To investigate the relationship between in-bed mobile phone use, quality of sleep and levels of depression, anxiety and stress in young adults

Alycia Rowlinson

Supervised by: Elaine Reeves

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ABSTRACT

Electronic media is becoming increasingly more dynamic, portable and is emerging into most aspects of life. Presently, it is popular to use electronic devices in the hours preceding bedtime and it has become of recent interest to consider whether electronic media use in-bed is related to the quality of sleep followed. A poor sleep can lead to psychological health problems. The present study aimed to investigate the relationship between in-bed mobile phone use, sleep quality and symptoms of depression, anxiety and stress in a young adult population in order to extend the emerging research base regarding electronic media use, sleep quality and psychological well-being. This study is one of the first to investigate the association between in-bed mobile phone use explicitly, alongside the variables sleep quality and depression, anxiety and stress, particularly in young adults. 256 young adults aged 18-39 completed a series of online self-report questionnaires that provided scores for each variable. Foremost, Pearson's correlation coefficients established relationships between all variables. Three main research questions were addressed. However, after a series of regression analyses and further testing to determine the significance of mediators, sleep quality was presented to be the most influential predictor of depression, anxiety and stress symptoms.

KEY WORDS:	ELECTRONIC MEDIA	PSYCHOLOGICAL WELL-BEING	SLEEP QUALITY	ONLINE QUESTIONNAIRE	CORRELATIONAL RESEARCH

Introduction

Electronic media is becoming increasingly more dynamic, portable and emerging into most aspects of our life. Eighty-six percent of households in Great Britain have internet access, with 96% of adults accessing the internet “on the go”, away from home or work, via electronic devices such as smartphones and tablets every day (Office for National Statistics, 2016). Today, it is popular to use said devices in the hours preceding bedtime (Gradisar et al., 2013; Bruni et al., 2015), and it has become of recent interest to recognise whether in-bed electronic media use influences the quality of sleep followed. ‘In-bed media use’ refers to the use of electronic media, such as smartphones, laptops/computers, tablets, television or video games, whilst in bed during the hours before sleep. The National Health Service advises around eight hours of good quality sleep a night in order to function properly and avoid health implications such as obesity, heart disease or long-term mood disorders like depression and anxiety (NHS.uk, 2015). It is therefore unsurprising that sleep quality has stimulated research interest in regards to in-bed electronic media use.

A publication by Cain and Gradisar (2010) dominates this emerging area of interest. They are acknowledged for highlighting the main findings in this area with an extensive review of 36 papers that investigated the relationship between sleep and electronic media use in school-aged children and adolescents. Their critique concluded that the use of electronic media, particularly in the hours preceding bedtime, is related to sleep disturbance**.** Numerous variables were investigated across the 36 studies, however, a delayed bedtime and short sleep time were found to be most consistently related to electronic media use. Although respectively this review boasts a large data capture, its generalisability is limited as the studies included participants aged approximately 5-17 years only.

Derived from this, Cain and Gradisar (2010) proposed a theoretical framework (Figure 1) to explain the possible mechanisms that affect the relationship between electronic media use and poor sleep**.** The model consists of factors that may explain why electronic media influences sleep foremost, such as social or developmental factors, before further explaining possible mechanisms that prevent sleep onset. Mechanisms include 1) media use directly replaces sleep, 2) media use increases mental/emotional/physiological arousal, and 3) bright light exposure delays the

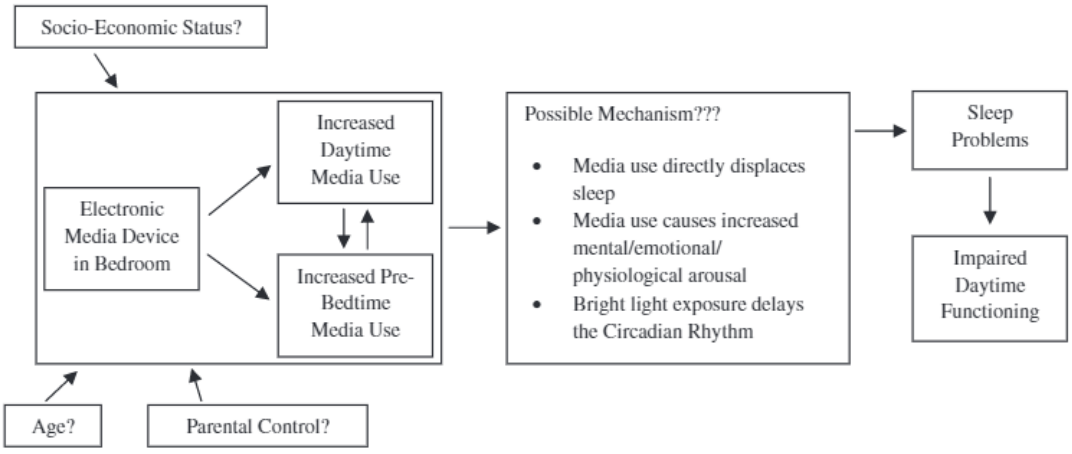

Figure 1. Cain and Gradisar (2010) Theoretical model representing the possible impact of electronic media on sleep

Circadian Rhythm, otherwise known as the 'body clock'. Disruptions in the Circadian Rhythm have been found to correlate with neurological issues such as depression (Smyth, 1999). Using models to explain human behaviour is criticised for being too over simplistic, however it does provide a sound graphical representation of the potential impact of electronic media on sleep for this emerging area of interest. Research has effectively followed and provided support for this model (Lemola et al., 2014).

Previous research findings in this area support the mechanisms proposed by Cain and Gradisar (2010). There is a general consensus across a number of studies that, in respect to their time consuming nature, the use of an electronic device in bed may be directly replacing sleep. Studies found smartphone users to delay their bedtime or 'lights out' due to using the devices instead of sleeping (Munezawa et al., 2011; Gamble et al., 2014; Lemola et al., 2014).

Additionally, in support of mechanism 3, experiments have noted the role of light in preventing sleep by showing how even the small lights emitted from electronic devices can confuse the brain and delay the onset of sleep (Figueiro et al., 2009; Gellis and Lichstein, 2009; Zeitzer et al., 2000). This is due to the photoreceptors in our eyes that sense light, which indicate to the brain the status of the 'outside world', and aligns our circadian rhythms accordingly, e.g. prepares us for sleep or waking, via our melatonin levels (Sleepfoundation.org, 2015). Melatonin is a natural hormone secreted by the pineal gland in the brain when darkness occurs, which in turn encourages sleep. Bright light directly inhibits the release of melatonin thus delays the onset of sleep (Sleepfoundation.org, 2016). To criticise, some research did not find bright light to effect physiological sleep activity (Higuchi et al., 2005). However, a double-blind experimental study conducted by Wood et al. (2006) exposed or sham-exposed 55 adult volunteers to 30 minutes of mobile phone emissions before bedtime. They reported that although there was no significant difference in total night time melatonin levels between each group, the pre-bedtime melatonin levels in subjects who were genuinely exposed to the phone emissions were significantly lower. These results indicate that mobile phone light emissions delay the commencement of melatonin secretion thus postpone sleep onset.

Correspondingly, poor sleep increases the risk of developing mental health problems (Chang et al., 1997). Research has consistently found associations between sleep disturbance and depressive symptoms (Brunborg, 2011; Lemola et al., 2011; Oshima et al., 2012; Short et al., 2013; Wong et al., 2013). Following Cain and Gradisars' (2010) model, Lemola et al. (2014) examined electronic media use at night and compared this with sleep disturbances and levels of depression**.** Established questionnaires assessed a variety of sleep quality variables, electronic media use

before sleep such as smartphone use, watching TV or playing video games, and depressive symptoms in 390 adolescents. Electronic media use in bed was found to negatively correlate with sleep duration and positively correlate with sleep difficulties, which in turn related to symptoms of depression. Specifically, results found that owning a smartphone was associated with a later bedtime. This relates to the findings of Wood et al. (2006) in regards to the delay of sleep onset, as well as proposals made by Cain and Gradisar (2010) that phone use may be directly replacing sleep. Importantly, sleep disturbance was found to mediate the relationship between electronic media use in bed and symptoms of depression. Although favored for its large sample size, findings indicate that further research regarding in-bed electronic media use in relation to sleep and psychological well-being would be beneficial, notably with older populations or with a focus on a specific media device.

A similar study by Demirci et al. (2015) considered the use of smartphones specifically. The research investigated whether the severity of smartphone use is associated with sleep quality, depression and anxiety in 319 university students**.** Participants were stratified into three groups based on their smartphone usage; a smartphone non-user group (N = 71), a low smartphone use group (N = 121), and a high smartphone use group (N = 127). A series of established questionnaires evaluated participants' quality of sleep and symptoms of depression and anxiety. Measures included the 'Pittsburgh Sleep Quality Index', 'Becks Depression Inventory' and 'Becks Anxiety Inventory.' Analysis found significant positive correlations between variables particularly in the high smartphone use group. Regression analyses indicated that high levels of smartphone use and poor sleep quality predicted depression and anxiety scores. Statistical significance was achieved where $p < .001$, allowing researchers to conclude that depression, anxiety and sleep quality was associated with smartphone overuse. This implies that overuse of a smartphone could lead to a higher risk of developing psychological health issues.

To compare, research by Thomée et al. (2011) investigated whether high use of ICT (Information and Communication Technology) was a risk factor for developing psychological symptoms among 20-24 year olds (N = 4156). ICT or electronic media usage and symptoms of stress and depression were assessed foremost, and once more at a one-year follow up. Although causal mechanisms are unclear due to correlational design, associations were achieved between some variables. Results particularly indicated that high frequency mobile phone use could increase risk for developing sleep disturbances and symptoms of stress and depression. These findings are further supported by similar research which state that severe use of an electronic device puts an individual at risk for psychological symptoms (Thomée et al., 2007; Demirci et al., 2015).

Thomée et al.'s (2011) research is favoured for its sample of young adults; a population rarely included in this research area to date. This is important as Ofcom, UK communications regulator, discovered that 27% more adults are now using the internet in any location and their time spent online per week has more than doubled

since 2005 (Ofcom, 2015). There is no shortage of studies in relation to the media habits and psychological well-being of adolescents and young children (Cain and Gradisar, 2010; Lemola et al., 2014; Demirci et al., 2015). It is respected that at one time adolescents and young children may have been technologies largest consumer, however present day electronic media is indulged by a much wider audience; 89% of UK adults now own a smartphone (Ofcom, 2015). Thus, based on previous suggestions, we must conclude that it is essential to study the possible health implications of mobile phone exposure specifically and a range of populations should now be acknowledged (Cain and Gradisar, 2010; Thomée et al., 2011; Fossum et al., 2013). Based on this, the present study included a population of young adults.

Gradisar et al. (2013) and Higuchi (2005) considered the interactive qualities of different types of electronic devices. Interactive electronic devices refer to those such as smartphones, computers/laptops and video game consoles, unlike passive electronic devices such as TV and music players. Research concluded that interactive electronic devices are most strongly associated with sleep disturbances. This relates to the notion that electronic media use increases mental/emotional/physiological arousal and prevents the onset of sleep (Cain and Gradisar, 2010) perhaps due to their interactive properties. Findings encouraged the present study to focus on interactive electronic devices, specifically the use of a smartphone due to its portable and interactive qualities.

A major UK communications company report that the use of alternative devices to access the internet has increased considerably over the last decade (Ofcom, 2015). Mobile phones have become an essential part of daily life (Kenichi, 2011; Eyvazlou, 2016), with adolescents and adults deeming them the most necessary medium of communication in a nationwide survey (Kenichi, 2011). Importantly, because of the consistent development and widespread use of mobile phones and the effect they are having on every day communication, this piece of technology is now potentially the most frequently used media device. Despite this, there are relatively few studies regarding the use of mobile phones specifically and their impact on our psychological well-being. The majority of research includes the use of electronic media as a whole and so the present study intentionally deviates from that.

To date, self-report questionnaires appear to be the dominating method of data capture in this research area, particularly to supply a correlational design. Experimental research is limited; causal studies are yet to establish cause-effect relationships between electronic media, sleep quality and psychological well-being. In spite of this, research regarding health and electronic media is still an emerging interest and so correlational research appears to be the most suitable for gathering a knowledge base firstly, before evolving to a range of other methods.

Using a correlational design, the following research was primarily conducted to add to the existing psychological literature concerning in-bed mobile phone use, quality of sleep and psychological well-being. In the present study, psychological well-being refers to symptoms of stress, anxiety and depression. Derived from previous psychological research (Thomée et al., 2007; Cain and Gradisar, 2010; Demirci et al., 2015), three research questions were produced:

Research Question 1: To what extent does in-bed mobile phone use and sleep quality predict symptoms of stress, anxiety and depression in young adults?

Research Question 2: Does a higher duration of in-bed mobile phone use determine a poor quality sleep?

Research Question 3: Does poorer sleep quality mediate between in-bed phone use and stress, anxiety and depression?

Secondary aims of the research include investigating the relationship between in-bed mobile phone use, sleep quality and psychological well-being, alongside age and gender of participants. Also, to explore whether more mobile phone use at night delays sleep onset. Accordingly, the overall aim of the present research was to investigate the relationship between in-bed mobile phone use, sleep quality and depression, anxiety and stress, with a focus on a young adult population.

Method

Design

A correlational design investigated the predictive value of in-bed mobile phone use and sleep quality on psychological well-being symptoms, stress, anxiety and depression. Participants were required to complete a series of online surveys which measured the predictor variable; in-bed mobile phone use, the possible mediating variable; quality of sleep (PSQI) and the criterion variable; psychological well-being, in regards to levels of stress, anxiety and depression (DASS).

Participants

Based on an abundance of research primarily studying the electronic media habits of young children and adolescents, this current research branches out to a slightly older audience of young adults; those aged 18-39 (M = 23.34, SD = 5.30, N = 256). According to Green (1991), to accumulate a sufficient sample size, a minimum of 106 participants were required for this research, following $N \geq 104 + m$, where *'m'* is the number of predictors. 256 respondents completed the online survey overall. This sample was achieved via an opportunity sample originating from an invitation containing a link to the online survey posted on social media. This particular sampling method was appropriate due to the nature of the research; using social media as a platform to recruit participants for an online questionnaire is likely to recruit mobile-phone users (Taylor-Powell and Hermann, 2000).

Measures

Mobile Phone Use in Bed Before Sleep

Participants' mobile phone use in bed before sleeping was assessed via a series of questions created by the researcher (Appendix 6). Participants were required to specify how many days per week that they thought they used their smartphone in bed before sleeping, and to specify on average how many minutes per night they spent on their smartphone in bed before sleeping. Their response to each question was multiplied by each other to produce a 'Total Phone Use' variable. This variable indicates approximately how many hours per week each participant spends on their smartphone in bed before sleeping.

Pittsburgh Sleep Quality Index

Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI) (Appendix 7). Created by Buysse et al. (1989), the PSQI is a 19-item self-report questionnaire used as an instrument to measure the overall quality of sleep a person has; referred to as a 'Global PSQI score'. Seven components are measured, this includes 'subjective sleep quality', 'sleep latency', 'sleep duration', 'habitual sleep efficiency', 'sleep disturbances', 'use of sleep medication' and 'daytime dysfunction'. The sum of each component score produces the 'Global PSQI score'. A Global PSQI score of '5' or more is indicative of a poor quality sleep. Participants were expected to

subjectively answer questions based on the experience of their sleep within the past month by scoring themselves on a 0-3 point Likert scale, whereby 3 reflects a poorer quality of sleep. Numerous international studies have supported this measure in its high internal consistency and reliability coefficient (α = 0.83) (Smyth, 1999). Copyright holders grant permission for this measure to be reproduced for not-for-profit educational purposes.

DASS Scale

The DASS (Depression Anxiety Stress Scale) measure provided the data for participants' psychological well-being scores; 'depression', 'anxiety' and 'stress' (Appendix 8). Produced by Lovibond and Lovibond (1995), the DASS consists of three self-report scales that measure the negative emotional states of depression, anxiety and stress. Due to researcher preference, the 42-item questionnaire was used in particular for this study as opposed to the shorter 21-item questionnaire. Hence, each scale consists of 14 items (Depression: 3, 5, 10, 13, 16, 17, 21, 24, 26, 31, 34, 37, 38, 42; Anxiety: 2, 4, 7, 9, 15, 19, 20, 23, 25, 28, 30, 36, 40, 41; Stress: 1, 6, 8, 11, 12, 14, 18, 22, 27, 29, 32, 33, 35, 39). Each scale has a subscale of 2-5 items that measure similar content. Participants were required to subjectively rate the severity and frequency of said emotional states over the past week on a 4-point Likert scale, where 0 'Did not apply to me at all' and where 3 'Applied to me very much or most of the time'. Assessment of the psychometric properties on a large non-clinical sample (N = 2914) found an acceptable reliability value for each of the three scales (depression α = .91, anxiety .84 and stress .90) (Crawford and Henry, 2003). An internet administered version of the questionnaire (*N* = 1138) found excellent internal consistency scores for each of the scales (depression *α* = .95; anxiety *α* = .93; stress *α* = .94) (Zlomke, 2009). Scoring for the scale is a simple process that involves calculating the sum of the scores for the relevant items assigned to each of the emotional states. This then indicates whether emotional levels are 'normal' to 'extremely severe' whereby a higher score reflects more severity. The DASS is readily available in public domain hence permission from the author was not required.

Procedure

The following study was performed in accordance with the ethical standards required by the British Psychological Society (BPS) and ethical approval was granted from The Manchester Metropolitan University before the commencement of this research. Via social media site 'Facebook', young adults (aged 18-39) were invited to complete a series of online questionnaires hosted by online survey research platform Qualtrics (Qualtrics, 2015). Following the link posted online, participants were presented with an invitation letter (Appendix 2) which briefly informed them of the intentions of the present study. Following this, a 'Participant Information Sheet' (Appendix 3) provided sufficient information for them to voluntarily give their informed consent to take part; this further explained the purpose of the study, outlined what was expected of their participation and ethical grounds were established regarding their anonymity and right to withdraw. Participants were fully briefed before obtaining their informed consent (Appendix 4); a requirement before commencing the study. Participants were prompted that, due to the online format, by clicking 'Continue' to the survey they indicated their consent to voluntarily involve themselves in the research. Recruits were

encouraged to complete the online-survey in a quiet setting whereby they could concentrate on providing their honest answers. Participants then completed a series of questions comprising of the measures for In-bed Mobile Phone Use (Appendix 6), the Pittsburgh Sleep Quality Index (PSQI) (Appendix 7) and the Depression Anxiety Stress Scale (DASS) (Appendix 8). All questions were compulsory to answer and took approximately 20 minutes to complete. Upon completion, each participant was fully debriefed, thanked for their time and reminded of their right to withdraw up until the date of analysis (Appendix 5). Here, participants were required to create a personal pseudonym in order to create and maintain anonymity; this would have ensured an easy identification and withdrawal of participant details if a participant wished to withdraw from the research. Participants were also offered the researchers' and the universities counselling and well-being contact details should they have wished to discuss their feelings regarding the study. Finally, using an online statistical package programme, raw scores were quantitatively analysed.

Results

Raw data was downloaded from Qualtrics and appropriately analysed using IBM® Statistical Package for the Social Sciences 22.0 (SPSS) for Windows (Appendix 9). Firstly, all participant scores were entered into SPSS and data was prepared for analysis. Scale totals were calculated for each measure according to the authors instructions (Appendix 7 and 8). Participant scores for the 'Total Phone Use' variable were simply created by multiplying how many days per week that participants indicated that they used their smartphone in bed before sleeping by how many minutes per night they spent on their smartphone in bed before sleeping – this gave an approximate total weekly score of in-bed mobile phone use. Tests of normality distribution revealed data to be within normal boundaries (Appendix 9). Following this, internal consistency was assessed and Cronbach's alpha (α) coefficients were produced for each individual scale (PSQI – Sleep Quality, DASS Depression, DASS Anxiety, DASS Stress) (Table 1).

Table 1

Internal Consistency and Confidence Intervals for Sleep Quality and Depression, Anxiety and Stress Measures

	Number of items	Cronbach's alpha	95% Confidence Interval for alpha	
			Lower	Upper
Sleep Quality	7	.76*	.71	.80
Depression	14	.95***	.94	.96
Anxiety	14	.89***	.87	.91
Stress	14	.93***	.91	.94

Note: *F* test with true value = 0.7, * $p < .05$ *** $p < .001$

All scales demonstrated a Cronbach's alpha value significantly above 0.7, indicating that each scale possesses at least an acceptable level of reliability (Nunnally, 1978). Moreover, 'Depression' and 'Stress' scales displayed an excellent level of internal consistency and the 'Anxiety' scale a good level, each showing significance where $p < .001$, consistent with previous clinical research (Brown et al., 1997). Following this, descriptive statistics were calculated for each measure and the demographic variable 'Age' (Table 2).

Table 2
Overview of Means and Standard Deviations for the Total Scores of Each Variable

Variable	*M*	*SD*
Age	23.34	5.30
Total Phone Use	622.52	285.92
Sleep Quality	6.97	3.40
Depression	23.79	9.93
Anxiety	21.50	7.30
Stress	27.63	9.52

There was a vast difference in gender distribution among who completed the online questionnaires (Males N = 50, Females N = 206). For this sample, the average time spent in bed on a mobile phone is over 10 hours per week (M = 622.52). The mean 'Sleep Quality' score for participants indicate a poor sleep quality; a score of 5 or greater (Buysse et al., 1989). 'Depression', 'Anxiety' and 'Stress' scores indicate that participants generally have 'Severe' to 'Extremely Severe' levels of psychological symptoms, according to Lovibond and Lovibond (1995).

A series of Pearson bivariate correlations (2-tailed) were conducted between all measures to establish whether there were significant relationships between variables, with the addition of age and gender (Table 3). 'Total Phone Use' refers to participants self-reported total weekly in-bed mobile phone use.

Table 3
Pearson Correlation Matrix Between All Measures and Demographic Variables of Age and Gender

	1	**2**	**3**	**4**	**5**	**6**	**7**
1. Age	-	.04	.08	-.19**	-.05	-.13*	-.05
2. Gender	-	-	.05	.07	.03	.03	.14*
3. Total Phone Use	-	-	-	.22**	.14*	.12**	.14*
4. Sleep Quality	-	-	-	-	.50**	.43**	.48**
5. Depression	-	-	-	-	-	.72**	.77**
6. Anxiety	-	-	-	-	-	-	.78**
7. Stress	-	-	-	-	-	-	-

Note: *p <.05 ** p <.01 (2-tailed)

The correlation matrix showed a significant negative correlation between 'Age' and 'Total Phone Use' (r(256) = -.19, p<.01), indicating that in-bed mobile phone use decreases significantly as age increases in this sample of young adults (N = 256). 'Total Phone Use' and 'Sleep Quality' positively correlated significantly (r(256) = .22, p<.01), signifying that in-bed mobile phone use determines a poorer quality of sleep. Furthermore, 'Sleep Quality' positively and significantly correlated with all measures of psychological well-being symptoms; 'Depression' (r(256) = .50, p<.01), 'Anxiety' (r(256) = .43, p<.01) and 'Stress' (r(256) = .48, p<.01). This indicates the negative influence that a poor quality sleep has on psychological factors. Correlations also showed that 'Depression', 'Anxiety' and 'Stress' significantly intercorrelate with each other, in line with past research (Clark and Watson, 1991; Brown et al., 1997).

A separate Pearson's bivariate correlation revealed a significant positive correlation between hours spent on phone in bed at night and how long it takes participants to fall asleep each night (r(256) = .30, p<.001) (see Figure 1).

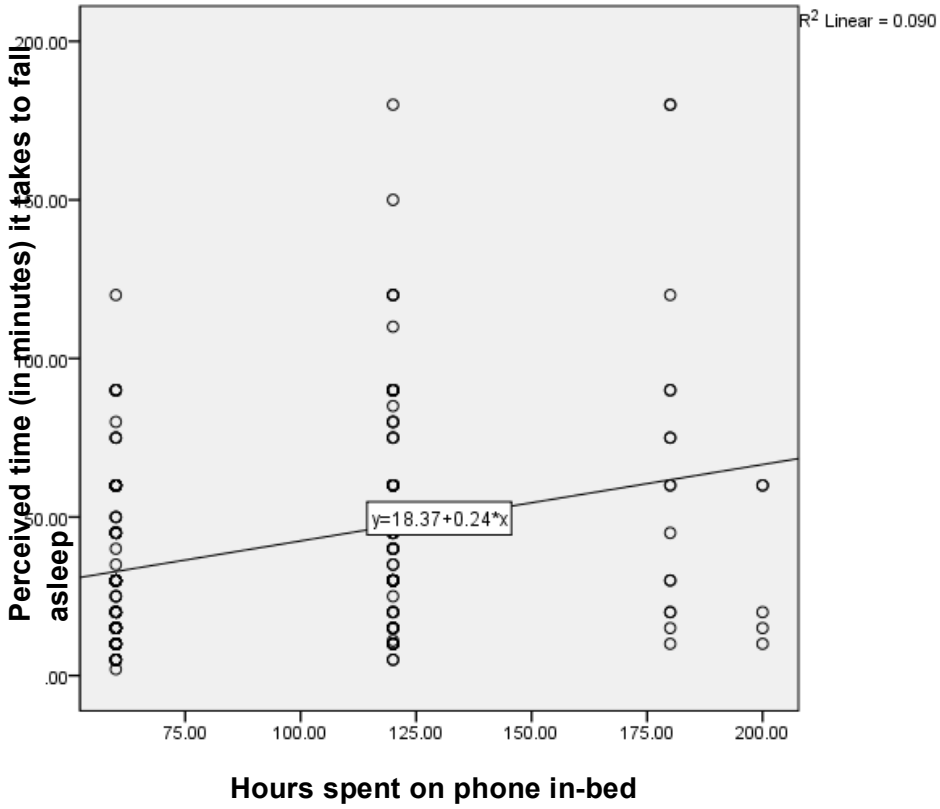

Figure 1. Scatterplot showing significant positive correlation between hours spent on phone in-bed each night and participants perceived time it takes to fall asleep

As significant correlations were found between in-bed mobile phone use, sleep quality and depression, anxiety and stress scores, a series of linear regression analyses were conducted to investigate the research questions. Tests found that limits of multicollinearity did not exceed the normal standards in all regression models thus specified no cause for concern. Normal standards entail VIF values displaying less than 10 and tolerance values above .2 (Menard, 1995; Everitt, 1996).

Research Question 1: To what extent does in-bed mobile phone use and sleep quality predict symptoms of stress, anxiety and depression in young adults?

To investigate Research Question 1, three multiple linear regressions were conducted, using the enter method, with ‘Total Phone Use’ and ‘Sleep Quality’ as predictors and psychological well-being symptoms ‘Depression’ (Table 4), ‘Anxiety’ (Table 5) and ‘Stress’ (Table 6) as the respective criterion variables.

Table 4

Summary of Multiple Linear Regression Analysis for In-bed Mobile Phone Use and Sleep Quality Scores Predicting DASS Depression Scores

Variable	*B*	β	*t*	*Sig.*(*p*)
Constant (intercept)	13.04			
Total Phone Use	.001	.04	8.7	.531
Sleep Quality	1.41	.49	.63	<.001

Note: R^2 = .25

The regression model explained 25% of the variance in 'Depression' scores, and this overall model was statistically significant, $F(2, 251) = 41.39$, $p < .001$.

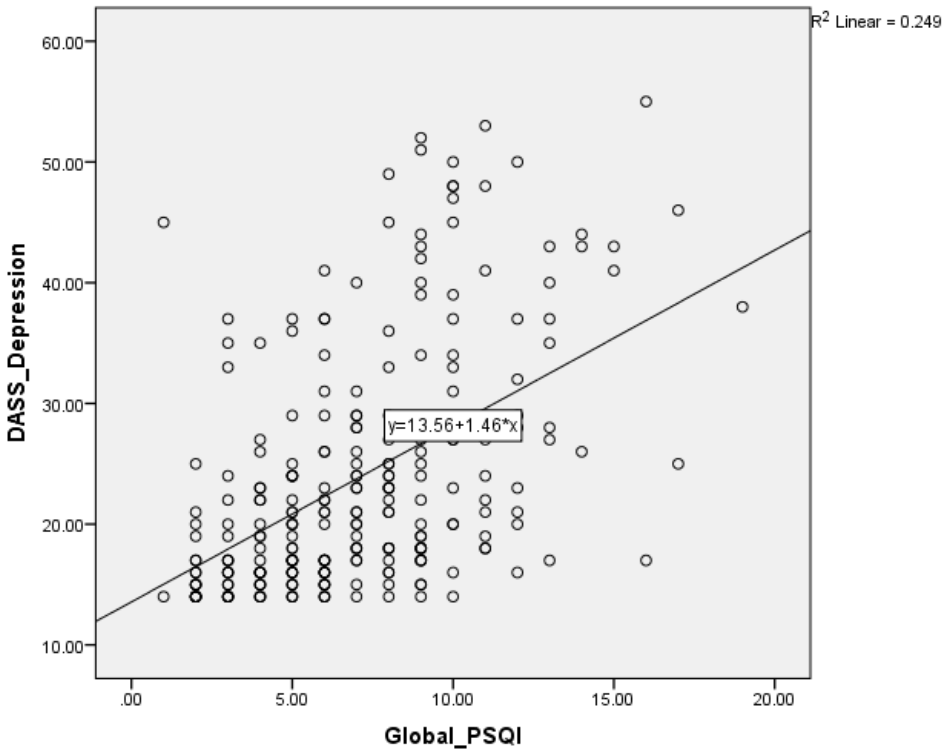

Figure 2. Scatterplot with regression line showing significant positive relationship between PSQI (Sleep Quality) and DASS Depression scores

The analysis above indicates that for every 1 standard deviation that 'Sleep Quality' increases, the 'Depression' score increases by .49.

Table 5

Summary of Multiple Linear Regression Analysis for In-bed Mobile Phone Use and Sleep Quality Scores Predicting DASS Anxiety Scores

Variable	*B*	β	*t*	*Sig.*(*p*)
Constant (intercept)	13.88			
Total Phone Use	.01	.10	1.72	.086
Sleep Quality	.86	.40	6.87	<.001

Note: $R^2 = .19$

The regression model explained 19% of the variance in 'Anxiety' scores, and this overall model was statistically significant, $F(2, 251) = 29.00$, $p < .001$.

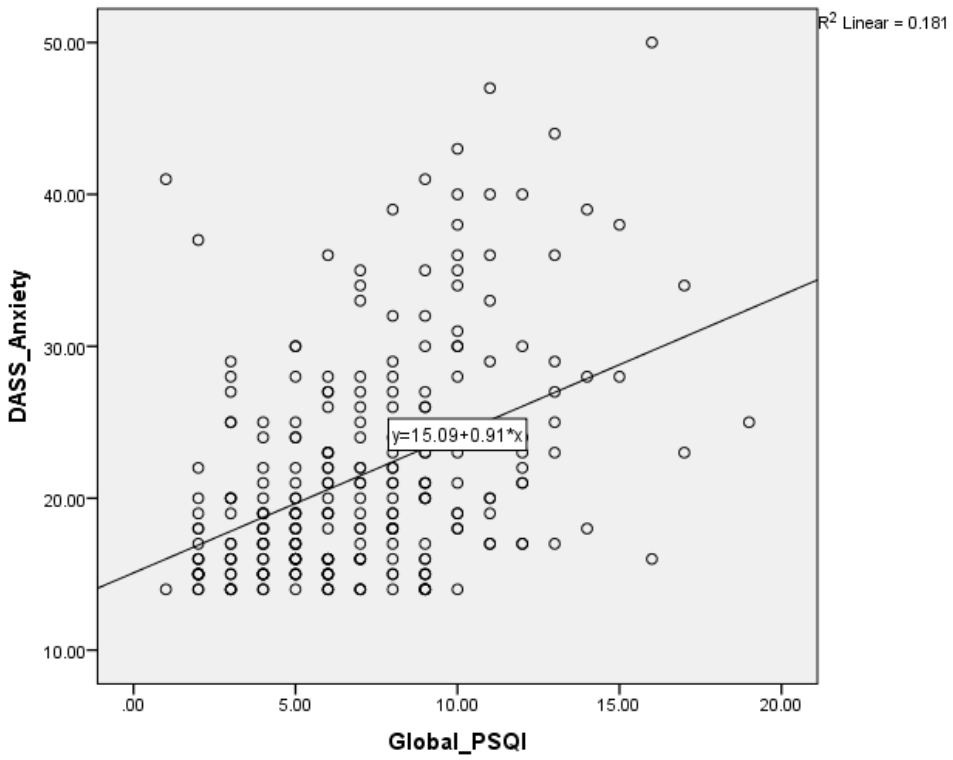

Figure 3. Scatterplot with regression line showing significant positive relationship between PSQI (Sleep Quality) and DASS Anxiety scores

The analysis above indicates that for every 1 standard deviation that 'Sleep Quality' increases, the 'Anxiety' score increases by .40.

Table 6
Summary of Multiple Linear Regression Analysis for In-bed Mobile Phone Use and Sleep Quality Scores Predicting DASS Stress Scores

Variable	*B*	β	*t*	*Sig.*(*p*)
Constant (intercept)	17.38			
Total Phone Use	.01	.04	.64	.524
Sleep Quality	1.36	.49	8.68	<.001

Note: R^2 = .25

The regression model explained 25% of the variance in 'Stress' scores, and this overall model was statistically significant, $F(2, 251) = 40.99$, $p < .001$.

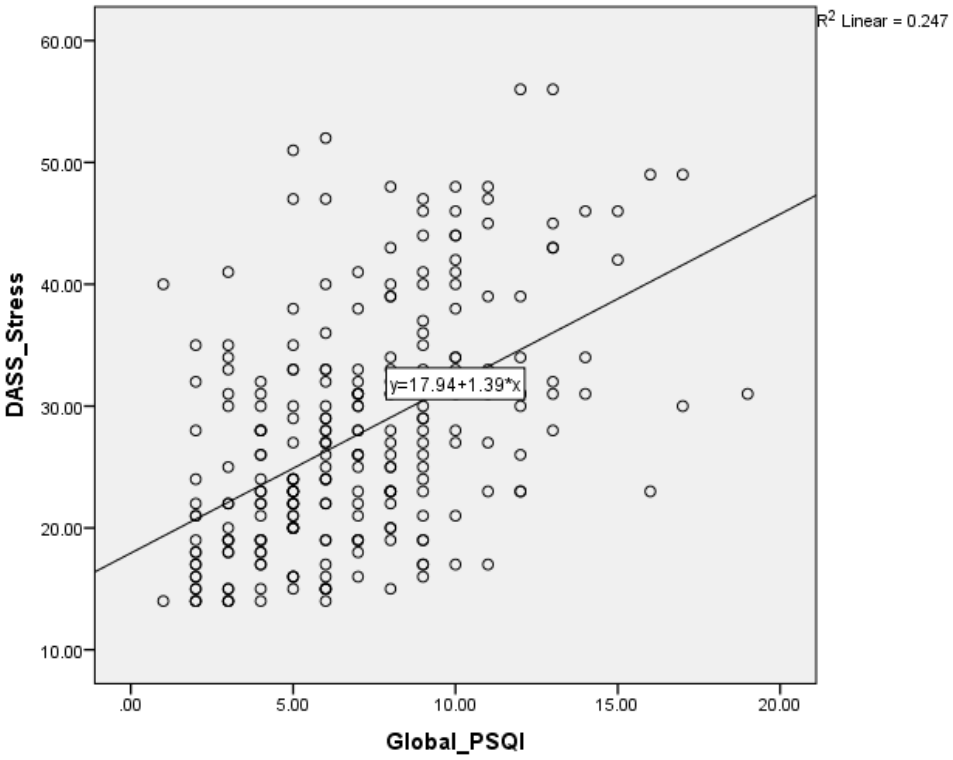

Figure 4. Scatterplot with regression line showing significant positive relationship between PSQI (Sleep Quality) and DASS Stress scores

The analysis above indicates that for every 1 standard deviation that 'Sleep Quality' increases, the 'Stress' score increases by .49.

Research Question 2: Does a higher duration of in-bed mobile phone use determine a poor quality sleep?

Research question 2 was investigated by conducting a simple linear regression to investigate the influence of in-bed mobile phone use (predictor) on sleep quality (criterion).

Table 7
Summary of Linear Regression Analysis for In-bed Mobile Phone Use Predicting Sleep Quality

Variable	*B*	β	*t*	*Sig.*(*p*)
Constant (intercept)	5.35			
Total Phone Use	.01	.22	3.54	<.001

Note: $R^2 = .05$

The regression model explained 5% of the variance in 'Sleep Quality' scores, and this overall model was statistically significant, $F(2, 252) = 12.56$, $p < .001$.

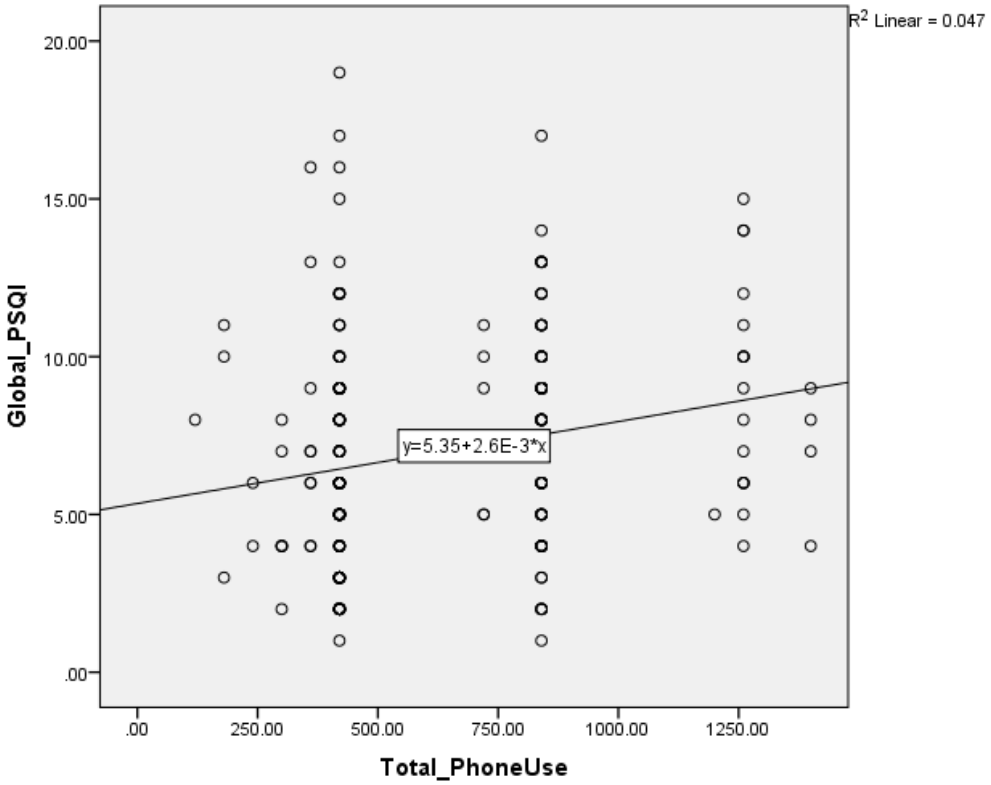

Figure 5. Scatterplot with regression line showing significant positive relationship between Total Phone In-Bed Phone Use and Global PSQI (Sleep Quality) scores

The analysis above indicates that for every 1 standard deviation that 'Total Phone Use' score increases, the 'Sleep Quality' score increases by .22.

Research Question 3: Does poorer sleep quality mediate between in-bed phone use and stress, anxiety and depression?

To investigate whether sleep quality mediated between in-bed mobile phone use and psychological well-being symptoms, the four-step method suggested by Baron and Kenney (1986) was followed. The first step includes demonstrating that the initial predictor variable affects the criterion variable in a regression analysis. Next, a second regression analysis must show the predictor to affect the mediator. Thirdly, a further regression analysis must include both the predictor and the mediator, and the mediator must show to affect the criterion variable. Here, it is important that the effect of the initial predictor variable reduces in comparison to the first regression analysis. If the predictor variable is shown to have no significant effect when the mediator is controlled, it is said to have achieved perfect mediation. Furthermore, Preacher and Hayes (2004) encouraged a Sobel test to calculate the significance of the mediation (Soper, 2016). Following these steps, mediation was determined for each psychological well-being symptom separately.

DASS Depression

The first step of mediation, to demonstrate that the predictor variable (In-bed mobile phone use) has an effect on the criterion variable (Depression) is displayed in Table 8.

Table 8
Summary of Linear Regression Analysis for In-bed Mobile Phone Use Predicting DASS Depression Scores

Variable	*B*	β	*t*	*Sig.*(*p*)
Constant (intercept)	20.60			
Total Phone Use	.01	.14	2.27	.024

Note: R^2 = .02

The regression model found 'Total Phone Use' to be a significant predictor of depressive symptoms, thus as in-bed mobile phone use increases, depression levels are shown to increase.

The second step to determine mediation as proposed by Baron and Kenney (1986) was satisfied in the regression analysing Research Question 2. In-bed mobile phone use was shown to have a significant effect on sleep quality ($F(1,252) = 12.56$, $p < .001$) (Table 7).

The third step of the criteria to determine mediation was also satisfied in a prior analysis. A multiple linear regression assessed the association between 'In-bed Mobile Phone Use' and 'Sleep Quality' Scores and DASS Depression Scores (Table 4).

Finally, a Sobel test was conducted to determine the significance of sleep quality as a mediator of in-bed mobile phone use and depression (Soper, 2016). The Sobel test showed that sleep quality was a perfect mediator of the relationship between in-bed mobile phone use and depression (z = 3.02, p = .003) (2-tailed) (Figure 6).

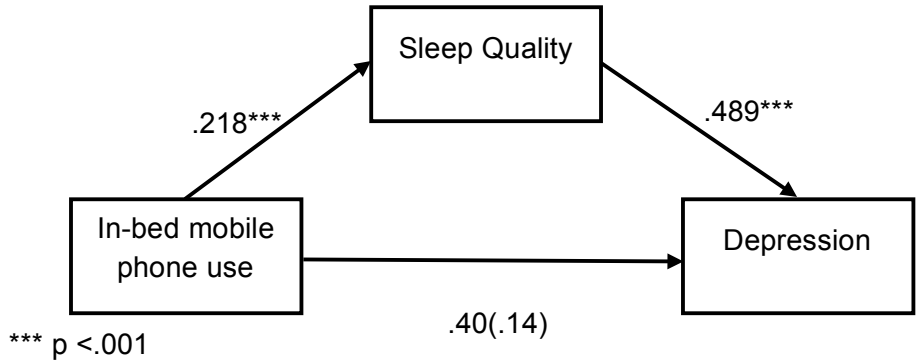

Figure 6. A diagram to illustrate the perfect mediation of sleep quality between in-bed mobile phone use and levels of depression

DASS Anxiety

The first step to determine mediation, to demonstrate that the predictor variable (In-bed mobile phone use) has an effect on the criterion variable (Anxiety) is displayed in Table 9.

Table 9
Summary of Linear Regression Analysis for In-bed Mobile Phone Use Predicting Symptoms of Anxiety

Variable	*B*	β	*t*	*Sig*.(*p*)
Constant (intercept)	18.46			
Total Phone Use	.01	.19	3.03	.003

Note: R^2 = .04

The regression model found ‘Total Phone Use’ to be a significant predictor of anxiety scores, thus as in-bed mobile phone use increases, anxiety levels increase.

Step two of mediation was satisfied in the regression analysing Research Question 2. In-bed mobile phone use was shown to have a significant effect on sleep quality ($F(1,252) = 12.56$, $p < .001$) (Table 7).

The third step of the mediation criteria was also satisfied in a prior analysis. A multiple linear regression assessed the association between ‘In-bed Mobile Phone Use’ and ‘Sleep Quality’ Scores and DASS Anxiety Scores (see Table 5).

Finally, results of a Sobel test showed that sleep quality was a perfect mediator of in-bed mobile phone use and anxiety ($z = 3.20$, $p = .001$) (2-tailed) (Figure 7).

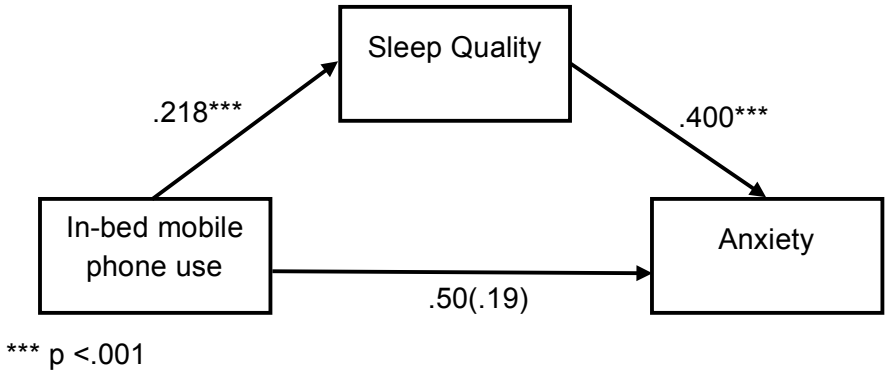

Figure 7. A diagram to illustrate the perfect mediation of sleep quality between in-bed mobile phone use and levels of anxiety

DASS Stress

The first step to determine mediation, to demonstrate that the predictor variable (In-bed mobile phone use) has an effect on the criterion variable (Stress) is displayed in Table 10.

Table 10
Summary of Linear Regression Analysis for In-bed Mobile Phone Use Predicting Symptoms of Stress

Variable	*B*	β	*t*	*Sig*.(*p*)
Constant (intercept)	24.66			
Total Phone Use	.01	.14	2.27	.024

Note: R^2 = .02

The regression model found 'Total Phone Use' to be a significant predictor of stress scores, thus as in-bed mobile phone use increases, stress levels increase.

Step two of mediation was satisfied in the regression analysing Research Question 2. In-bed mobile phone use was shown to have a significant effect on sleep quality ($F(1,252) = 12.56$, $p < .001$) (Table 7).

The third step of the mediation criteria was also satisfied in a prior analysis. A multiple linear regression assessed the association between 'In-bed Mobile Phone Use' and 'Sleep Quality' Scores and DASS 'Stress' Scores (Table 6).

Finally, results of a Sobel test showed that sleep quality was a perfect mediator of in-bed mobile phone use and stress ($z = 3.10$, $p = .002$) (2-tailed) (Figure 8).

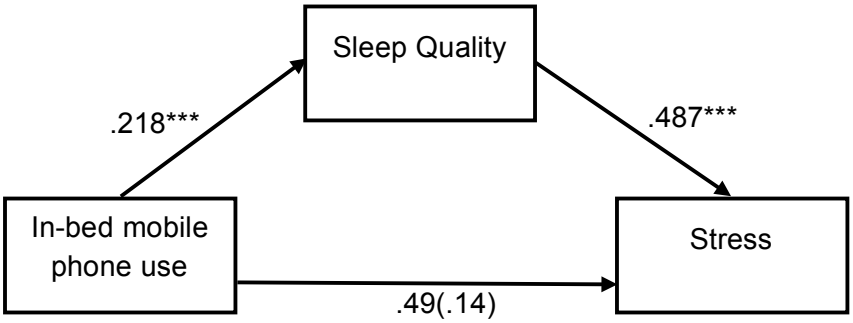

Figure 8. A diagram to illustrate the perfect mediation of sleep quality between in-bed mobile phone use and levels of stress

Generally, results have indicated significant relationships between in-bed mobile use, sleep quality and psychological well-being. Moreover, sleep quality significantly moderated the relationship between phone use and depression, anxiety and stress.

Discussion

The present study aimed to investigate the relationship between in-bed mobile phone use, sleep quality and psychological well-being symptoms of depression, anxiety and stress in a young adult population. Foremost, Pearson's correlation coefficients established relationships between predictor variables 'In-bed mobile phone use' and 'Sleep Quality' with criterion variable psychological well-being; symptoms of 'Depression', 'Anxiety' and 'Stress'. Importantly, the relationship found between in-bed mobile phone use and sleep quality suggests that a poorer sleep may be due to phone use preceding bedtime. Furthermore, sleep quality positively and significantly correlated with measures of depression, stress and anxiety; this is suggestive of the negative influence that a poor quality sleep has on psychological factors. Subsequently, three main research questions were addressed alongside investigating secondary aims.

Research Question 1

Greater in-bed mobile phone use and poorer sleep quality positively related to levels of depression, anxiety and stress. However, further multiple regression analyses found only sleep quality to influence depression, anxiety and stress levels significantly. Findings support those of Demirci et al. (2015) who's regression analyses also discovered that higher levels of smartphone use and poor sleep quality predicted levels of depression and anxiety in university students.

Research Question 2

A simple linear regression analysed the positive association between in-bed mobile phone use and sleep quality further. A significant regression model was produced which suggests, in-line with other research findings (Fossum et al., 2013; Demerci et al., 2015; Eyvazlou et al., 2016), that a high duration of in-bed mobile phone use during the hours preceding sleep influences the quality of sleep followed.

Research Question 3

A mediation analysis as proposed by Baron and Kenney (1986) was performed to investigate the significance of sleep quality as a mediator between in-bed mobile phone use and depression, anxiety and stress. Analysis against each psychological well-being measure found sleep quality to mediate between them. Sobel tests confirmed sleep quality to be a perfect mediator between in-bed mobile phone use and each psychological well-being measure. This suggests a poor quality sleep to be a good predictor of levels of depression, anxiety and stress.

A secondary aim explored the relationship between variables with the addition of age and gender. A correlation matrix exposed positive correlations between females and every other variable, which may suggest that females are spending more time in-bed on a mobile device thus affecting sleep quality and, according to findings, stress levels in particular. A significant negative correlation between age and weekly in-bed phone use was presented; this signifies that in-bed mobile phone use decreases significantly as age increases. Similarly, Khan (2008) found younger people to be the most

intensive phone users. These findings justify the sampling decisions made by the vast majority of past research in this area which have focused solely on younger populations in regards to their electronic media use (Cain and Gradisar, 2010; Thomée et al., 2011; Lemola et al., 2014; Bruni et al., 2015; Demirci et al., 2015).

Additionally, relationships indicated that a longer time spent on a mobile phone in bed before sleeping had an influence on the duration it took for participants to fall asleep afterward; the more time spent on a mobile device before sleeping increased the duration it took to fall asleep proceeding this. Firstly, this finding offers support for the model proposed by Cain and Gradisar (2010). Particularly in reference to mechanism 3: Bright light exposure delays the Circadian Rhythm, the findings of this present research, alongside others (Zeitzer et al., 2000; Wood et al., 2006; Figueiro et al., 2009; Gellis and Lichstein, 2009), suggest that mobile-phone light emissions at bedtime interfere with the commencement of melatonin secretion, which in turn delays the onset of sleep. If this were proven to be the case, findings would contradict those of Higuchi et al. (2005). Comparable to results of Orzech et al. (2016), if participants were occupied with an activity on their phone that is particularly interactive or arousing either mentally, emotionally or physiologically, mechanism 2 of Cain and Gradisar's (2010) model also provides a possible explanation for the relationship found between in-bed phone use and duration of falling asleep time.

Although significance was found amongst results, limitations must be considered. Firstly, causal relationships between variables cannot be concluded from the correlational research design; although findings are indicative that in-bed phone use and particularly sleep quality have a major influence on psychological well-being symptoms, precise effects still remain uncertain. It is possible that participants were a sample of the population with high levels of depression, stress and anxiety for other reasons. Therefore, this may have affected their in-bed electronic media habits foremost. For example, phone use in-bed may be due to difficulty falling asleep because of psychological health problems initially, and so participants resort to engaging with a smartphone in-bed because falling asleep is difficult (Tavernier and Willoughby, 2014). This notion is supported by research by Demerci et al. (2015) that found levels of anxiety and depression to predict poor sleep quality and phone use. In order to compensate for the correlational design, this study conducted a series of regression analyses and Sobel tests to enhance the explanations of variance between the variables. Regardless of the correlational nature, the present study has extended the existing knowledge base in what is an emerging area of interest.

This study proposes some further methodological issues. Established self-report questionnaires were carefully selected to effectively measure variables and produce the raw data. However, questionnaires were reproduced into an online format, which presents the issue of being unaware of the true sample or extent of the geographic region of participants. In an attempt to control for participants who may confound the data, recruits were advised not to participate if they were aware of any existing psychological health issues they may have. Additional problems with self-report questionnaires also include the potential for socially desirable answers (Huang et al., 1998) and retrospective recall issues (Brewer et al., 2004). However, for an emerging area of interest, this is an ideal method for obtaining a large data capture. Also as

previously mentioned, the online format is an excellent participant recruitment strategy for this specific population (Taylor-Powell and Hermann, 2000), which is reflected in the large sample size of this study. Fossum et al. (2013) propose that future research may benefit from more continuous observation methods such as a sleep and media use diary.

Importantly, the present study is favoured for addressing electronic media use in-bed, which very few previous studies have explicitly acknowledged (Gellis and Lichstein, 2009; Munezawa et al., 2011). Findings deviate from those of a recent study by Eyvazlou et al. (2016) who did not succeed in finding significant associations between mobile phone use, sleep quality and general health beyond multivariate regression analysis; this prompts for further study in this area. A main strength of this research is that with in-depth mediation analysis, associations between variables were considered significant. With this basis, the future direction of research could sought to examine these variables in an experimental setting, to establish causal relationships.

Findings pose a number of practical implications. Improving sleep quality may improve symptoms of stress, anxiety and depression, therefore suggestions to better sleep hygiene can be implied accordingly. Sleep hygiene advice generally recommends for no electronic device presence in the bedroom (Gamble et al., 2014). Consequently, better management of electronic media in the hours preceding bedtime could enhance the psychological well-being of young adults. As findings support those of Cain and Gradisar (2010), it would be logical to advise minimal bright-light exposure (mobile-phone screen) in the hours before sleeping. Future research could endeavour to experimentally find a cause-effect relationship between bright-light exposure and sleep quality, in which case, public health strategies could include advice that helps young adults to set limits for their electronic media use. For example, the population could be encouraged to use the ‘brightness’ switch on their smartphone to their advantage, by dimming the brightness on their screen when it comes to the evening time.

Overall, findings of the present study appear to be consistent with previous literature where possible, though few studies have investigated into in-bed mobile phone use before sleeping predominantly. Therefore, by explicitly investigating the effects of mobile-phone use before sleep, in regards to psychological well-being, this present study has contributed to an emerging area of knowledge. Findings show in-bed mobile-phone use and sleep quality to be important factors in determining psychological well-being. More notably, this research is significantly indicative of sleep quality possessing a mediating role between in-bed phone use and levels of depression, stress and anxiety. This strongly suggests that a poor quality of sleep is related to developing psychological symptoms of depression, anxiety and stress. Derived from findings, suggestions for regulating media use and developing sleep hygiene strategies can be offered.

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