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Does social networking sites use predict mental health and sleep problems when prior problems and loneliness are taken into account? A population-based prospective study

Abstract

It is unclear to what extent the use of social networking sites (SNS-use) predicts mental health or sleep problems, over and above prior problems. The aim of this study is to examine the independent predictive values of SNS-use. We extracted data from the *Longitudinal Internet studies for the Social Sciences panel* (LISS panel), based on a random sample of Dutch residents. Using logistic and multiple regression analyses, we assessed the predictive values of SNS-use (Read, Post, Chat) among the total study sample (N=3486), six age categories, and subgroups with low and high loneliness levels. The three types of SNS-use were significant predictors for mental health and sleep problems on the short and longer term among the total sample, but not after controlling for prior mental health and sleep problems, loneliness and demographics. Analyses among the six age groups revealed some mixed but very weak effects. Among a few age categories, more SNS-use was very associated with

more sleep problems. No differences were observed within subgroups with low or high loneliness levels. We conclude that, when controlling for prior problems and loneliness, SNS-use does not or hardly predict mental health and sleep problems on the short or long term.

Keywords: Social Networks Sites, Social media, Mental health, Sleep problems, Loneliness, Age

1. Introduction

Numerous studies have shown the protective role of social relationships and support for well-being and mental health throughout the human life span, from childhood into old age (Greenberg, Rosenblum, McInnis, & Muzik, 2014; Holt-Lunstad, Smith, & Layton, 2010; Holt-Lunstad, 2018; Kawachi & Berkman, 2001; Kelly et al., 2017; Shor & Roelfs, 2015). Social support may enhance well-being directly by, for instance, providing positive affect, cognition, appreciation, connectedness and a sense of stability in one's life. Social support may also act as a buffer against stress when people are confronted with negative life-events, stressful circumstances or potentially traumatic events. In these situations, which may place great demands on one's coping abilities, social support may provide practical and emotional support that can diminish the effects (or cause of) of these events or circumstances (Cohen & Wills, 1985). According to the Conversations of Resources Theory (COR), people strive to develop, maintain or restore important resources such as social relationships (COR-theory: Hobfoll, 1989; 2002). Social networking sites provide opportunities to develop, maintain and enhance these relationships by using social network sites facilities such as Facebook, WhatsApp, Flickr and others (cf. Valkenburg, Peter, & Schouten, 2006). Obar and Wildman (2015), seeking to synthesize (current) definitions on SNS-use, have defined SNS as follows: 1) social media services are (currently) Web 2.0 Internet-based applications; 2) user-generated content is the lifeblood of social media; 3) individuals and groups create user-specific profiles for a site or app designed and maintained by a social media service; and 4) media services facilitate the development of social networks online by connecting a profile with those of other individuals and/or groups.

An important question in this perspective is to what extent SNS-use indeed contributes to the mental health of users, also given the concerns expressed in the media and

among policy makers about the potentially negative effects on users' mental health (Berryman, Ferguson, & Negy, 2018). To date, many cross-sectional studies have assessed the associations between time spent on social networking sites, social media or social media platforms (hereafter referred to as social networking sites use, SNS-use), and mental health or mental health-related issues. Neglecting differences between these studies, such as differences in study samples, country of origin, period in which SNS-use was assessed, measures of SNS-use, conducted analyses and use of control variables, a main conclusion to be drawn is that the results do not show a clear pattern (Gnambs & Appel, 2017; Song et al., 2014; Verduyn, Ybarra, Résibois, Jonides, & Kross, 2017). Remarkably, studies found indications for neutral, positive and negative associations between SNS-use and mental health.

For instance, in their cross-sectional study among students, Brailovskaia and Margraf (2018) found that SNS-use independently explained only 0.4% of current depressive symptoms. SNS-use did not independently predict anxiety or stress symptoms. In contrast, the study of Vannuci and colleagues (2017) among nationally-representative samples of emerging adults found that greater SNS-use was associated with increased odds of probable anxiety disorder. Mérelle and colleagues (2017) found significant associations between emotional problems, conduct problems, hyperactivity, and suicidal thoughts on the one hand, and problematic SNS-use on the other among a very large sample of young students. Primack and colleagues (2017), in their turn, using a nationally-representative sample of young adults, found that time spent on social media was not independently associated with depressive symptoms or anxiety symptoms, in contrast to the use of multiple social media platforms (cf. Shensa et al., 2017). Morgan and Cotton (2003) found that higher numbers of hours spent on e-mailing and chat room/instant messaging (IM) were associated with *lower* depressive

symptom levels, although increased Internet hours for shopping, playing games, or research is associated with increased depressive symptoms. However, effects were small.

An additional important question in this perspective is: to what extent does SNS-use predict an increase or decrease of mental health problems over and above prior mental health problems? Most if not all longitudinal studies show that mental health variables are best predicted by prior mental health variables. Cross-sectional studies are, due to their study designs, unable to fully address this important question and confirm (or reject) the assumption that associations between both are not confounded by prior problems. Fortunately, a growing number of longitudinal studies, although still relatively limited in number, are devoted to assessing the independent predictive value of SNS-use for mental health of mental health-related problems.

What are the results of these longitudinal studies? We identified fourteen longitudinal studies that are relevant here. Given the relatively limited number, but also given the differences between these studies, for instance in study samples, time-intervals and assessed SNS-use, we briefly discuss these studies to obtain a clear picture. We excluded more recent studies that only focus on the longitudinal relationships between (compulsive) general Internet use, instead of SNS-like use of Internet, and mental health (cf. Carli et al., 2012; Salmela-Aro, Upadyaya, Hakkarainen, Lonka, & Alho, 2017). We included a few studies on instant messaging because of the fourth definition, as Obar and Wildman (2015, p. 747) wrote (see above): "*social media technology is among the more controversial as it could be suggested that earlier communication technologies (such as the telephone) allowed individuals to develop, facilitate and maintain social networks, suggesting that online communication technologies should not be identified as uniquely social*".

1.1. Longitudinal studies among adolescents

We start with nine longitudinal studies among adolescents on SNS-use and mental health. They were conducted in the past 10 years although most studies are, for obvious reasons, very recent. We discuss them in a chronological order.

The study by Van den Eijnden and colleagues (2008) among students on instant messaging showed that instant messaging was positively related to feelings of depression *six months* later while controlling for, among others, depressive feelings at baseline (remarkably, compulsive Internet use was not associated with depressive feelings at follow-up). However, the study by Selfhout and colleagues (2009) among middle-adolescents found that instant messaging was not predictive of depressive feeling *one year* later while controlling for, among others, depressive feelings at baseline. However, the interaction between messaging and perceived friendship quality was associated with less depressive symptoms at follow-up, explaining about 5% of the variance. Findings by Van Eijnden et al. (2008) and Selfhout et al. (2009) suggest that the time-interval between measurements may be a crucial variable.

Van Zalk and colleagues (2011) used a design with shorter time-interval assessments among students, i.e. 4 months. They assessed the associations between (categories of) hours spent chatting with friends and chatting with Internet-peers (peers found exclusively on Internet), depressive symptoms and self-esteem, and the mediating effects of supportiveness (reported by peers) and moderating role of extraversion. Results showed that hours spent chatting with friends did not predict depressive symptoms or low self-esteem at follow-ups among the students, while among less extraverted respondents hours spent chatting with Internet-peers was positively associated with higher self-esteem at follow-ups. A negative relationship between hours spent chatting with Internet-peers and later depressive feelings was found among those with low extraversion levels, but the effects were mediated by supportiveness.

The study by Kross and colleagues (2013) used a study design where, besides pre- and post-assessments, adolescent/young adults were assessed daily. Text-messages were sent 5 times per day during a 15-day period to answer 5 online questions (feel right now, worried right now, lonely right now, how much Facebook use since last time). Results showed that Facebook use predicted a decline in well-being: in how people feel from moment to moment and how satisfied they were with their lives. However, effects were small.

Following the results of the study by Kross and colleagues (2013), Verduyn and colleagues (2015) addressed the question "*How does Facebook usage lead to these declines (in well-being)*?", by means of two separate studies: an experimental study among undergraduate students (10-minute experiment) and a field study among a convenience sample of adolescents and young adults. They assessed whether active use (activities that facilitate direct exchanges with others) versus passive use (consuming information without direct exchanges) impacted well-being. Experimental findings showed that (randomly assigned) passive use of Facebook was associated with a significant drop in affective well-being relative to both their baseline and post-manipulation affect levels, in contrast to active use participants. The field study, comparable with the Kross et al. study design but with a 6-day period, showed that passive compared to active use of Facebook predicted declines in how good people felt over time (estimated 5%). Importantly, the found associations were not moderated by other factors such as depressive symptoms and loneliness. Frison and Eggermont (2015) also assessed the role of active (public or private) and passive Facebook use among (young) adolescents within the longitudinal loneliness-depression relationship. Loneliness independently predicted both passive and active public Facebook use. Private Facebook use and passive use related (weakly) positively and negatively, respectively, to perceived friendship support at the 6-month follow-up, while perceived friendship support was (weakly) negatively associated with depressed mood and

avoidant coping (and avoidant coping positively associated with depressed mood), above other variables in the model.

Two studies used other analytic strategies. Romer and colleagues (2013) started with a cluster analysis revealing six subgroups of (young) adolescents based on 10 media use indicators (low, moderate high information users, heavy TV users, Internet communicators, and gamers). Results showed that Internet communicators did not experience more depressive symptoms during the year after controlling for use of videogames, while depressive symptoms decreased among heavy information users. No effects were found among the other groups. The authors suggest that heavy Internet use and video gaming may more likely be a symptom of mental health problems than a cause. Coyne and colleagues (2018) first assessed latent classes of texting trajectories over 6 years with 1-year time-intervals among adolescent respondents (cf. Romer et al., 2013). They identified four classes (perpetuals, decreasers, moderates, and increasers). Results showed that perpetuals (with high levels of texting on all waves, 14%) had higher levels of depression at the last follow-up than the decreasers and the moderates. However, depression symptoms at baseline were not controlled for, while other results showed that perpetuals had higher levels of depressive symptoms than decreasers at baseline, which may explain differences at the last follow-up. Nevertheless, no differences were found in baseline depressive symptoms between perpetuals and moderates.

The study by Tavernier and Willoughby (2014) on the associations between, among others, online social networking and sleep problems among students may shed more light on Romer et al.'s (2013) suggestion regarding the causality. Findings showed that sleep problems predicted online social networking at follow-ups after one and two years, but that online social networking did not independently predict sleep problems. They concluded (2013, p. 389) that their findings "*suggest that emerging adults appear to seek out media as a means of coping with their sleep problems*".

In sum and neglecting differences in study designs (such as measures and samples), these studies do not share one clear conclusion (as was also observed among the cross-sectional studies). Either way, the findings stress the necessity of using more uniform measures on SNS-use to be able to compare findings across study samples (cf. Kelley & Gruberb, 2010).

1.2. Longitudinal studies including the elderly

While many studies have been conducted among adolescents and students, very few studies have included or specifically targeted the elderly (cf. Aarts, Peek, & Wouter, 2015; Nef, Ganea, Müri, & Mosimann, 2013). We start with the study by Kraut and colleagues (2002), a follow-up to the study by Kraut and colleagues published in 1998 (starting in 1995). They assessed Internet use among parents and children during a period when Internet was still in its relative infancy and when SNS-use was not a well-known concept. Nevertheless, their study among children and parents showed that SNS-use was positively related with depressive symptoms at the first follow-up (12-24 months, cf. Kraut et al., 1998), but negatively related with depressive feelings at the second follow-up while controlling for, among other things, prior depressive symptoms (about 2 years later).

In the study by Cotton and colleagues (2014), Internet use was assessed by one simple item ("Do you regularly use the World Wide Web, or the Internet, for sending and receiving e-mail or for any other purpose…? (Yes, No)"). They estimated that Internet use reduced depression by about 30% among a group of retired participants.

The study by Shakya and colleagues (2017) among a large representative sample of the population also found "positive" results. The analyses over 3 years showed that Facebook use was negatively associated with physical health and mental health problems. Mental health

status decreased by 7% of a standard deviation for each 1-standard deviation increase in lifetime like count, 8% of a standard deviation for each 1-standard deviation increase in 30-day link count.

Yoo and Jeong (2017) first excluded non-SNS-users. Results showed that among SNS-users with low Internet social capital scores, SNS-use was positively associated with depressive symptoms one year later. They also found that initial depressive symptoms were positive (and very strongly) associated with later SNS-use. Among users with high social capital scores, SNS-use was not related to depressive symptoms but negatively associated with loneliness. Again, depressive symptoms were positively (and strongly) associated with later SNS-use.

In contrast to Cotton and colleagues (2014), Van Ingen and colleagues (2017) found that SNS-use was not an independent predictor among older adults for later subjective well-being but was (to a small extent) predictive of social loneliness when, among other variables, prior well-being and loneliness were taken into account. In addition, the interaction effect between SNS-use and disabilities was an independent (but limited) predictor for later subjective well-being and loneliness. As in all studies reporting autoregressive correlations, prior mental health and disabilities were the strongest independent predictors of later mental health or mental-related variables.

As was found among studies that focused on adolescents, longitudinal studies differed in study designs and samples, and no clear pattern of findings emerged showing positive, neutral or negative effects. However, in contrast to all other studies, Yoo and Jeong (2017) did examine associations among SNS-users and excluded non-users and found negative effects of SNS-use among a subsample of respondents with low Internet social capital scores.

1.3. The present study

In sum, the outcomes of the longitudinal studies described above do not show a clear pattern with respect to the independent predictive values of SNS-use for mental health and related problems. However, these studies are mixed with respect to study designs, SNS-use measures, sample sizes and time-intervals in longitudinal studies. The number of longitudinal studies assessing the predictive values on the short and longer term using the same sample(s) and instruments is very limited (cf. Van Zalk et al., 2011; Coyne et al., 2018; Vriens & Van Ingen, 2017). There is a need for longitudinal studies based on large representative samples (Mérelle et al., 2017). The results also raise the fundamental question whether the associations between SNS-use on the one hand and mental health on the other differ between age groups.

In the present study, we focus on mental health problems and sleep problems (cf. Woods & Scott, 2016) as dependent variables. Our first research question is: To what extent do different types of SNS-use independently predict mental health and sleep problems, while controlling for demographics and prior mental health problems, sleep problems and loneliness, in the short and long term among a representative sample of adult Dutch residents? The second question is: To what extent do different age groups within this sample differ in terms of associations between SNS-use and mental health and sleep problems?

A lack of social ties or loneliness affects mental health, but Vriens and Van Ingen (2017) found no indications that social media use is linked to an erosion of social relationships. Given the possible (moderating) effects of prior loneliness (cf. Van Eijnden et al., 2008; Kim, Larose, & Peng, 2009; Teppers, Luycks, Klimstra, & Goossens, 2014), it is important to examine and compare these associations among respondents with relatively low and high prior levels of loneliness (cf. Yoo & Jeong, 2017). The third research question is

therefore: to what extent do associations between SNS-use and mental health and sleep problems differ between people with low versus high prior levels of loneliness?

As described, Yoo and Jeong (2017) used a somewhat different selection process of respondents compared to other longitudinal studies, i.e. they excluded non-users from the analyses. It is unclear to what extent such a selection process influences results. We therefore also assessed associations among the subgroup of SNS-users.

Types of SNS-use we distinguished in the present study were a) Reading and viewing SNS (such as Facebook and YouTube), b) Chatting via SNS (such as WhatsApp Snapchat, Facebook), and c) Posting pictures, messages and videos via SNS (such as Flickr and Instagram).

2. Materials and methods

2.1. Procedures and Participants

The data for this study were collected in *Longitudinal Internet studies for the Social Sciences panel* (LISS panel), administered by CentERdata (Tilburg, The Netherlands). The LISS panel is the central element of a project titled *Measurement and Experimentation in the Social Sciences*, granted by the Netherlands Organization for Scientific Research. The panel is based on a representative random sample drawn from the Dutch population register by Statistics Netherlands and includes about 5000 households comprising approximately 7500 participants. Panel members receive an incentive of 15 euros per hour for their participation. Respondents who do not have a computer and/or Internet connection are provided with the necessary equipment. Part of the interview time available in the LISS panel is reserved for the LISS Core Study. This longitudinal study is repeated yearly and covers a wide range of

topics. For the present study we used two modules from this study: Social Integration and Leisure and Health. All data collected in the LISS panel are available for scientific research, free of charge. More details can be found in Scherpenzeel and Das (2011), and on the (English) website www.lissdata.nl. Examples of earlier studies that used the LISS panel on the related topics are Aarts et al. (2015, see above) and Van Ingen et al. (2017; see above).

Four waves from the core modules were extracted for this study: we used two waves from the Social Integration and Leisure module covering SNS-use and loneliness conducted in October-November 2016 (T1, $Response^{completers}$ = 85.7%) and in October-November 2017 (T3: $Response^{completers}$ = 80.4%, and two waves from the Health module covering mental health problems and sleep problems, conducted in November-December 2016 (T2: $Response^{completers}$ = 84.7%) and November-December 2017 (T4: $Response^{completers}$ = 79.2%). For a graphical overview of the surveys and extracted data see Table 1. For the present study, we selected respondents who were between 16 and 74 years old in October 2016.

Table 1 Overview of surveys and extracted data

Time	Survey and assessment
Oct 2016	Demographics
Oct-Nov 2016	SNS-use and loneliness (T1)
Nov-Dec 2016	Mental health and sleep problems (T2)
Oct-Nov 2017	SNS-use (T3)
Nov-Dec 2017	Mental Health and sleep problems (T4)

In total, 3496 respondents with complete data participated in all four surveys. Previous research using the LISS panel has shown that non-response is not associated with health, mental health problems and disabilities (Van der Velden et al., 2016). Data on demographics reported in October 2016 were used in the present study.

2.2. Measures

2.2.1. SNS-use

Respondents were first asked: "Can you indicate whether you ever spent time on the following online activities (with answer categories: 1=*yes*, 2=*no*): a) Reading and viewing social media? (e.g. Facebook, Instagram, Twitter, YouTube, LinkedIn, Google+, Pinterest, Flickr or similar services); b) Chatting, video calling or sending messages via WhatsApp, Telegram, Snapchat, Skype or similar services? and c) Posting messages, photos and short films on social media yourself ? (e.g. Facebook, Instagram, Twitter, YouTube, LinkedIn, Google+, Pinterest, Flickr, or similar services)". If respondents answered "yes" for one or more types of media use, for each type they were further asked "Can you indicate the mean number of hours per week you spend time on these online activities?". In the 2017 wave of the Social Integration and Leisure module, in contrast to the 2016 wave, respondents were offered the opportunity to report hours spent in decimals and a small number of respondents did (especially between 0 and 1 hour and most often above 0.5 hour). For the present study, answers in decimals were therefore recoded as follows: 0.001 thru 1=1; 1.01 thru 2=2; 2.01 thru 3=3; 3.01 thru 4=4; 4.01 thru 5=5; 5.01 thru 6=6; 9.01 thru 10=10.

2.2.2. Mental health and sleep problems

General mental health problems (MHP) at T2 and T4 were examined using the Mental Health Index or Inventory (MHI-5, 5-item subscale of the MOS 36-item short-form health survey; Means-Christensen, Arnau, Tonidandel, Bramson, & Meagher, 2005; Ware & Sherborne, 1992). Low scores are predictive of mental disorders (Means-Christensen et al., 2005). Respondents were asked to rate their mental health during the past month on 6-point Likert scales, such as 'This past month I felt very anxious' (0 = *never* to 5 = *continuously*). After recoding the positively phrased items, the total scores were computed. The total score according the MHI is the 100 minus the sum score multiplied by four (to obtain a range of 0–100) where low scores reflect more MHP (Cronbach's alphas ≥ .87).

In the health survey, respondents were also asked if they regularly had sleep problems (single item: 0 = no, 1 = *yes*), and whether they used medication for at least one week for sleep problems (single item: 0 = *no*, 1 = *yes*). If respondents answered 'yes' to at least one question, they were considered to have sleep problems.

2.2.3. Loneliness

Loneliness was assessed at T1 using the 6-item De Jong Gierveld Loneliness Scale (de Jong Gierveld & Van Tilburg, 2006). Respondents are asked to rate items such as 'I often feel deserted' and 'There are enough people I can count on in case of a misfortune' on 3-point Likert scales (1 = *yes*, 2 = *more or less*, 3 = *no*). For the present study, we calculated the total score after recoding the three negatively formulated items (Cronbach's alphas ≥ .83), but we did not use the prior dichotomization of the response categories (range 6-18; cf. Van der Velden, Pijnappel, & Van der Meulen, 2017). Higher scores reflect less loneliness. Previous research has shown that the correlation between scales with and without prior dichotomization is optimal (Spearman's rank (rho) correlation =.99).

2.3. Data Analyses

Since the variable sleep problem is dichotomous (no: n=2712, 77.8%; yes: n=774, 22.2%), first multivariate logistic regression analyses were conducted with sleep problems and dichotomized mental health problems as dependent variables. Mental health problems were dichotomized into relatively low-medium levels (scores > 60; n=2871, 82.4%) and high levels of mental health problems (scores ≤ 60; n=615, 17.6%), according to the Dutch norm tables (Driessen, 2011).

At step 1 in the logistic regression analysis, one SNS variable at T3 (total amount of hours) was entered as bivariate short-term predictor. At step 2, prior mental health problems (T2, total scores), loneliness (T1, total scores), sleep problems (T2), as well as demographics (gender, age, education level, employment status) were entered as predictors. Where total scores were entered in the analysis significant results indicate that an increase by 1 point (a 1-unit change), the odds of having mental health problems or sleep problems must be multiplied by the Odds ratio. Similar analyses were conducted with SNS-use at T1 instead of T3 as predictors to assess long-term effects, totaling $2^{\text{T1\&T3}} * 2^{\text{health\&sleep}} * 3^{\text{red\&post\&chat}}$ equals 12 logistic regression analyses among the total study sample. The complete set of analyses was repeated among the different age groups, totaling $6^{\text{six age groups}} * 2^{\text{T1\&T3}} * 2^{\text{health\&sleep}} * 3^{\text{red\&post\&chat}}$ equals 72 analyses. We also assessed these associations among respondents with relatively low (score =18; n=1523, 43.7%) and high levels of loneliness (6 ≤ score ≤ 14; n=641, 18.4%) among the total group, totaling $2^{\text{low\&high}} * 2^{\text{T1\&T3}} * 2^{\text{health\&sleep}} * 3^{\text{red\&post\&chat}}$ equals 24 analyses, and among those who did use SNS, totaling $2^{\text{T1 use\&T3 use}} * 2^{\text{health\&sleep}} * 3^{\text{red\&post\&chat}}$ equals 12 logistic regression analyses. Given the number of

multivariate logistic regression analyses (124), we may expect some significant findings by chance (chance =1-.95^{124}). In these cases, the so-called Bonferroni correction is suggested (p-value divided by number of analyses/comparisons) but given the critique on this method we did not use this correction (Perneger, 1998).

Logistic regression does not provide the R^2 statistic (after each step or in total) as multiple regression does. However, SPSS provides the Nagelkerke's R^2 statistic (after each step or in total) which is a pseudo R^2 (with values between 0 and 1) that provides information on the extent to which a new variable improves the prediction of the dependent variable.

As robustness checks, we repeated the analyses with the total score of mental health problems as dependent variable using multiple regression analyses, entering the same variables as in the logistic regression analyses.

In all analyses, respondents with outliers or extreme numbers of hours in one or more types of media use were excluded from all analyses. On a somewhat arbitrary basis, we considered 71 hours or more per week for at least one type of media use as outliers ($n^{outliers}$=10). We chose the cut-off of 71 hours because this would indicate that respondents used SNS every day for more than 10 hours, which we considered unrealistic given the time needed for sleep, shopping and eating, working and/or studying. The total study sample therefore consisted of 3486 respondents. IBM SPSS version 24.0 was used to perform the statistical analyses.

3. Results

3.1. Participants

The characteristics of the study samples are presented in Table 2. As might be expected, educational level (highest level with or without diploma) decrease by age categories. In addition, a higher proportion of respondents with relatively severe mental health problems is associated with being younger, SNS-use differs between respondents of the different age categories.

Table 2 Characteristics of study samples

	Total sample	Age categories (in years)						
	(N=3486)	16 - 24 (n=288)	25-34 (n=364)	35-44 (n=479)	45-54 (n=666)	55-64 (n=834)	65-74 (n=855)	F/χ^2
	%/ M(SD)	*%/ M(SD)*	*%/ M(SD)*	*%/ M(SD)*	*%/ M(SD)*	*%/ M(SD)*	*%/ M(SD)*	*p*
Females	52.6	62.5	55.5	53.4	52.9	53.7	46.3	.000
Education type T1								
-junior/senior high school[1]	30.4	35.8	4.4	15.2	27.5	36.5	44.7	.000
-intermediate vocational education	24.2	14.6	20.9	31.7	32.9	23.7	18.1	
-higher vocational education	28.4	23.6	40.9	30.3	25.7	27.5	26.7	
-university	17.0	26.0	33.8	22.8	14.0	12.4	10.5	
Employment status T1	51.9	18.8	79.1	83.9	78.5	59.1	5.8	
Loneliness T1	16.2 (2.45)	16.2 (2.46)	16.2 (2.58)	16.1 (2.58)	16.1 (2.49)	16.1 (2.48)	16.4 (2.23)	.290
Mental health problems T2	75.7 (16.08)	70.0 (14.67)	72.7 (12.64)	72.2 (16.50)	76.5 (15.05)	76.7 (16.61)	79.1 (14.75)	.000
Mental health problems T4	76.3 (16.03)	70.9 (16.17)	74.3 (15.62)	73.1 (16.48)	76.4 (16.35)	77.5 (16.64)	79.6 (14.33)	.000
Mental health problems T4, high scores	17.6	25.7	19.8	22.5	17.0	16.5	12.9	.000
Sleep problems T2	22.0	16.0	16.2	16.9	23.1	27.8	22.9	.000
Sleep problems T4	22.2	18.8	12.6	17.3	23.0	28.3	23.6	.000
Read & view SNS T1	2.45 (4.47)	6.11 (7.79)	3.49 (4.22)	2.78 (4.71)	2.30 (4.06)	1.98 (3.65)	1.23 (2.92)	.000
Read & view SNS T3	2.49 (4.26)	5.47 (6.08)	3.57 (4.69)	2.77 (4.24)	2.40 (3.91)	2.19 (4.35)	1.25 (2.61)	.000
Posting on SNS T1	0.58 (1.67)	1.34 (2.77)	0.84 (1.95)	0.65 (1.95)	0.58 (1.45)	0.48 (1.35)	0.30 (1.18)	.000
Posting on SNS T3	0.59 (1.63)	1.23 (2.66)	0.73 (1.74)	0.69 (1.47)	0.64 (1.58)	0.49 (1.65)	0.32 (1.05)	.000
Chatting on SNS T1	2.02 (4.66)	7.25 (10.52)	3.58 (6.15)	1.74 (3.55)	1.60 (2.98)	1.23 (2.26)	0.86 (1.97)	.000
Chatting on SNS T3	2.03 (3.81)	5.80 (7.45)	3.27 (4.64)	2.00 (3.00)	1.73 (2.92)	1.49 (2.72)	0.99 (2.37)	.000

SNS=Social networking sites. M=mean. SD=standard deviation. [1]including primary school (n=106 (3.0%)).

3.2. Results of logistic regression analysis among total study sample

Short term

Table 3 shows that at step 1, more hours spent on Reading and viewing on SNS, Posting messages on SNS and Chatting on SNS at T3, was significantly associated with a higher risk of mental health problems at T4. However, when adjusted for prior mental health problems, loneliness, sleep problems and demographics, the three types of media use were no longer significant. Chatting on SNS at T3 was not associated with sleep problems on a bivariate level. The results of step 2 among respondents with relatively low levels (score=18, n=1557) and high levels of loneliness (score ≤ 14, n=642) at T1 did not change this pattern (in these analyses the total score of loneliness as predictor was omitted). As SNS-use was not significant at step 2, Nagelkerke's (pseudo) R^2 was omitted from Table 3.

None of the three types of SNS-use at T3 were independent predictors for dichotomized mental health problems or sleep problems at T4 (data not shown).

Table 3 Results of logistic regression analyses including SNS-use at T3 as predictor (short-term effects, N=3486)

	Step 1			Step 2		
Predicting mental health problems T4	*OR*	*95% CI*	*p*	*AOR*	*95% CI*	*p*
- Read & view SNS T3	1.05	1.03-1.07	.000	1.01	0.99-1.04	.223
Mental health problems T2				1.41	1.37-1.46	.000
Loneliness T1				1.12	1.07-1.16	.000
Sleep problems T2				1.37	1.08-1.75	.011
- Posting on SNS T3	1.13	1.08-1.19	.000	1.04	0.98-1.11	.151
Mental health problems T2				1.41	1.37-1.46	.000
Loneliness T1				1.12	1.08-1.17	.000
Sleep problems T2				1.37	1.08-1.76	.010
- Chatting on SNS T3	1.04	1.02-1.06	.000	1.01	0.98-1.04	.541
Mental health problems T2				1.41	1.37-1.46	.000
Loneliness T1				1.12	1.08-1.17	.000
Sleep problems T2				1.38	1.08-1.77	.010
Predicting sleep problems T4						
- Read & view SNS T3	1.02	1.003-1.04	.022	1.00	0.95-1.02	.348
Mental health problems T2				1.08	1.04-1.13	.000
Loneliness T1				1.05	0.99-1.12	.111
Sleep problems T2				137.4	101.2-186.5	.000
- Posting on SNS T3	1.07	1.02-1.11	.005	1.02	0.94-1.10	.728
Mental health problems T2				1.08	1.04-1.13	.000
Loneliness T1				1.05	0.99-1.12	.118
Sleep problems T2				135.9	100.3-184.2	.000
- Chatting on SNS T3	1.01	0.99-1.03	.302	0.99	0.95-1.04	.838
Mental health problems T2				1.08	1.04-1.13	.000
Loneliness T1				1.05	0.99-1.12	.107
Sleep problems T2				136.2	100.5-184.7	.000

Step 1 = Corresponding SNS-use as bivariate predictors.
Step 2 = Besides corresponding SNS-use, prior mental health problems at T2, loneliness at T1, sleep problems at T2, and demographics (gender, age categories, education level, employment status at T1: data not shown in the table) were added as predictors.
OR= Odds Ratio
AOR = Odds Ratio adjusted for prior mental health problems at T2, loneliness at T1, sleep problems at T2, and demographics (gender, age categories, education level, employment status at T1: data not shown in the table).
95% CI = 95% confidence interval of AOR.
SNS=social network sites.

Long term

The same analysis with SNS-use at T1 instead of T3 as predictors among the total group showed similar results (see Table 4). Among the total group, again several social media variables were significant predictors of mental health problems and sleep problems at step 1. However, when entering prior mental health problems, loneliness, sleep problems and demographics as predictors, all significant associations disappeared (the AOR of the last predictors were omitted from the table because they were equal or almost equal to the AOR in Table 3).

Table 4 Results of logistic regression analyses including SNS-use at T1 as predictor (long-term effects, N=3486)

	Step 1			Step 2		
Predicting mental health problems T4	*OR*	*95% CI*	*p*	*AOR*	*95% CI*	*p*
- Read & view SNS T1	1.04	1.23-1.06	.000	1.01	0.995-1.04	.131
- Posting on SNS T1	1.09	1.05-1.14	.000	1.04	0.98-1.10	.235
- Chatting on SNS T1	1.02	1.004-1.04	.013	0.996	0.98-1.02	.772
Predicting sleep problems T4						
- Read & view SNS T1	1.02	1.001-1.03	.037	1.02	0.98-1.05	.351
- Posting on SNS T1	1.07	1.02-1.11	.003	1.07	0.996-1.15	.064
- Chatting on SNS T1	1.02	0.99-1.03	.031	1.02	0.99-1.05	.280

Step 1 = Corresponding SNS-use as bivariate predictors.
Step 2 = Besides corresponding SNS-use, prior mental health problems at T2, loneliness at T1, sleep problems at T2, and demographics (gender, age categories, education level, employment status) at T1 were added as predictors. AOR's of mental health problems at T2, loneliness at T1, and sleep problems at T2 are similar/almost similar to AOR's in Table 3 and therefore omitted.
OR= Odds Ratio
AOR = Odds Ratio adjusted for prior mental health problems at T2, loneliness at T1, sleep problems at T2, and demographics (gender, age categories, education level, employment status) at T1: data not shown in the table.
95% CI = 95% confidence interval of AOR.
SNS=social network sites.

Similar analyses among the selected group of SNS-users (respondents who spent one hour or more on each type of SNS-use; n=965) showed no significant effects for SNS-use at T1 and T3 on mental health problems or sleep problems.

The results of step 2 among respondents with relatively low and high levels of loneliness at T1 again did not change this pattern. The three types of social media at T1 were not independent predictors in these two subgroups.

3.3. Results among different age groups

We repeated the multivariate logistic regression analyses with SNS-use at T1 and T3 among the 6 age categories separately. Due to the large number of logistic regression analyses (72), in Table 5 we focus on the main outcomes of step 2 on the predictive values of SNS-use. To prevent lengthy tables, we do not show the bivariate OR's at step 1 or the adjusted OR's of mental health problems, loneliness, sleep problems and demographics at T1/T2. We added Nagelkerke's (pseudo) R^2 of Step A (in these analyses all variables were entered except SNS-use) and Step B (in these analyses all variables including SNS-use were entered) in Table 3 in case of significant findings. Table 3 shows that high levels of mental health problems were not independently predicted by SNS-use at T3 and T1 in any age group.

Table 5 Summary table results of step 2 logistic regression analyses among six age groups

		Step B			Nagelkerke R^2	
With media use at T3 as predictor (short term effects)		*AOR*	*95% CI*	*p*	Step A	Step B
Predicting mental health problems T4						
16-24 y.	No SNS variable significant at Step 2	-	-	-	-	-
25-34 y.	No SNS variable significant at Step 2	-	-	-	-	-
35-44 y.	No SNS variable significant at Step 2	-	-	-	-	-
45-54 y.	No SNS variable significant at Step 2	-	-	-	-	-
55-64 y.	No SNS variable significant at Step 2	-	-	-	-	-
65-74 y.	No SNS variable significant at Step 2	-	-	-	-	-
Predicting sleep problems at T4						
16-24 y.	No SNS variable significant at Step 2	-	-	-	-	-
25-34 y.	No SNS variable significant at Step 2	-	-	-	-	-
35-44 y.	Posting on SNS T3	1.24	1.02-1.51	.032	.610	.619
45-54 y.	No SNS variable significant at Step 2	-	-	-	-	-
55-64 y.	Posting on SNS T3	1.12	1.01-1.24	.031	.782	.784
65-74 y.	No SNS variable significant at Step 2	-	-	-	-	-
With media use at T1 as predictor (long term effects)		*AOR*	*95% CI*	*p*	Step 1	Step 2
Predicting mental health problems T4						
16-24 y.	No SNS variable significant at Step 2	-	-	-	-	-
25-34 y.	No SNS variable significant at Step 2	-	-	-	-	-
35-44 y.	No SNS variable significant at Step 2	-	-	-	-	-
45-54 y.	No SNS variable significant at Step 2	-	-	-	-	-
55-64 y.	No SNS variable significant at Step 2	-	-	-	-	-
65-74 y.	No SNS variable significant at Step 2	-	-	-	-	-
Predicting sleep problems at T4						
16-24 y.	No SNS variable significant at Step 2	-	-	-	-	-
25-34 y.	No SNS variable significant at Step 2	-	-	-	-	-
35-44 y.	No SNS variable significant at Step 2	-	-	-	-	-
45-54 y.	No SNS variable significant at Step 2	-	-	-	-	-
55-64 y.	No SNS variable significant at Step 2	-	-	-	-	-
65-74 y.	Posting on SNS T1	1.20	1.03-1.40	.021	.788	.791
	Chatting on SNS T1	1.12	1.002-1.24	.047	.788	.791

Step B = Besides prior mental health problems at T2, loneliness at T1, sleep problems at T2, and demographics (gender, age categories, education level, employment status at T1) SNS-use was added as predictor.
AOR = Adjusted Odd ratio. *95% CI* = 95% confidence interval of AOR.
No significant results = $p \geq .050$. y.= years.
SNS=social networking sites.

Results on sleep problems show a slightly different pattern. Analyses among the 16-24 years, 25-34 years, and 45-54 years old respondents revealed no significant outcomes for SNS-use on sleep problems (among the 25-34 years old respondents, due to low cell counts, the first two education levels were taken together among this subgroup). Among 35-44 years and 55-64 years old respondents, those who spent more hours on Posting on SNS at T3 were more likely to have sleep problems at T4 (*AOR*=1.24 and *AOR*=1.12 respectively). Finally, analyses among the 65-74 years old respondents, those who spent more hours on Posting and Chatting on SNS at T1 were more likely to have sleep problems at T4 (*AOR*=1.20 and *AOR*=1.12 respectively). However, Table 3 shows that the differences in Nagelkerke's R^2 between Step A (all variables except SNS-use) and Step B (all variables including SNS-use) were very small.

Due to low cell counts (less than 25) of answer categories of predictors in several age groups, we did not further examine and compare these associations between respondents with relatively low and high levels of loneliness at T1.

3.6. Analyses using multiple regression analyses

The multiple regression analyses among the total study sample with mental health problems at T4 as dependent variable showed identical results as the logistic regression analyses. There was one minor exception. More hours spent on Reading on SNS at T1 was associated with more mental health problems at T4 among the total sample, but explained only a very small proportion (0.1%) of the variance of mental health problems at T4 over and above other predictors [$\beta^{\text{Read T1}}$ =-.026, p=.035; $F^{\text{change}}(1, 3477)$=4.47, p=.035]. A similar effect was found among those with low levels of loneliness [R^2=0.01, $\beta^{\text{Read T1}}$ =-.029, p=.048; $F^{\text{change}}(1, 2835)$=3.91, p=.048]. No significant effects were found among respondents with

high levels of loneliness. In addition, no significant effects of any SNS-use variable were found among the selected group of SNS-users.

The results of multiple regression analyses among the six age categories were almost identical with some minor exceptions. Among respondents aged 45-54, more Reading on SNS at T3 was independently associated with more mental health problems at T4, but explained only a very small proportion of the variance (0.5%) of mental health problems at T4 [$\beta^{\text{Read T3}}$=-.071, p=.011; F^{change}(1, 657)=6.49, p=.011]. The same pattern was observed for Reading on SNS at T1 [$\beta^{\text{Read T1}}$=-.078, p=.005; F^{change}(1, 657)=7.955, p=.005; explained variance 0.6%]. With respect to respondents aged 65-74, more reading at T3 was independently though very weakly predictive of less mental health problems at T4 [$\beta^{\text{Read T3}}$=.055, p=.023; F^{change}(1, 846)=5.22, p=.023; explained variance 0.3%].

4. Discussion

As for instance the studies by Shakya and Christakis (2017), Cotten et al. (2014) and Van Ingen et al. (2017), this study is one of the very few (general) population-based prospective studies on SNS-use and mental health. In contrast to previous studies, we prospectively assessed the independent predictive values of three types of SNS-use on the short and long term among six population-based age categories, enabling conclusions about possible differences across age groups while using the same instruments, time-frame and statistical analyses.

4.1 Main conclusions

The analyses among the total study sample show a very clear pattern: once prior mental health problems, sleep problems, loneliness and demographics are taken into account, hours spent on SNS-use are no longer independent predictors for (more) mental health problems and/or sleep problems on the short or longer term. These findings underscore the necessity of longitudinal studies and studies controlling for prior mental health and mental health-related variables to prevent over-estimations of the positive or negative effects of SNS-use on mental health and sleep problems. Similarly, SNS-use did not independently predict problems among those with relatively low and relatively high levels of loneliness. Thus, we found no indications for differences in associations between those with low or high prior loneliness levels among the total study sample (cf. Kim et al., 2009; Teppers et al.,2014; Van Eijnden et al., 2008; Yoo & Jeong, 2017). Analyses among the selected group of SNS-users revealed no significant effects. These results do not support the conclusion of Song and colleagues (2014, p. 451) in their meta-analysis that *"Lonely individuals may specially benefit from social applications of the Internet such as Facebook*". In effect, we found no indications that among lonelier people, a larger number of hours spent on SNS-use was associated with less mental health or sleep problems at follow-up.

This is the first study assessing and comparing the predictive values of SNS-use among different age categories. A comparison of results of the 72 logistic regression analyses among the six age groups on the one hand and the total study sample, with respect to the prediction of mental health problems at follow-up, on the other shows that findings hardly differed. Among 34-44, 55-65 and 65-74 years old respondents, more hours spent on Posting messages on SNS was an independent predictor for sleep problems but hardly improved the prediction of sleep problems according the Nagelkerke's (pseudo) R^2 statistic. The results of the multiple regression analyses with mental health problems as dependent variable hardly differed from the results of the logistic regression analyses with the dichotomized mental

health problems variable as dependent variable. Hours spent on reading was significantly associated with mental health problems but the very low proportion of explained variance indicates that the practical relevance of this finding is almost zero.

4.2 Comparisons with other studies

Nevertheless, the findings with respect to the respondents aged 16-24, i.e. no effects, are in line with the results of Tavernier and Willoughby (2014) on the effects of SNS-use on sleep problems among students.

The study by Cotton and colleagues (2014) among retired residents, drawn from the Health and Retirement study, estimated that Internet use reduced depression (CES-D ≥ 4) by about 30% among this older group. Importantly, in this study Internet use was assessed by one simple item ("Do you regularly use the World Wide Web, or the Internet, for sending and receiving e-mail or for any other purpose…? (Yes, No)"). In our study we found no indications that higher levels of SNS-use were associated with significantly lower levels of mental health problems at follow-ups (the MHI-5 includes items that refer to depression) among 65-74 years old, although we used more specific items to assess SNS-use. We did find a significant effect in the same direction but Reading and Chatting on SNS explained only 0.3% of the variance of mental health problems in our study, which is in sharp contrast to the Cotton study.

It was outside the goal of this study to assess whether SNS was related to public health services use (cf. Capurro et al., 2014). Several studies make a distinction between active and passive use of SNS, such as the study by Frison and Eggermont (2015). Although it is tempting to consider Chatting as active and Read & view Posting as passive use of SNS,

we did not use these labels because we have no information on the extent to which respondents started or took the initiative to use SNS. It was outside the goal of the present study to examine predictors of SNS-use of compulsive SNS-use (cf. Carli et al., 2012; Ciarrochi et al., 2016).

Earlier, Romer et al. (2013) and Tavernier and Willoughby (2014) suggested that high levels of Internet use and video gaming might rather be a symptom of mental health problems than a cause, and that people may seek out media as a means of coping with their sleep problems, rather than being a cause of sleep problems. In the cross-sectional study by Mérelle and colleagues (2017), mental health problems independently predicted problematic media use. Our findings that SNS-use no longer predicts mental health or sleep problems after controlling for previous mental health and sleep problems, loneliness and demographics strongly support these suggestions: that SNS-use may occur as a symptom of underlying problems. As such, these findings offer alternative explanations for the results of the cross-sectional study by Vannuci et al. (2017). Either way, these findings stress the necessity of controlling for previous problems to prevent speculative conclusions about SNS-use as the cause of problems. Importantly, as said, findings were not different among respondents with low or high levels of previous loneliness, and loneliness was an important independent predictor for mental health problems at follow-up. In other words, we found no indications that SNS-use enhanced social relationships (that more SNS-use was negatively related to mental health problems at follow-up among the low loneliness subgroup) or that SNS undermined social relationships (that more SNS-use was positively related to mental health problems at follow-up among the high loneliness subgroup) on a group level.

4.1. Limitations

We did not conduct clinical interviews, which would have enriched our study. We cannot rule out the possibility that SNS-use (independently) increases the risk for other mental health problems.

We did not examine the reasons or context for SNS-use. In the cross-sectional study by Weiser (2001), for instance, personal and professional Internet use were very weakly associated with psychological well-being but had contrasting indirect effects on well-being via socio-affective regulation (negative: such as meeting others) and information acquisition (positive: such as gaining knowledge) respectively. In the longitudinal study by Selfhout and colleagues (2009), the social context in which adolescents use Internet moderated the effects of use on internalizing problems: adolescents with low quality friendships who spend more time on Internet for communication purposes develop less depression over time. As said, in our study we found no indications that prior loneliness affected the relationships between SNS-use and mental health problems or sleep problems among the total sample.

The data on SNS-use are based on self-reports, and not on objective data such as actual media use in Kraut's and colleagues' studies (1998, 2002), or on multi-source data such as in the study by Van Zalk and colleagues (2011). This study does not include young children and a recent review concluded that the number of studies on the impact of social media on younger children is limited (cf. Richards, Caldwell, & Go, 2015).

4.2. Final remarks

In sum, we found no indications that the three types of SNS-use are modest to strong independent predictors of mental health or sleep problems among a large population-based sample, nor across age groups or across respondents with low or high levels of loneliness.

The found effects were, also taking the number of comparisons into account, limited to a few cases and very weak effects, especially compared to prior mental health and sleep problems, and loneliness.

Berryman and colleagues recently (2018, p. 313) asked, "*Why the popular press, suicide advocates and policy makers continue to hone in on time spent online as a cause of mental health problems is an interesting question, particularly given lack of clear evidence for this relationship*". It is clear that our study does not provide such evidence, but perhaps we should consider the period in which our and other recent studies were conducted. SNS-use is a relatively new phenomenon, use is increasing among all age categories, is becoming steadily more integrated in daily life, but it is unknown how SNS-use will develop in the future (for example its integration with virtual reality facilities), or how it will influence for example social relationships. The absence of evidence now is no guarantee that in the future, when SNS-use may have developed further and/or differently, SNS-use will not clearly and independently, positively or negatively be associated with mental health or sleep problems. Perhaps the "positive" finding by Morgan and Cotton (2003; they found that higher numbers of hours spent on e-mailing and chat room/instant messaging (IM) hours were associated with *lower* depressive symptom levels), could be viewed in this perspective. This study was conducted in 2002 when current SNS platforms such as Facebook, WhatsApp and Twitter were almost non-existent. Other than for example the effects of smoking on health, the effects of SNS-use may be time and context dependent, at least in part because of future developments. Therefore, future research is warranted.

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