1   Title page

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3   **The relationship between online communication and adolescents' mental**

4   **health: Long-term evaluation between genders**

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The relationship between online communication and adolescents' mental health: Long-term evaluation between genders

Abstract

Aims: In a relatively short time, online communication has become an important part of adolescents' lives, and concerns have been raised about its potential effects on mental health. The first aim was to compare mental health status and online communication in 15-year-old Icelanders born in 1988 and 1994. The second aim was to assess if the relationship between online communication and mental health has changed among 15-year-old Icelanders from 2003 to 2015 across genders.

Methods: Analysis used data from self-reports from 2003 (N=385, 51% males) and 2015 (N=302, 42% males). Mental health was assessed with subscales of SCL-90 and online communications with self-reports. To evaluate the difference in anxiety and depression, a factorial ANOVA was conducted between gender and years. Multigroup structural equation modeling was used to assess the change in the relationship between years.

Results: Symptoms of anxiety and depression remained unchanged for males. Symptoms of depression increased for females while anxiety was stable between 2003 and 2015. In 2003, there was no relationship between online communication and mental health. However, in 2015, an association was found for females.

Conclusions: Depression is getting worse for adolescent females and an association between time spent online communicating and mental health has emerged for them in 2015, which did not exist in 2003. These finding add to the possibility that online communication is harmful for mental health, but more detailed studies are still needed.

Keywords*: Online communication, social media, mental health, depression, anxiety, adolescence, gender differences.*

Word count: 2898

43   **Background**

44   The relationship between online communication, such as social networking and social

45   media, and mental health is unclear and debated [1–3]. The advancements in broadband

46   technology and smartphones over the last two decades have made the internet and

47   communication online almost instantly available anywhere and anytime. In 2003, online

48   communication was still emerging, with only 36% of adolescents using the internet for

49   online communication such as e-mails and instant messaging [4]. In 2015, most people

50   had access to social media networks such as Facebook, which had 1.22 billion users

51   worldwide [5]. At the same time, around 84% of teens had smartphones [6]. This digital

52   access indicates that both adolescents in 2003 and 2015 had the option to communicate

53   online, but its scope has changed immensely.

54

55   There are indications of an increase in mental health problems in the 21st century,

56   especially among females [7, 8], which is a public health concern. The growth has been

57   most evident in internalizing problems, including symptoms of depression and anxiety.

58   For instance, depressive symptoms increased from 9% in 2005 to 14.8% in 2015 in a

59   longitudinal cohort study of British 14-year-olds [9]. Furthermore, females have more

60   depressive and anxiety symptoms than males during adolescence [7, 8]. Adolescent

61   females are also more likely to have symptoms of depression than males [9].

62

63   In general, online communication has been shown to be related to mental health

64   problems in adolescents [10–12], while other studies show little to no relationship with

65   online communication [1, 13]. Studies on the relationship between online

66   communication and anxiety symptoms, in particular, are scarce. A recent systematic

67 review concluded that previous studies indicate an association between anxiety

68 symptoms and general internet use. However, most of those studies have

69 methodological limitations, including many cross-sectional studies [14]. A meta-analysis

70 and a systematic review of online communication and depression have shown mixed

71 results but mainly weak to moderate associations [2, 15]. One possible reason for mixed

72 results, according to Valkenburg et al. [3], is that many studies lack the inclusion of

73 gender in their analysis.

74

75 Although there is an indication that mental health problems are increasing

76 simultaneously as online communication among adolescents is on the rise, there is

77 limited information in the current literature on the relationship between mental health

78 and online communication and if the association has changed over the years. I addition,

79 studies on gender differences in the matter are also lacking. The motivation and novelty

80 behind this study is to compare an early-born cohort at the rise of online communication

81 to a younger cohort during the current online usage on the assocation between online

82 communication and mental health.

83

84 **Aims**

85 The aim of the study is twofold. The first aim was to compare mental health status and

86 online communication in 15-year-old Icelanders born in 1988 and 1994. The second aim

87 was to assess if the relationship between online communication and mental health has

88 changed among 15-year-old Icelanders from 2003 to 2015 across genders.

| 89 | **Methods** |

90 *Sample and data collection*

91 All data was collected with self-report questionnaires in Icelandic. An overview of the

92 two cohorts can be seen in Figure 1. The older cohort, born in 1988, came from 18

93 randomly selected elementary schools located all-over Iceland (60% of those schools

94 were in the capital are of Iceland). Participants were assessed in 10th grade during the

95 school year 2003-2004. A total of 661 were invited to participate and 385 participants

96 (195 males and 190 females) accepted and had complete data for the variables of

97 interest (58% participation rate). This data has been used in a few other studies [e.g. 16].

98 The younger cohort, born in 1999, came from six elementary schools in the capital area

99 of Iceland and was from April to September 2015 [17]. A total of 471 were invited to

100 participate and 302 participants (127 males and 175 females) accepted and had

101 complete data for the variables of interest (73% participation rate). Therefore, the total

102 sample data for both cohorts was 687 (53% females).

103 **[Insert figure 1]**

104

105 *Ethics*

106 All participants and their parents or guardians signed informed consent. The study was

107 approved by the Icelandic Data Protection Authority and the National Bioethics

108 Committee (VSNb200605002/03 for 2003 and VSNb2015020013/13.07 for 2015).

109 *Measures*

110 Socio-economic status was approximated by maternal education, where the mothers

111 are grouped by university education and no university education based on self-reports

112 from the participants.

113

114 Participants were asked how many hours per day they spent online during weekdays

115 and weekends, with examples of online communication such as *chatrooms* in 2003 and

116 *Facebook* in 2015. Since the question was in two parts, with one for average use on

117 weekdays (5 days of a 7-day week) and another for the weekend (2 days of a 7-day

118 week), the weighted average (weekend*0.29 + weekdays*0.71) was taken to generate a

119 single variable measuring the amount of total weekly online communication. In 2003

120 the possible responses were: 1 = Almost none, 2 = 0.5-1 hours, 3 = about 1 hour, 4 =

121 about 2 hours, 5 = about 3 hours, 6 = about 4 hours, 7 = about 5 hours, 8 = 6 hours or

122 more. In 2015 the possible answers were almost the same, but the maximum score was

123 7 for "More than 5 hours". Because of this discrepancy in the Likert scales between

124 years, the following transformation was done in accordance with Schwarz et al. [18].

125 They concluded that subjects answering the scale might be using the response

126 alternatives as a comparison for their answer instead of the actual meaning of *hours* in

127 the options [18]. Therefore, response option = 8 (meaning 6 or more hours) from 2003

128 was transformed to response option 7, representing 5 or more hours. The

129 transformation had minimal effect on the mean, which lowered only by .05 for males

130 and females.

131

132 Symptoms of depression and anxiety were measured with the depression and anxiety

133 subscales of the Icelandic translation of Symptom Checklist 90 (SCL-90). The scale asks

134 how various symptoms had bothered the participant over the last week. Scoring options

135 were: 1 = not at all, 2 = a little bit, 3 = moderately, 4 = quite a bit, and 5 = extremely. The

136 depression subscale has 10 items; examples are "*Feeling no interest in things*" and

137 "*feeling blue*." The anxiety subscale has four items; examples are: "*Suddenly scared for*

138 *no reason*" and "*Feeling tense or keyed up.*" Each subscale was summed up for the

139 FANOVA. Depression scores ranged from 5 minimum to 50 maximum, and anxiety scores

140 ranged from 5 to 20. The original version has shown a good construct validity [19] and a

141 good factor structure and reliability [20]. A newer study shows that the scale is

142 acceptable for screening and as an outcome measure for adolescents [21]. The

143 Cronbach's alpha from 2003 was .89 for the depression subscale and .74 for the anxiety

144 subscale. The Cronbach's alpha from 2015 was .94 for the depression subscale and .88

145 for the anxiety subscale, indicating acceptable to excellent internal consistency.

146

147 *Statistical analysis*

148 Data analysis was conducted in Jamovi and R [22]. The structural equation modeling

149 used Lavaan for R [23]. The descriptive statistics for all variables included the mean and

150 dispersion for all four groups (both males and females in 2003 and 2015). An

151 independent t-test was used to assess the difference in average time spent online

152 communicating between genders and between years. To evaluate the differences

153 between the four groups across the factors of time and gender, two separate factorial

154 analysis of variance (FANOVA) (one for anxiety and one for depression) was used. Alpha

155 level was set at 0.05 for all analyses. The Tukey post hoc test was used to assess

156 differences between groups if the interaction was statistically significant.

157

158 A multigroup structural equation modeling was conducted to determine if the

159 association between online communication and mental health (depression and anxiety)

160 had changed. Online communication was treated as an exogenous variable in the model.

161   Depression and anxiety were treated as endogenous latent variables with raw scores of

162   the depression and anxiety items from SCL-90 as indicators. The model also included

163   covariance between the two latent variables and variance for each item. Dependent

164   variables for all groups were slightly positively skewed, heteroscedastic, and based on

165   ordinal Likert scores. Therefore, the Maximum Likelihood to estimate model fit (the

166   standard) did not suffice. Instead, Diagonally Weighted Least Squares (DWLS) was used

167   with the Satorra-Bentler method to scale the chi-square for better approximation

168   because of non-normality. The comparative fit was assessed with the Comparative Fit

169   Index (CFI) and Tucker Lewis Index (TLI). For both indices, a value over .90 indicates an

170   acceptable fit and over .95 a good fit [24]. The root mean square error of

171   approximation (RMSEA) was also used to assess the goodness-of-fit where the index

172   should ideally be under .05 or at least under .08 [24]. Two versions of the model were

173   computed to assess a difference between groups. One version had the intercepts and

174   regressions coefficients free to vary between groups and the other version where they

175   were constrained across the four groups. Then the significance between the two models

176   was assessed using the Chi-squared difference test.

177 **Results**

178 Demographic characteristics of samples both from 2003 (cohort 1988) and 2015 (cohort

179 1999) are presented in Table I. In 2003 the proportion of males and females was almost

180 identical in size (51% males), and in 2015 females were in greater numbers (58%). The

181 proportion of participants´ mothers having a university education was 21% in 2003 and

182 60% in 2015.

183 **[Insert Table 1 here]**

184 There were no gender differences regarding time spent online communicating in 2003

185 (t(383) = .23, p=.818.), where males scored 3.20 (approximately 70 minutes a day) and

186 females 3.16 (approximately 70 minutes; Table II). Compared to males, females spent,

187 on average, almost an hour longer online communicating in 2015, scoring 4.21 and

188 males 3.31 (approximately 130 minutes and 80 minutes, respectively, t(300) = 5.89,

189 p<.001). Time online communicating for males did not change between 2003 and 2015.

190 The time for females increased significantly by approximately an hour from 2003 to 2015

191 (t(363) = 5.61, p<.001).

192 **[Insert Table 2 here]**

193 *Gender differences in mental health between the years 2003 and 2015*

194 The factorial ANOVA for anxiety revealed a statistically significant interaction between

195 year and gender on anxiety (F (1,1) = 4.519, p = .033). A simple main effect for gender

196 was also significant (p < .001), showing that females scored higher on anxiety compared

197 to males (Figure 2a). Year alone did not have a main effect (p=.541). The post hoc Tukey

198 test for anxiety showed that females had more anxiety symptoms than males both in

199 2003 and 2015.

200

201 For the analysis of depression, the factorial ANOVA also revealed statistically significant

202 interaction between year and gender on depression ($F(1,1)$ = 6.960, p = .009) with

203 significant main effect for both year (p = .008) and gender (p < .001; Figure 2b). The post

204 hoc Tukey test for depression showed that females had a significantly higher score on

205 depression both. The Tukey test also showed a statistical difference between depression

206 for females in 2003 and females in 2015, indicating depression is getting worse for

207 females (Figure 2b).

208 **[Insert figure 2 here]**

209 *The relationship between online communication and mental health across gender*

210 The fit for the constrained model was $\chi2(394, N = 687) = 1007$, p < .001 (scaling

211 correction factor = .312), TLI = .90, CFI = .91, RMSEA = .10. The model fit with all

212 parameters freely estimated for all groups, was $\chi2(352, N = 687) = 526$, p < .001 (scaling

213 correction factor = .240), TLI = .99, CFI = .99, RMSEA = .05. All indicators for latent

214 variables for all groups in both models were acceptable, suggesting construct validity of

215 depression and anxiety. The Chi-squared difference test between model fits indicated a

216 significant difference (p<.001), rationalizing the use of the model with the better fit,

217 which was the one where the parameters were not constrained between groups, thus

218 indicating valid differences between groups. The results from that model (Figure 3) show

219 that there is no significant relationship between time spent online communicating and

220 anxiety or depression, except for females in 2015, where anxiety increased significantly

221 by .14 standard deviations and depression by .21 standard deviations for each increase

222 in the score for time online communicating.

223 **[Insert figure 3 here]**

Discussion

224
225
226 The main findings were that adolescent females in 2015 spent more time online

227 communicating and had more symptoms of depression compared to adolescent females

228 in 2003. Whereas males spent similar time online communicating at both time points,

229 and no difference was found in their depressive symptoms. Anxiety symptoms did not

230 change for males or females from 2003 to 2015. In 2003, time spent online

231 communicating was not associated with mental health (symptoms of depression and

232 anxiety) for either males or females. However, in 2015, there was a relationship

233 between time spent online communicating and both anxiety and depressive symptoms

234 for females.

235

236 As relationship between online communication and mental health was only apparent for

237 females and only in 2015 begs the question: What has changed between 2003 and 2015

238 that seems to be affecting females only? One possible answer is the ever-present

239 reminder of how females are represented online on social media, which was instantly

240 available through smartphones in 2015 but not in 2003. Supporting that idea is that

241 females use social media more than males [25], thus adding to the possibility the

242 content on social media that affects mental health. Social media and other means of

243 online communication could affect females' body image more than males through

244 skewed standards for females presented online [26]. In return, body image

245 dissatisfaction increases the risk of depression [27]. Another proposed mechanism has

246 been online bullying [28], where girls are more likely to be bullied online than boys [29].

247 Related to that is that females have higher levels of fear of cybercrimes which could

248 contribute to the relationship [30]. Another possible mechanism could be the fact that

249   sedentary behavior and low levels of physical activity are more common in adolescent

250   girls [31], and both are related to mental health [32, 33]. There is also a possibility that

251   the relationship could be attributable to mediating variables such as sleep problems

252   [34]. As the current study is cross-sectional, reverse causality cannot be ruled out.

253   However, longitudinal studies have not found reverse causality [35]. Further cross-

254   sectional and longitudinal research on mediation variables is needed, where gender is

255   included, to understand the relationship better. The lack of analysis of gender

256   differences in online communication could be part of the weak association found in

257   previous studies between social media and mental health [3].

258

259   An expected increase for 15 years old adolescents was found in online communications

260   from 2003 to 2015 but only for females. That is in accordance with previous studies

261   where female adolescents are found to be more internet users in general compared to

262   males, whereas adolescent males tend to be gaming more [25]. In 2003, males and

263   females spent almost similar time online communicating, but females surpassed males

264   by approximately an hour more per day in 2015.

265

266   There was no increase in anxiety symptoms over time in the present study, which is in

267   contrast to previous studies [8], which have found a rise in anxiety among adolescent

268   females. One possible reason why anxiety has not increased could be traced to the fact

269   that mental health discussion has increased in Iceland, and thus, more people seek

270   treatment for mental health problems [36]. It could also be speculated that a more

271   sensitive measurement tool, with more than only four items assessing symptoms of

272   anxiety, might have detected an increase in symptoms of anxiety.

273

274   This study has a few limitations. The independent variable of time online communicating

275   had minor discrepancies between Likert levels from 2003 and 2015 but was dealt with

276   by transforming the data, which had minimal effect on the mean. The time spent using

277   online communication platforms was based on self-report. In the future objective data

278   from screen time reports from adolescent's devices will increase the accuracy of time

279   spent on different social media and other digital tools. Another limitation is that the

280   data from 2003 had schools from all over Iceland. In contrast, the data from 2015 had

281   schools only from the capital area, which could partly explain the discrepancies in the

282   mother's educational level and possibly the difference in depression between the

283   cohorts. However, no study to date has explored the difference in the symptoms of

284   depression between the capital area and other parts of the country, so there is a

285   possibility that the data represent two different populations. But overall, education in

286   Iceland has changed similarly all over Iceland during this time. In 2003, around 30% of

287   women in Iceland had completed a university degree but in 2015, the number was

288   almost 50% [37]. Furtermore, a study from 18 found that parental education did not

289   seem to have an effect on trends in depression from 1991-2018 [38]. Finally, it should be

290   noted that adolescent males play games more often than females [25, 39] and that

291   games today are mostly played online and often include communication. Therefore,

292   there is a possibility that online communication could be related to mental health for

293   males if games were included in the analysis of the current study. However, since games

294   can also be non-communicative, it was not included in this study as we did not have a

295   question about communications in games specifically.

296   **Conclusions**

297   The main finding are that depression scores are getting worse for adolescent females

298   and time spent online comunicating has increased for them from 2003 – 2015. The

299   results also suggest that the time spent online communicating could affect female and

300   male adolescents differently since an association was found between mental health and

301   online communication in 2015 for females only. These findings hint that there is a

302   possible relationship between online communication and mental health. However, more

303   detailed gender comparison is needed to shed light on potential mechanisms affecting

304   the association between online communication and mental health.

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422

423 **Tables**

424 Table 1:

425

426 Table I. Demographic characteristics of both samples.

	2003	2015
Total N	385	302
Males	195 (51%)	127 (42%)
Females	190 (49%)	175 (58%)
Mean age	15.3 (SD 0.3)	15.9 (SD 0.3)
Minimum age	14.7	14.5
Maximum age	16.1	16.4
Maternal education:		
- University education	81 (21%)	182 (60%)
- No university education	304 (79%)	120 (40%)

427 *Note.* All percentages are calculated within columns (years).

428   Table 2:

429

430   Table II. Descriptive statistics for time online communicating, anxiety, and depressive
431   symptoms by year and gender.

	Year	Gender	n	M	SD	Min.	Max.
Time online communicating	2003	Males	195	3.20	1.75	1.00	7.00
		Females	190	3.16	1.79	1.00	7.00
	2015	Males	127	3.31	1.05	1.71	7.00
		Females	175	4.21	1.47	1.58	7.00
Anxiety	2003	Males	195	5.70	2.33	4.00	20.0
		Females	190	7.05	2.99	4.00	16.0
	2015	Males	127	5.35	2.48	4.00	17.0
		Females	175	7.69	4.01	4.00	20.0
Depression	2003	Males	195	14.51	5.80	10.00	50.0
		Females	190	17.31	6.94	10.00	43.0
	2015	Males	127	14.51	6.19	10.00	41.0
		Females	175	20.38	10.23	10.00	50.0

432   *Note.* Time online communicating is shown with the Likert score, not hours. M = Mean, SD = Standard
433   deviation, Var = Variance, Min = minimum score and Max = maximum score.
434

435 **List of figure captions**

436

437 **Figure 1.** Timeline showing the main description of the cohorts used in the study.

438 **Figure 2.** a) Anxiety scores for males and females from 2003 to 2015 showing estimated

439 marginal means. b) Depression scores for males and females from 2003 to 2015 showing

440 estimated marginal means.

441 **Figure 3.** Comparison of the relationship between time spent online communicating and

442 mental health.

443 *Note for figure 3.* The figure shows the standardized parameter estimates with

444 the p-value in the parenthesis where the asterisk (*) indicates significance at *p* <.05. The

445 single-headed arrow shows regression, and the double-headed arrow shows covariance.

446 The 14 indicators for the latent variables are excluded for clarity of the diagram.

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