with coefficients ranging from 0.28 (FOMO) to 0.52 (anxiety), all $p < 0.001$. A similar pattern was evident for over-estimation of risk with correlations ranging from 0.21 (loneliness) to 0.44 (anxiety), all $p < 0.01$. Underestimation of risk was correlated with social media use during daily activities, $r = 0.21$, $p = 0.002$, but the correlation between over-estimation of risk and social media use during daily activities was not significant, $r = 0.12$, $p = 0.08$. However, it should be noted that over and underestimation of COVID risk were significantly interrelated, $r = 0.54$, $p < 0.001$, which may reflect that many teens in this sample demonstrated accurate COVID-19 knowledge (i.e., low scores both on under- and over-estimation of risk). Neither of the risk estimation variables was associated with adolescent age, gender, or family income.

Discussion

The present study directly examined the relation of adolescent knowledge of COVID-19 with indicators of adjustment and well-being (i.e., loneliness, FoMO, depression, anxiety, stress), along with the role of social media in these relations. In addition, experiences of quarantine in relation to adolescent adjustment during the initial COVID-19-related lockdowns were investigated. Developmentally, quarantine or related social distancing were theoretically thought to negatively impact socialization opportunities, particularly with peers, which are paramount during adolescence.

Importantly, accurate knowledge of COVID-19 was related to better well-being across measures (i.e., lower anxiety, stress, depression, FoMO, loneliness). In this sense, knowledge could be a protective factor against distress in an otherwise difficult or uncertain time. Therefore, public health efforts to ensure that adolescents receive accurate medical information appear to have psychosocial benefits. Importantly, these associations appeared independent of demographic factors such as adolescent age, gender, and

SES. Furthermore, social media engagement did not generally moderate this relation. An exception was that more frequent checking of social media among adolescents with good COVID-19 knowledge was related to somewhat higher anxiety than was reported by adolescents with good COVID-19 knowledge but low frequency of checking social media. On the one hand, the pattern of this interaction underscored the apparent benefits of accurate COVID-19 knowledge in the present adolescent sample (Fig. 1). On the other hand, the protective benefits of COVID-19 knowledge appeared limited in the context of high social media use. COVID-19 knowledge was associated with seeking news about the virus but not with using social media for such purposes. Therefore, although social media may serve as an important source of interpersonal connectedness for adolescents, more cautious use may be warranted during times of crisis, such as the initial escalation of the COVID-19 pandemic. This point is supported by evidence that social media is a conduit of misinformation (Brown et al., 2019; Islam et al., 2020; Su, 2021).

We also specifically examined whether over- or underestimation of risk was associated with demographic factors as well as adolescent adjustment as an extension of our investigation of overall COVID-19 knowledge. Age, gender, and SES were not related to misunderstanding of risk. However, both over- and under-estimation of risk were related to maladjustment as conceptualized in this study. That is, inaccurate information/knowledge in either direction was associated with greater feelings of distress and isolation among adolescents. Again, these findings emphasize the importance of accurate public health information for young people during significant events such as the COVID-19 pandemic.

In the present study, the connections of social media engagement with accurate COVID-19 knowledge and well-being were mixed. Use of social media during daily activities was associated with less accurate knowledge of COVID-19, as well as with symptoms of anxiety, stress, and depression. However, reported frequency of checking social media had a small positive relation with COVID-19 knowledge and was generally unrelated to mental health. Thus, social media engagement did not appear to have a uniformly positive or negative impact on adolescents' adjustment during the initial months of the COVID-19 pandemic. Instead, the extent to which social media interfere with, or are present during, teens' daily activities may be an important indicator of distress or maladjustment, as might be the specific content and intentions that govern adolescent social media use. These issues need more specific consideration in future research.

In addition, the COVID-19 pandemic brought quarantine/lockdown and social distancing for individuals in many locations, including throughout the United States. In the present sample, a higher degree of reported quarantine restrictions was associated with greater distress (i.e.,

anxiety, depression, stress, FoMO) but was not significantly associated with loneliness. More importantly, perceptions that quarantine/lockdown interfered with relationships and other aspects of adolescents' lives were clearly associated with indices of distress, including loneliness, with these correlations being moderate to high in magnitude (Table 3). Other research points to similar experiences for youth in Australia (Sciberras et al., 2020) and Switzerland (Werling et al., 2022), with distress reported across domains related to quarantine or lockdowns, and in the latter study, in relation to media use. These findings indicate the disruptiveness of quarantine for adolescents during the COVID-19 pandemic and a need for attention to increased or emerging distress from this highly atypical experience. It should also be noted that adolescents who self-reported relatively greater enhancement of experiences due to quarantine also tended to have lower COVID-19 knowledge. It may be that adolescents with higher COVID-19 knowledge were more apt to recognize that quarantine/lockdown was not ideal in terms of their social lives, even if it was deemed necessary for containing the spread of the virus. In general, based on these correlations, one's mindset regarding experiences, such as quarantine, may play a role in concurrent adjustment. Importantly, recent evidence indicates that supportive friendships were an important social factor in preventing increases in internalizing problems during the initial phase of the COVID-19 pandemic (Bernasco et al., 2021). Intervention efforts might, then, be best directed toward fostering peer support and a positive mindset during times of widespread social isolation for adolescents.

Limitations

This study had a number of limitations that must be considered in interpreting the findings. First, the cross-sectional design does not allow for conclusions about the temporal connections between the variables of interest. For example, it is unclear whether relatively poor knowledge of COVID-19 precipitated feelings of distress or whether adolescents suffering from distress seek and/or use less reliable sources of information. Further, the sample consisted mostly of adolescents who identified as White; thus, the generalizability of the findings to the broader population of adolescents is uncertain, particularly for minoritized populations which are known to have borne the brunt of the pandemic (Fortuna et al., 2020). In addition, the study relied almost entirely on adolescent self-report, and although self-report is essential for measuring many of the constructs in this study (e.g., loneliness, depression, perceived interference/enhancement), shared source variance may have accounted for some of the observed relations. Thus, a broader array of measurement approaches would allow for a more comprehensive understanding of the issues considered

in this study. As noted above, some of the measures were developed for the purposes of this study, so further work is needed to determine the psychometric properties and utility of these tools for broader samples and research questions. The Impact of Quarantine measure did not show a robust two-factor solution (see Supplementary Analysis); however, the overall pattern of results, including the interrelation between the two theoretical factors, demonstrated that adolescents were likely to perceive both positive and negative aspects of quarantine/lockdown.

An additional issue is the array of unassessed personal and contextual factors that might have a role in adolescent COVID-19 knowledge and adjustment. We attempted to consider some such factors such as community size, family income, and gender, but there may be other relevant variables that are informative for adolescent well-being during the pandemic. Lastly, we caution against overinterpretation of the interaction involving anxiety, as similar regression models for other indicators of well-being did not yield a similar finding; thus, replication of such a model, particularly at different stages of a public health issue or crisis is needed.

Conclusions and Future Directions

The COVID-19 pandemic has altered day-to-day social life in clear and pervasive ways, and evidence is now emerging as to the mental health-related experiences of young people during the pandemic. A key finding from the present study is that accurate knowledge of COVID-19 was related to better adolescent mental health and sense of well-being. Clearly, longitudinal studies are needed to determine the longer-term psychological outcomes from COVID-19 knowledge and experiences. However, risk perception and knowledge about infectious disease can not only influence people's engagement in preventive behaviors (Fleary et al., 2018) but also potentially decrease negative psychosocial outcomes. Although adolescents in our study had generally good knowledge of COVID-19, addressing gaps in knowledge, in addition to fostering social support (Bernasco et al., 2021), can have benefits in terms of both physical and mental health. Furthermore, attention is needed concerning the sources of adolescents' health information (e.g., social media), as inaccurate knowledge can result in problematic health behaviors and generally worse well-being. Lastly, the unique and novel experience of quarantine during the pandemic points to expected difficulties (i.e., distress, loneliness) perhaps especially when considering the social and emotional developmental context of adolescence. For adolescents encountering potentially catastrophic events, whether at the global or community-specific level, best practices may be to ensure accurate age-appropriate information about the situation and opportunities for continued social connectedness to others.

Data availability

The data from this study are available from S.Z.M. upon request.

Compliance with Ethical Standards

Appendix. COVID-19 Knowledge Items (True/False)

1. Knowing the facts about COVID-19 symptoms and how it spreads will help protect us and our community. (True)
2. There is a lot of misinformation about COVID-19, so it's important to check information from a reliable resource. (True)
3. Information on Facebook and other social media regarding COVID-19 is always reliable. (False)
4. Most of the people who get COVID-19 will get very sick or die. (False)
5. COVID-19 only affects people older than 50, so young people don't have to worry. (False)
6. Drinking lots of hot drinks stops COVID-19. (False)
7. COVID-19 can transmit through coughs, sneezes, or respiratory droplets. (True)
8. COVID-19 usually presents with a cough but can have other symptoms such as fever. (True)
9. Washing your hands with soap and water helps prevent COVID-19. (True)
10. If someone is not coughing, it means that they do not have COVID-19. (False)
11. Hospitals are contaminated, so anyone who goes there will get COVID-19. (False)
12. Ordering or buying products shipped from overseas will make a person sick. (False)
13. Only people with visible symptoms of COVID-19 are capable of spreading the virus. (False)
14. COVID-19 is no worse than the seasonal flu. (False)
15. Everyone who has COVID-19 knows that they have it. (False)
16. Spraying alcohol, chlorine, or another disinfectant all over one's body will kill COVID-19. (False)
17. Only people who have symptoms of COVID-19 should wear masks in public. (False)

18. The United States has had more cases of COVID-19 than any other country in the world. (True)

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