

## Time Spent Using Digital Technology, Loneliness, and Well-Being Among Three Cohorts of Adolescent Girls and Boys – A Moderated Mediation Analysis

Boris Jokić, Zrinka Ristić Dedić, and Jana Šimon

Institute for Social Research in Zagreb, Zagreb, Croatia

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### Abstract

Significant changes to daily life and educational routines due to the COVID-19 pandemic resulted in changes in social interactions and might have contributed to an increase in screen-based activities, loneliness, and mental health issues among adolescents. Two years after the pandemic outbreak, the present study examined the relationships between time spent using digital technology (DT), loneliness and well-being among three cohorts of adolescents in Croatia. A moderated mediation model of relationship between time spent using DT and well-being was tested, with loneliness as a potential mediator and gender as a moderator. A nationally representative sample included 3706 11-year-olds, 3866 13-year-olds and 8815 17-year-olds. The study was conducted in lower and upper secondary schools in the spring of 2022. The questionnaire contained a single item self-report measure of time spent using DT and loneliness, while the adapted WHO-5 was used for measuring adolescents' well-being. Results indicated that time spent using DT was positively associated with loneliness and negatively associated with well-being. Loneliness mediated the relationship between time spent using DT and well-being in all cohorts. This mediation was moderated by gender in the group of 11-year-olds only. Gender moderated the direct effect on well-being among 11- and 13-year-olds. Effects were stronger among girls and younger participants. The results are discussed in light of the displacement hypothesis, which posits that negative effects on well-being are a consequence of the replacement of in-person activities with screen-based activities.

*Keywords:* time spent using digital technology, well-being, loneliness, adolescents, gender differences

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Boris Jokić  <https://orcid.org/0000-0001-6640-9755>

Zrinka Ristić Dedić  <https://orcid.org/0000-0002-7520-2139>

Jana Šimon  <https://orcid.org/0000-0001-7585-0286>

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✉ Boris Jokić, Institute for Social Research in Zagreb, Amruševa 11, 10000 Zagreb, Croatia.  
E-mail: [boris@idi.hr](mailto:boris@idi.hr)

## Introduction

Even prior to the COVID-19 pandemic, there was robust evidence indicating that screen-based activities have become a normative way of spending time and communicating for adolescents globally (e.g., Twenge et al., 2019). Significant changes to daily life and educational routines and practices due to the pandemic resulted in a further increase in the time spent using digital technologies (DT) (Kastorff et al., 2023). Both quantitative (Jokić et al., 2022; Vejmelka & Matković, 2021) and qualitative (Žulec et al., 2023) research with Croatian samples have supported these claims. From a developmental perspective, the most significant increase in time spent in screen-based activities occurs in early adolescence during the transition from primary to lower secondary education (Booker et al., 2018; World Health Organization [WHO], 2020). Longitudinal and cross-national time-use studies indicate that boys report more frequent screen-time behaviours than girls and experience a greater increase in the time spent using DT with age (Gracia et al., 2022).

Extensive research on the relationship between time spent using DT and various psychological outcomes among adolescents have yielded diverse results, ranging from a linear negative association (e.g., Orben & Przybylski, 2019) to a non-linear association (e.g., Przybylski & Weinstein, 2017), no association (e.g., Best et al., 2014) and a positive association (e.g., Antheunis et al., 2016). This relationship becomes even more important considering evidence demonstrating the negative effects of the pandemic on various aspects of psychological functioning, including well-being and loneliness, among adolescents (Farell et al., 2023; Loades et al., 2020). These negative effects were more prominent among older adolescents and girls (Kauhanen et al., 2023; Samji et al., 2022).

In this paper, based on the results of a large-scale study with nationally representative samples of three cohorts of Croatian adolescents, we aim to model the relationship between time spent using DT, loneliness, and well-being two years into the COVID-19 pandemic. Consistent with previous research, we also aim to examine whether gender moderates the relationship between time spent using DT and loneliness and time spent using DT and well-being. Because the focus is on the effects of time spent using DT on the two aforementioned psychological concepts; the moderating effect of gender on the relationship between loneliness and well-being was not investigated.

### Time Spent Using DT and Well-Being

Diverse theoretical and conceptual approaches have been applied to examining the relationship between use of DT and well-being. The *stimulation hypothesis* specifies that use of DT can be beneficial to well-being by offering opportunities to connect, reconnect and make new connections with others (Valkenburg & Peter,

2007). The *Digital Goldilocks hypothesis* proposes a non-linear relationship between involvement in digital activities and adolescents' well-being, emphasising the importance of moderation in use (Przybylski & Weinstein, 2017). The dominant *displacement hypothesis* suggests a negative relationship between use of DT and well-being as a result of disruptions to personal relationships, leisure time activities and other spheres of life that can come with increased DT use (Kraut et al., 1998). Numerous studies have found time spent using DT is associated with various negative well-being and psychological outcomes, such as lower levels of perceived life quality, school life satisfaction and self-esteem as well as higher levels of reported anxiety and depression symptoms (e.g., Forte et al., 2023). Studies in the Croatian context corroborate these findings (Bilić, 2023; Perić et al., 2022; Varga et al., 2022). Furthermore, longitudinal studies suggest that changes in total recreational screen time are negatively associated with adolescents' psychological well-being (Babic et al., 2017).

Some studies indicate that time spent using DT is more strongly associated with lower levels of well-being among girls than boys (Twenge & Martin, 2020). Explorations of the relationship between different online activities and psychological outcomes including well-being suggest that negative effects of such activities are more robust for girls than boys (Twenge & Farley, 2021). Similar conclusions were drawn in a cross-sectional study conducted by Svensson et al. (2022), who found that social media use is associated with higher levels of depression, anxiety, and loneliness symptoms among girls. In the Croatian context, results from a longitudinal study conducted by Keresteš and Štulhofer (2020) indicated that girls who spent more time using online social networks expressed lower levels of life satisfaction. Furthermore, in comparison to boys, girls spent more time using online social networks and expressed lower levels of life satisfaction overall. Although there is a significant amount of research examining the relationship between DT and well-being among children and youth, the period covering the transition from childhood to early adolescence seems to be less researched (Odgers & Jensen, 2020). Some studies indicate that the negative correlation between time spent using DT and well-being is larger for older than for younger adolescents (Shafi et al., 2019). Even so, research indicates adverse effects even among lower secondary school pupils (Bruggeman et al., 2019). It is important to note that most studies yielded a small-to-moderate negative effect of time spent using DT on various psychological outcomes (e.g., Dienlin & Johannes, 2020; Meier & Reinecke, 2021), warranting more research on this topic, especially from developmental and gender perspectives, as well as caution in interpreting the results.

### **Digital Technology Use, Loneliness, and Well-Being**

Loneliness, defined as the perception of deficient social relationships leading to negative emotions (Goossens, 2018), represents a risk factor for negative mental and physical health outcomes (Xerxa et al., 2021). Even prior to the pandemic, studies

have demonstrated an increase in perceived loneliness among adolescents (Twenge et al., 2019). This increase has been notably larger in girls than in boys and higher levels of loneliness have consistently been correlated with lower levels of well-being among adolescents (e.g., Twenge et al., 2021). DT use has been cited as a significant factor impacting perceived levels of loneliness (MacDonald & Schermer, 2021; O'Day & Heimberg, 2021). One of the most negative aspects of the COVID-19 pandemic was an increase in perceived loneliness among adolescents from various age cohorts (Farell et al., 2023). An experimental study with college students indicated that limiting social media usage leads to a decrease in loneliness (Hunt et al., 2018), suggesting a causal path from time spent using DT to loneliness. Of importance for our research, some studies have reported that loneliness plays a mediating role in the relationship between use of DT and well-being among college students (Gong et al., 2021). This is consistent with the robust finding that in-person social interaction is a protective factor against loneliness (e.g., Pea et al., 2012), where a decline in in-person social interaction may have led to both an increase in time spent using DT and loneliness.

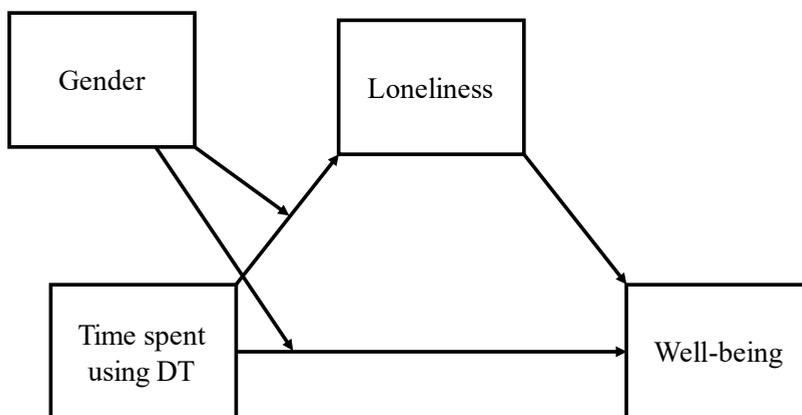
### **The Present Study**

The present study explores the relationships between time spent using DT, loneliness, and well-being in three generations of adolescents: those in the 5<sup>th</sup> grade of Croatian lower secondary education (average age: 11 years), 7<sup>th</sup> grade of lower secondary education (average age: 13 years) and 3<sup>rd</sup> grade of upper secondary education (average age: 17 years). The decision to conduct cohort specific analytical procedures was informed by the knowledge of differing organisational structures and functioning of educational institutions at different levels and a wish to inform targeted policy measures aimed at different stages of adolescence in the Croatian context. To our knowledge, it is one of the few studies (and the first study in Croatia) exploring this issue across three cohorts at different stages of adolescence and, therefore, addresses a need for such research in the national context (Perić et al., 2022).

The aims of the present study are twofold. First, we tested whether loneliness mediates the relationship between time spent using DT and well-being. Secondly, we explored whether gender moderated the relationship between time spent using DT and loneliness, and between time spent using DT and well-being. The model of moderated mediation is presented in Figure 1.

**Figure 1**

*Model of Moderated Mediation*



We proposed and tested the following hypotheses across three cohorts of adolescents:

Hypothesis 1. Time spent using DT is negatively associated with well-being.

Hypothesis 2. Loneliness mediates the relationship between time spent using DT and well-being.

Hypothesis 3. Gender moderates the direct (H1) and indirect (H2) relationship between time spent using DT and well-being. The effects of time spent using DT on loneliness and well-being are stronger for girls than for boys.

## Method

### Participants

This study was conducted with a random stratified sample of 81 elementary (single structure primary and lower secondary schools) and 83 upper secondary schools. School location (6 regions in Croatia) served as stratum for sampling in both elementary and upper secondary schools. An additional stratum of type of programme (vocational education and training [VET], gymnasium or both) was used for sampling upper secondary schools. The number of schools reflects the proportion of each stratum within the population. In each selected school, all pupils in the target age cohorts (5<sup>th</sup> and 7<sup>th</sup> grades in elementary schools and 3<sup>rd</sup> grade in upper secondary schools) were invited to participate. In total, 3706 5<sup>th</sup> grade and 3866 7<sup>th</sup> grade pupils participated in the study. This sample represents 10.8% (5<sup>th</sup> grade) and 11.2% (7<sup>th</sup>

grade) of the total number of pupils in the respective elementary school cohorts in Croatia. The average age of pupils in 5<sup>th</sup> and 7<sup>th</sup> grades was 11 and 13 years, respectively. The upper secondary school sample included pupils in the 3<sup>rd</sup> grade of gymnasium and VET programmes, with an average age of 17 years. Overall, 8815 3<sup>rd</sup> grade pupils participated in the research, representing 24.7% of the total number of pupils attending this grade in Croatia. The samples in each cohort consisted of approximately equal numbers of girls and boys (50.8% girls in 5<sup>th</sup> grade, 49.5% in 7<sup>th</sup> grade and 52.9% in 3<sup>rd</sup> grade).

## **Procedure**

Data collection was carried out face-to face in May and June of 2022, when school coordinators administered questionnaires during regular school lessons. In elementary schools, only those pupils with parental consent were granted participation. Average return rate of parental consent and participation across schools was 86.1% in 5<sup>th</sup> grade and 84.4% in 7<sup>th</sup> grade cohort. The average time of completion ranged between 31 to 39 minutes depending on the cohort. The study was conducted in compliance with all ethical principles of research involving children and young people and received authorisation from the Croatian Ministry of Science and Education and the approval of the Ethics Committee of the Institute for Social Research in Zagreb (no. 03/2021).

## **Measures**

### ***Well-Being***

Well-being was assessed using an adapted version of the World Health Organisation Well-Being Scale-WHO-5 (WHO, 1998). This 5-item instrument measures well-being in the period of the previous two weeks (examples of items: “I have felt calm and relaxed. I woke up feeling fresh and rested.”). The original 6-point response scale (0-5: *at no time – all the time*) was replaced with a 5-point scale (1-5: *never to almost always*). This adaptation was conducted after piloting of the initial version of the questionnaire for reasons of clarity and comprehension, which revealed that the youngest cohort had problems answering items using the original scale format. The total score was calculated as the average of responses on all items. Using confirmatory factor analysis and the maximum likelihood procedure in Mplus (Muthén & Muthén, 2007), a good-to-excellent fit was confirmed for all three cohorts (root mean square error of approximation [RMSEA]<sub>range</sub> = .06–.07, comparative fit index [CFI]<sub>range</sub> = .98–1.00, root mean square residual [SRMR]<sub>range</sub> = .01–.02). Although the Chi-square ( $\chi^2$ ) values were all statistically significant at  $p < .001$ , the fit was deemed acceptable as  $\chi^2$  values were inflated due to large sample sizes. Scale reliability was deemed adequate for all cohorts (Cronbach  $\alpha_{range}$  = .84–.88).

### ***Time Spent Using Digital Technology***

A single item self-report measure of time spent using DT was used for the purposes of this study. This general measure encompasses time spent engaged in all types of activities on various digital devices excluding school tasks. Participants were asked: “Think about your typical workday (from Monday to Friday), how much time do you spend using digital technology (mobile phone, computer, tablet, PlayStation etc.) excluding conducting school tasks?” Responses were given on a 6-point scale, ranging from 0 to 5: *not at all*, *up to 1 hour daily*, *1–2 hours daily*, *2–3 hours daily*, *3–4 hours daily* and *more than 4 hours daily*. The decision to use the workday as a reference point was made due to the qualitative and quantitative differences in adolescent DT use during school days and weekends (Smahel et al., 2020). The exclusion of DT use related to school tasks serves the purpose of exploring time spent using DT on activities that were not assigned to adolescents by the educational system. Between 1.3% and 3.3% of participants (across cohorts) in the present study reported no DT use whatsoever and they were excluded from further analyses.

### ***Loneliness***

Loneliness was assessed using a single self-report item asking adolescents to report how frequently they felt lonely over the previous two weeks: “How often did you feel lonely in the last two weeks?” Responses were given on a 5-point scale ranging from 1 (*never*) to 5 (*almost always*). This single item measure of loneliness has been frequently used in large-scale panel surveys. Mund and colleagues (2023) found that the scores on single-item measures of loneliness possess adequate reliability and correlate highly with other well-known self-report measures of loneliness and informant-ratings.

### ***Statistical Analysis***

The linearity of the relationship between time spent using DT and psychological outcomes (loneliness and well-being) was tested for participants who reported using digital technology (responses from 1 = *up to 1 hour daily* to 5 = *more than 4 hours daily*). The relationships between time spent using DT and loneliness and time spent using DT and well-being were both linear in all cohorts, thus justifying further analytical procedures.

The proposed moderated mediation model was tested separately with three cohorts (Hayes’ PROCESS macro in SPSS 20.0 - Model 8; Hayes, 2022) using a bootstrapping approach (bias-corrected 95% confidence intervals, based on 5000 random samples). We tested the conditional direct effect of time spent using DT (predictor variable) on well-being (outcome variable) and the conditional indirect effect of time spent using DT on well-being via loneliness (mediator variable), while also examining the moderating effects of gender on the direct and indirect effects of

time spent using DT and well-being. Time spent using DT as the predictor variable was centred prior to the analysis.

## Results

### Preliminary Analysis

Descriptive statistics for the study variables are reported in Table 1. All correlation coefficients were statistically significant at  $p < .001$ . As expected, negative associations were found between time spent using DT and well-being, as well as between loneliness and well-being. Time spent using DT was positively related to loneliness. Girls had lower scores on the well-being measure and reported higher levels of loneliness in comparison to boys. The sizes of correlations were weak to moderate, with the exception of the association between loneliness and well-being, which was moderate to large.

**Table 1**

*Descriptive Statistics and Correlations of Study Variables*

	<i>M</i>	<i>SD</i>	1	2	3
11-year olds (5 <sup>th</sup> GRADE) <sup>a</sup>					
1. Time spent using DT	2.59	1.27			
2. Loneliness	2.02	1.12	.14***		
3. Well-being	3.66	0.87	-.19***	-.41***	
4. Gender	-	-	.09***	-.10***	.13***
13-year olds (7 <sup>th</sup> GRADE) <sup>b</sup>					
1. Time spent using DT	3.40	1.33			
2. Loneliness	2.29	1.18	.16***		
3. Well-being	3.32	0.94	-.17***	-.45***	
4. Gender	-	-	-.06***	-.19***	.27***
17-year olds (3 <sup>rd</sup> GRADE) <sup>c</sup>					
1. Time spent using DT	3.65	1.28			
2. Loneliness	2.43	1.15	.08***		
3. Well-being	3.21	0.91	-.08***	-.45***	
4. Gender	-	-	-.09***	-.15***	.26***

*Note.* Gender: -1 = female; 1 = male. <sup>a</sup> $n = 3379$ . <sup>b</sup> $n = 3616$ . <sup>c</sup> $n = 8314$ .

\*\*\* $p < .001$ .

The association between gender and time spent using DT was small but depended on age cohort. Among 11-year-olds, boys reported spending more time using DT. However, in the 7<sup>th</sup> grade of lower secondary school and the 3<sup>rd</sup> upper-secondary grade, girls reported spending more time using DT.

## Moderated Mediation Analysis

Table 2 presents the estimated unstandardised coefficients of the moderated mediation models for all three cohorts.

**Table 2**

*Estimated Unstandardised Coefficients of the Moderated Mediation Models*

Variables	Mediator: Loneliness			DV: Well-being		
	<i>b</i>	<i>SE</i>	<i>t</i>	<i>b</i>	<i>SE</i>	<i>t</i>
<b>11-YEAR-OLDS<sup>a</sup></b>						
Time spent using DT	0.14	0.02	9.14***	-0.10	0.01	-8.97***
Gender	-0.13	0.02	-6.57***	0.09	0.01	6.57***
Loneliness				-0.30	0.01	-24.26***
Time spent using DT x Gender	-0.05	0.02	-3.32***	0.03	0.01	3.24**
Constant	2.03	0.02	106.47***	4.25	0.03	150.94***
<i>R</i> <sup>2</sup>	.04			.20		
<i>F</i>	42.40***			210.65***		
<b>13-YEAR-OLDS<sup>b</sup></b>						
Time spent using DT	0.13	0.01	9.24***	-0.06	0.01	-6.15***
Gender	-0.22	0.02	-11.31***	0.18	0.01	12.69***
Loneliness				-0.32	0.01	-26.58***
Time spent using DT x Gender	-0.02	0.01	-1.64	0.04	0.01	3.47***
Constant	2.29	0.02	119.94***	4.04	0.03	132.70***
<i>R</i> <sup>2</sup>	.06			.25		
<i>F</i>	76.80***			294.32***		
<b>17-YEAR-OLDS<sup>c</sup></b>						
Time spent using DT	0.06	0.01	6.32***	-0.02	0.01	-3.17**
Gender	-0.16	0.01	-13.04***	0.18	0.01	19.73***
Loneliness				-0.33	0.01	-43.09***
Time spent using DT x Gender	0.00	0.01	-0.41	0.00	0.01	0.60
Constant	2.41	0.01	193.69***	4.03	0.02	195.59***
<i>R</i> <sup>2</sup>	.03			.24		
<i>F</i>	75.33***			652.33***		

*Note.* Gender: -1 = female; 1 = male; Unstandardised regression coefficients (b) are reported. Time spent using DT was centred prior to analyses. <sup>a</sup>*n* = 3379. <sup>b</sup>*n* = 361. <sup>c</sup>*n* = 8314.

\*\**p* < .01. \*\*\**p* < .001.

The summaries of conditional indirect and direct effects are presented in Table 3.

**Table 3**

*Summary of Conditional Indirect and Conditional Direct Effects of the Moderated Mediation Model*

	Paths and effects						Index of moderated mediation
	Time spent using DT → Loneliness		Direct effect: Time spent using DT → Well-being		Indirect effect: Time spent using DT → Well-being via Loneliness		
	F	M	F	M	F	M	
<b>11-YEAR-OLDS<sup>a</sup></b>							
Estimates	.19	.09	-.13	-.06	-.06	-.03	.03
Boot SE	.02	.02	.02	.02	.01	.01	.01
95% CI	[.15, .23]	[.05, .13]	[-.16, -.10]	[-.09, -.03]	[-.07, -.04]	[-.04, -.01]	[.01, .05]
<b>13-YEAR-OLDS<sup>b</sup></b>							
Estimates	-	-	-.10	-.03	-.05	-.04	.02
Boot SE	-	-	.02	.02	.01	.01	.01
95% CI	-	-	[-.13, -.07]	[-.06, .00]	[-.06, -.04]	[-.05, -.02]	[.00, .03]
<b>17-YEAR-OLDS<sup>c</sup></b>							
Estimates	-	-	-.03	-.02	-.02	-.02	.00
Boot SE	-	-	.01	.01	.01	.01	.01
95% CI	-	-	[-.05, -.01]	[-.04, .00]	[-.03, -.01]	[-.03, -.01]	[-.01, .02]

*Note.* Gender: F = females; M = males. The dash (-) denotes that PROCESS macro did not calculate conditional effects, as no significant interaction term coefficient was found; <sup>a</sup>*n* = 3379. <sup>b</sup>*n* = 3616. <sup>c</sup>*n* = 8314.

**11-Year-Olds – 5<sup>th</sup> Grade of Lower Secondary Education**

For 11-year-olds, the model suggested a mediating effect of loneliness and moderating effect of gender (Figure 2). The interaction between time spent using DT and gender had a significant effect on loneliness ( $b = -.05, p < .001, 95\% \text{ CI } [-.08, -.02]$ ), indicating that the association between time spent using DT and loneliness was moderated by gender (this moderating effect is depicted in Figure A1 in the Appendix). Spending more time using DT led to higher levels of loneliness for both genders, but this association was stronger among girls (estimate = .19,  $p < .001, 95\% \text{ CI } [.15, .23]$ ) than boys (estimate = .09,  $p < .001, 95\% \text{ CI } [.05, .13]$ ).

The indirect effect of time spent using DT on well-being via loneliness was significant for both genders (girls =  $-.06, 95\% \text{ CI } [-.07, -.04]$ ; boys =  $-.03, 95\% \text{ CI } [-.04, -.01]$ ) in this age cohort. The bias-corrected percentile bootstrap CI demonstrated that the index of moderated mediation (IMM) was statistically significant (IMM = .03,  $95\% \text{ CI } [.01, .05]$ ), suggesting that the indirect effect was

moderated by gender. Again, the indirect effect of DT use on well-being through loneliness was stronger among girls than among boys.

In addition, there was evidence of moderation of the direct effect by gender, as the interaction term of time spent using DT and gender had a significant predictive effect on well-being ( $b = .03, p < .01, 95\% \text{ CI } [.01, .06]$ ). While the conditional direct effects of time spent using DT on well-being were significant for both girls (estimate =  $-.13, p < .001, 95\% \text{ CI } [-.16, -.10]$ ) and boys (estimate =  $-.06, p < .001, 95\% \text{ CI } [-.09, -.03]$ ), this direct effect was stronger for girls (see Figure A2 in the Appendix). Holding loneliness constant, an increase in time spent using DT was associated with a steeper decrease in well-being for girls than for boys. As a whole, the moderated mediation model explained 20.0% of the variance in well-being among fifth graders.

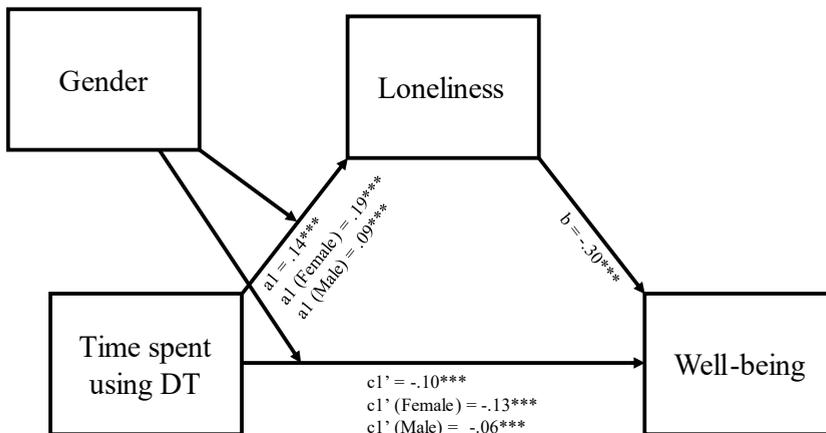
### 13-Year-Olds – 7<sup>th</sup> Grade of Lower Secondary Education

In the sample of 13-year-olds, the interaction term of time spent using DT and gender did not predict loneliness ( $b = -.02, p > .05, 95\% \text{ CI } [-.05, .00]$ ). As such, the conditional effects of time spent using DT on loneliness were not calculated.

The conditional indirect effects of time spent using DT on well-being via loneliness was significant for both genders (estimate =  $-.05, 95\% \text{ CI } [-.06, -.04]$ ; estimate =  $-.04, 95\% \text{ CI } [-.05, -.02]$ , for girls and boys respectively). These results supported the mediating effect of loneliness, but the index of moderated mediation was not significant ( $\text{IMM} = .02, 95\% \text{ CI } [.00, .03]$ ), suggesting that the observed mediation was not moderated by gender.

**Figure 2**

*Moderated Mediation Model of Time Spent Using DT on Well-being via Loneliness, with Gender as a Moderator Variable Among 11-Year-Olds*



Note.  $a1$  = unstandardised regression coefficient of relationship between time spent using DT and loneliness;  $b$  = unstandardised regression coefficient of relationship between loneliness and well-being;  $c1'$  = unstandardised regression coefficient of relationship between time spent using DT and well-being.

\*\*\*  $p < .001$ .

The direct effect of time spent using DT on well-being was moderated by gender ( $b = .04, p < .001, 95\% \text{ CI } [.02, .06]$ ). For girls, time spent using DT significantly predicted well-being (estimate =  $-.10, p < .001, 95\% \text{ CI } [-.13, -.07]$ ), while for boys the relationship became non-significant (estimate =  $-.03, p > .05, 95\% \text{ CI } [-.06, .00]$ ) (see Figure 3 and Figure A3 in the Appendix).

In total, the model for the 13-year-olds explained 25.0% of the variance in their well-being.

### 17-Year-Olds – 3<sup>rd</sup> Grade of Upper Secondary Education

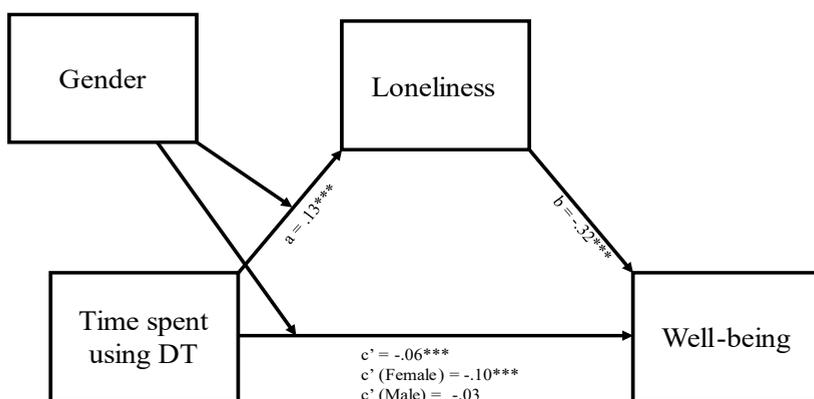
In the sample of 17-year-olds, the interaction term of time spent using DT and gender did not predict loneliness ( $b = .00, p > .05, 95\% \text{ CI } [-.02, .02]$ ).

The conditional indirect effect of time spent using DT on well-being via loneliness was confirmed for both genders and indicated a mediating role of loneliness. The values of these conditional indirect paths were identical for girls and boys (estimate =  $-.02, 95\% \text{ CI } [-.03, -.01]$ ). No moderating effect of gender on this indirect path was observed. The index of moderated mediation was not statistically significant (IMM =  $.00, 95\% \text{ CI } [-.01, .02]$ ), suggesting that the observed mediation is not moderated by gender.

In addition, gender did not moderate the direct effects of time spent using DT on well-being, as the interaction terms of time spent using DT and gender was not statistically significant ( $b = .00, p > .05, 95\% \text{ CI } [-.01, .02]$ ). However, the results indicated that the conditional direct effect of time spent using DT on well-being was observed only for girls (estimate =  $-.03, p < .01, 95\% \text{ CI } [-.05, -.01]$ ), while it was non-significant among boys (estimate =  $-.02, p > .05, 95\% \text{ CI } [-.04, .00]$ ). Overall, the model for 17-year-olds explained 24.0% of the variance in their well-being.

**Figure 3**

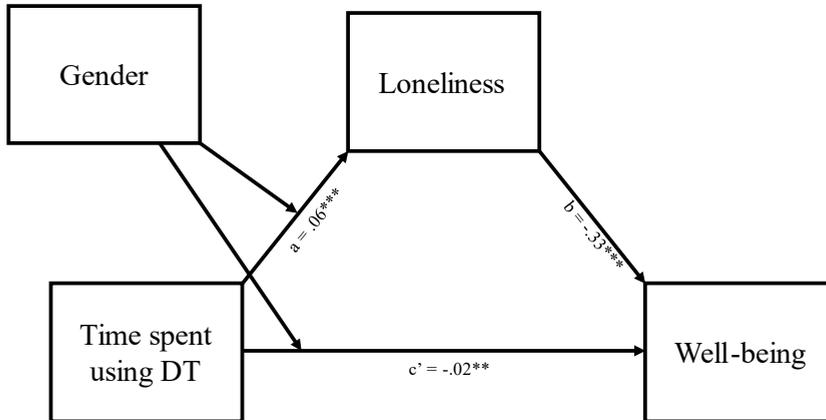
*Moderated Mediation Model of Time Spent Using DT on Well-being via Loneliness, with Gender as a Moderator Variable Among 13-Year-Olds*



Note.  $a$  = unstandardised regression coefficient of relationship between time spent using DT and loneliness;  $b$  = unstandardised regression coefficient of relationship between loneliness and well-being;  $c'$  = unstandardised regression coefficient of relationship between time spent using DT and well-being.  
 $*** p < .001$ .

**Figure 4**

*Moderated Mediation Model of Time Spent Using DT on Well-being via Loneliness, with Gender as a Moderator Variable Among 17-Year-Olds*



Note.  $a$  = unstandardised regression coefficient of relationship between time spent using DT and loneliness;  $b$  = unstandardised regression coefficient of relationship between loneliness and well-being;  $c'$  = unstandardised regression coefficient of relationship between time spent using DT and well-being.

\*\* $p < .01$ . \*\*\* $p < .001$ .

## Discussion

Moderated mediation analysis tested the conditional direct and indirect effects of time spent using DT on well-being via loneliness by gender. Both direct effects of time spent using DT on well-being and indirect effects through loneliness were significant in all three cohorts. Our first hypothesis about the negative direct effect was confirmed, where adolescents who reported spending more time using DT were more likely to score lower on the well-being measure. However, these direct effects were relatively small in all three cohorts, with the strongest effect obtained for 11-year-olds and the weakest effect for 17-year-olds. With the evidence of negative association between time spent using DT and well-being, the results of our study add to the large body of research demonstrating that the effect of time spent using DT is negative, but small (Appel et al., 2020), and is stronger for younger adolescents (e.g., Allen & Vella, 2015; Bruggeman et al., 2019).

Our second hypothesis regarding loneliness as a mediator of the relationship between time spent using DT and well-being was also confirmed, where significant (but small) indirect effects were observed in all three cohorts. These results, which suggest that spending more time using DT might lead to higher levels of loneliness that in turn reduces well-being, point to loneliness as one of the potential psychological mechanisms through which time spent using DT affects adolescents'

well-being. These findings are consistent with the results of previous studies examining social media use and well-being among college students (Satici, 2019) and adults (Martilla et al., 2021).

Our results regarding the negative association between time spent using DT, loneliness and well-being were in line with expectations summarised under the displacement hypothesis (Kraut et al., 1998; Orben & Przybylski, 2019), which posits that time spent using DT displaces time spent in face-to-face social interactions and leisure activities and that this replacement negatively influences well-being. It might be argued that activities in the digital world are not as enriching, meaningful and fulfilling as face-to-face social interactions and leisure activities, even though adolescents primarily use them for the purposes of entertainment, communication and establishing social contacts (Bond, 2022). Paradoxically, although adolescents use DT as a tool for entertainment and social interaction, spending more time engaged in these digital activities might limit their opportunities for building and maintaining relationships, aggravate feelings of loneliness and reduce overall well-being. This negative effect on loneliness and well-being among adolescents might have been amplified during the COVID-19 pandemic, when physical distancing measures and cancellation of various activities resulted in a reduction in face-to-face interactions and even more reliance on DT use to connect with others and structure free time.

Furthermore, our results indicated that the mediating effect of loneliness was present across different stages of adolescence but was largest for 11-year-olds. This finding might be interpreted in light of the fact that the older adolescents in our sample reported the highest DT use and were a group for whom the use of DT, and social media in particular, represented an established norm and a very common outlet for forming and preserving social ties. Such embeddedness of digital environments in their social landscape might mean that the negative effects of time spent using DT on loneliness and well-being are somewhat buffered by their interactions with peers and friends on social media.

Our third hypothesis regarding the moderating effect of gender on the direct and indirect effects of time spent using DT on well-being was fully confirmed for the youngest cohort only. In this group of 11-year-olds, both direct and indirect effects of time spent using DT on well-being were stronger among girls than among boys. Among 13-year-olds, gender moderated the direct effect (the effect was significant for girls only), but the mediation through loneliness was not moderated by gender. In the oldest cohort, direct and indirect effects on well-being were not dependant on gender. These results suggest that girls in early adolescence who use DT intensively were at increased risk of developing adverse psychological outcomes and might be viewed as a particularly vulnerable group of DT users. Previous research on this topic (e.g., Svensson et al., 2022) also demonstrated girls in early adolescence are more negatively affected by excessive DT use than boys. One of the explanations for this gender effect is related to the observation that girls, on average, place greater

importance on close and intimate friendships (Zarbatany et al., 2000). As such, replacement of in-person activities with online activities might have a stronger negative impact on the psychological well-being of girls who use DT frequently than for boys. Furthermore, there are indications that girls who use DT more often spend less time engaged in in-person social interactions and other leisure-time activities important for their development of identity (Rose & Rudolph, 2006). The observed gender effect on early adolescents' well-being might also be related to the differences in the ways girls and boys use DT. While boys in early adolescence primarily play video games and engage in different friendship-related tasks in which they can excel and be a fun and enjoyable companion (Rose & Asher, 2017), girls are more prone to engage in upward social comparison when using DT (and social media in particular), which negatively impacts their self-esteem (Vogel et al., 2014). Our results demonstrate that the moderating effect of gender on the association between time spent using DT and well-being weakens among older adolescents and become insignificant in the group of 17-year-olds. Among older adolescents, both girls and boys increasingly use DT and engage in various screen-based activities. The effect of these normative behaviours on psychological outcomes is probably equal for both gender groups and relatively weak, as the results of our study indicate.

The results of the present study have significant practical implications. While the focus of promotion and prevention programmes and activities regarding responsible use of DT should be directed towards pupils of both genders, the results across all three cohorts indicate that special attention should be devoted to girls. Furthermore, emphasis should be placed on earlier stages of adolescence in light of results indicating stronger effects within our model for the younger cohort. Such emphasis on promotion programmes among younger cohorts might result in more efficient prevention, and therefore contribute to a reduced need for intervention in later stages of adolescence and young adulthood.

The results presented here should be considered in the light of a number of study limitations. First, time spent using DT was measured using a broad and general single-item measure and therefore did not differentiate between various DT activities. Furthermore, this measure is based on self-reports that may be less accurate than objective time measures, such as time-monitoring applications (Dienlin & Johannes, 2020). A systematic review of correlations between self-reported and logged digital media use revealed only a modest association (Parry et al., 2021). Secondly, the study represents results of a single measurement time, which does not allow for exploration of the development of the postulated model over time.

Acknowledging these limitations, the present study examined adolescents' use of DT and its effect on loneliness and well-being in the context of the COVID-19 pandemic. By using large nationally representative samples and testing the same model across three adolescent cohorts, this study contributes new understanding of the relationship between time spent using DT and well-being at different stages of adolescence during the specific time point two years after the pandemic outbreak. As

such, this study may represent a starting point for further research for examining the mechanisms underlying the relationship between elements of the model and testing gender effects at different adolescence stages. Future research should incorporate a range of individual and contextual factors that might influence DT use and its effects on loneliness and well-being such as adolescent's social status, self-appraisals, peer attitudinal and behavioural norms, parental supervision of online activities etc. Longitudinal research designs are particularly warranted, as they would address questions related to changes over time, both within and between participants.

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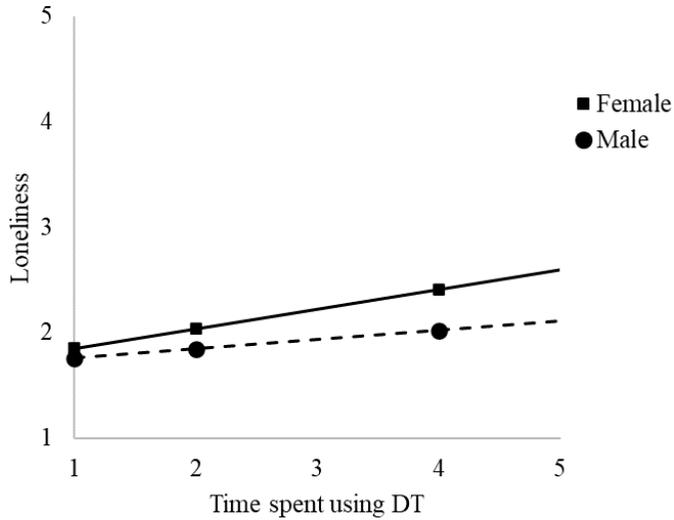
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**Appendix**

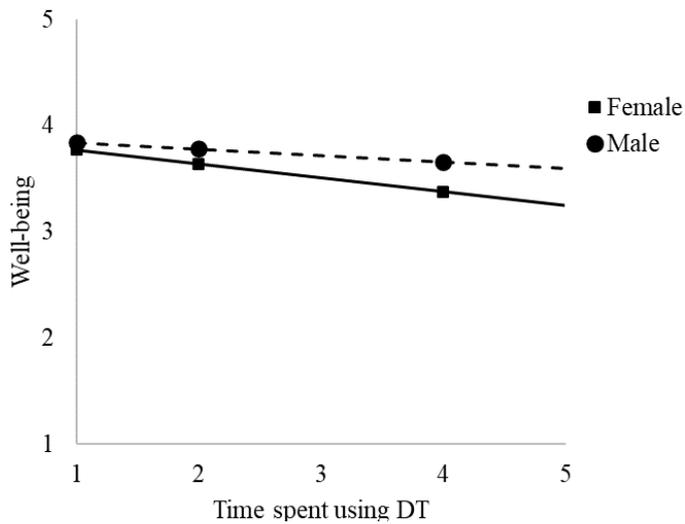
**Figure A1**

*Moderation of Time Spent Using DT by Gender on Loneliness Among 11-Year-Olds*



**Figure A2**

*Moderation of Time Spent Using DT by Gender on Well-being Among 11-Year-Olds*



**Figure A3**

*Moderation of Time Spent Using DT by Gender on Well-being Among 13-Year-Olds*

