

The Relationship Between Smartphone Addiction, Anxiety, Depression and Sleep Quality in Pregnant Women: A Cross-Sectional Study

Gebelerde Akıllı Telefon Bağımlılığı ile Kaygı, Depresyon ve Uyku Kalitesi Arasındaki İlişki: Kesitsel Çalışma

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ABSTRACT Objective: Smartphones have today entered into widespread use as a result of the numerous advantageous functions they offer, but they also have negative repercussions. These negative consequences merit investigation in specific populations, including comprehensive examinations of the physical and mental dimensions influenced by smartphones. The study investigates the relationship between smartphone addiction and its effects on anxiety, depression and sleep quality in pregnant women. **Material and Methods:** This cross-sectional study included 85 pregnant women who met the inclusion criteria, and who were administered the Hospital Anxiety and Depression Scale, Pittsburgh Sleep Quality Index (PSQI) and Smartphone Addiction Scale-Short Version. **Results:** The study identified no statistically significant relationship between the smartphone addiction scores of pregnant women and their anxiety, depression and PSQI scores ($p>0.05$). In contrast, a significant positive weak correlation was observed between smartphone addiction and depression scores among pregnant university graduates ($r=0.416$, $p=0.025$, $p<0.05$). **Conclusion:** Although the present study did not establish any relationship between smartphone addiction and anxiety, depression and sleep quality in pregnant women, the study findings emphasize the need for further investigations employing alternative study designs and larger sample sizes to validate and expand upon the results. The study findings deviate from those observed in the general population, indicating a need for prospective studies exploring the causal relationship, specifically in pregnant women. A deeper exploration of smartphone addiction and other behavioral addictions highlighted in literature is required to understand their impact on both the physical and mental health of expectant mothers and the developing fetus.

Keywords: Pregnancy; smartphone; anxiety; depression; sleep

ÖZET Amaç: Akıllı telefonlar, sunduğu pek çok avantajlı fonksiyon sayesinde günümüzde yaygın bir kullanıma girmiş olsa da olumsuz yansımaları da bulunmaktadır. Bu olumsuz sonuçların, akıllı telefonların etkilediği fiziksel ve zihinsel boyutların kapsamlı incelemeleri de dâhil olmak üzere belirli popülasyonlarda araştırılması gerekmektedir. Bu çalışmada, gebe kadınlarda akıllı telefon bağımlılığının anksiyete, depresyon ve uyku kalitesi üzerindeki etkisi araştırılmıştır. **Gereç ve Yöntemler:** Bu kesitsel çalışmaya, önceden belirlenen dâhil etme kriterlerini karşılayan ve daha sonra Hastane Anksiyete ve Depresyon Ölçeği, Pittsburgh Uyku Kalitesi İndeksi ve Akıllı Telefon Bağımlılığı Ölçeği-Kısa Versiyonu uygulanan 85 hamile kadın dâhil edilmiştir. **Bulgular:** Çalışmada, gebelerin akıllı telefon kullanım bağımlılık puanları ile anksiyete, depresyon ve uyku kalitesi puanları arasında istatistiksel olarak anlamlı bir ilişki saptanmadı ($p>0,05$). Buna karşılık üniversite mezunu gebelerde akıllı telefon bağımlılığı puanları ile depresyon puanları arasında pozitif yönde zayıf anlamlı bir ilişki gözlemlendi ($r=0,416$, $p=0,025$, $p<0,05$). **Sonuç:** Her ne kadar mevcut çalışmada, hamile kadınlarda akıllı telefon bağımlılığı ile anksiyete, depresyon ve uyku kalitesi arasında herhangi bir ilişki saptanmamış olsa da, çalışma bulguları, sonuçları doğrulamak ve genişletmek için alternatif çalışma tasarımları ve daha büyük örneklem büyüklükleri ile daha ileri araştırmalara duyulan ihtiyacı vurgulamaktadır. Çalışma bulguları genel popülasyonda gözlemlenenlerden farklılık göstermektedir; bu durum, özellikle hamile kadınlarda nedensel ilişkiyi araştıran prospektif çalışmalara ihtiyaç olduğunu göstermektedir. Akıllı telefon bağımlılığı ve literatürde vurgulanan diğer davranışsal bağımlılıkların, anne adaylarının ve gelişmekte olan fetüsün hem fiziksel hem de zihinsel sağlığı üzerindeki etkilerini anlamak için daha geniş araştırmalar yapılması gerekmektedir.

Anahtar Kelimeler: Gebelik; akıllı telefon; anksiyete; depresyon; uyku

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Smartphones are an important part of our lives as a source of information, a means of social interaction and a tool for workplace applications, aside from the access to various forms of entertainment they provide.¹ Smartphones have undoubtedly brought numerous advantages to our daily lives, although it is important to acknowledge that they can also have negative effects. Excessive smartphone usage can affect both the physical and mental well-being of individuals.² The term “problematic smartphone use (PSU)” has been coined in literature to describe the extent of smartphone usage that can lead to negative consequences or issues and encompasses the excessive and dysfunctional use of smartphones in daily life, often characterized by symptoms resembling those observed in substance addiction.³

In a systematic study I has been reported that the majority of studies (n=31) found a prevalence of PSU between 10% and 30%, with the median being 23.3%.⁴ In China, this rate has been reported to be between 52.8 and 65.8% in adults.⁵ In a Saudi Arabian study, PSU was reported in 66.9% of the study participants.⁶ PSU has been associated with a range of adverse consequences on mental health, including poor sleep quality, depression and anxiety.^{3,7,8}

PSU itself may increase depression and anxiety, and thus impair sleep.⁹ A meta-analysis study reported significantly increased levels of poor sleep quality, depression and anxiety in individuals with PSU.¹⁰ Both depression and anxiety have been shown to be independent predictors of PSU.¹¹ Increased anxiety has been associated with PSU.³ There are studies that associate PSU with sleep problems or poor sleep quality.¹²

While male usage tends to prioritize Internet searches, digital games and new technological devices, female users tend to prioritize social media use, instant messaging applications and phone calls, all of which pose a high risk for smartphone addiction.¹³ Among adolescent users, the female sex is a risk factor for PSU.¹⁴ To the best of our knowledge, investigating PSU among pregnant women has been studied in only one study yet.¹⁵

As a distinct population, pregnant women can be considered worthy of evaluation regarding the predictors of proble PSU, given the potential maternal and fetal consequences associated with such usage. Pregnancy is a transition period marked by substantial physical and emotional changes.¹⁶ Pregnant and breastfeeding women are considered at greater risk of excessive Internet use and the development of addiction than other subpopulations, for which several contributing factors have been identified, including their increased time spent at home, their restricted mobility and the limited opportunities they have for outdoor physical activities.¹⁵ The potential consequences of this unique period on the health of both the mother and infant must be investigated. While it is widely recognized that smartphones emit radiation, there is indeed limited information available in literature on the potential maternal and fetal effects of smartphone use during pregnancy. Studies have demonstrated that maternal exposure to radiofrequency waves may have negative effects on the neurodevelopment of the infant brain.¹⁷ The primary objective of the study is to investigate whether a relationship exists between usage of smartphone during pregnancy and anxiety, depression and sleep quality. As a secondary objective, the strength of this potential association is explored based on various demographic variables. The present study posits a hypothesis suggesting a linear relationship between PSU and anxiety and depression levels, and an inverse relationship between PSU and quality of sleep. Pregnancy is a peerless period in a woman’s life that is characterized by significant psychosocial, physical and physiological changes that demand particular attention and care.

It is thus necessary to ascertain how behavioral addictions in pregnant women interact with the mechanisms of adjustment to the changes they experience during pregnancy. The findings of the present study have the potential to increase awareness among primary healthcare professionals, obstetricians, gynecologists and psychiatrists of the factors behind PSU during pregnancy, and may help accelerate the implementation of preventive measures by highlighting the potential risks associated with excessive smartphone use.

MATERIAL AND METHODS

Included in the cross-sectional study were 85 pregnant women who met the study inclusion criteria, and who presented to a family health center for routine control visits. Of the 93 pregnant women approached to take part in the study, three did not give their consent for participation and five were excluded due to the presence of a psychiatric illness. Included in the study were pregnant women who presented to the family health center, who were aged 18 years and older and who were smartphone users, while those with a mental disease and/or weakness that would hinder their completion of the study scale, those who were illiterate and those who declined to sign the informed consent form were excluded from the study. All stages of the study were carried out in accordance with the principles of the Declaration of Helsinki 2008; all participants signed an informed consent form, and approval for the study was granted by the University of Health Sciences Sancaktepe Şehit Prof. Dr. İlhan Varank Training and Research Hospital Non-Invasive Research Ethics Committee (date: June 15, 2022; no: 99) and by the relevant Provincial Health Directorate. The respondents were administered the Hospital Anxiety and Depression Scale (HADS), the Pittsburgh Sleep Quality Index (PSQI) and Smartphone Addiction Scale-Short Version (SAS-SV). The forms were given to the participants by their family physician and they were asked to fill them out.

SAMPLE CALCULATION

G*Power (v3.1.9; Düsseldorf University, Düsseldorf, Germany) software was used to carry out a power analysis for the calculation of the sample size in accordance with the effect sizes described by Cohen. The power of a study is expressed as $1-\beta$

(β =probability of Type II error), and studies are generally expected to have a power of 80%. Using Cohen's effect size coefficients, it was calculated that the study should include at least 82 respondents to achieve a power of 80% with an alpha of 0.05, considering that the correlation between smartphone addiction scores and anxiety, depression and PSQI scores would have a moderate effect size ($r: 0.300$) (Cohen J. 1988).

STATISTICAL METHOD

IBM SPSS Statistics (Version 26.0. Armonk, NY: IBM Corp.) was used for statistical analysis. The study data were evaluated using descriptive; statistical methods and included mean, standard deviation, median, frequency, ratio, minimum and maximum values. A Kolmogorov-Smirnov test, Skewness-Kurtosis test and graphical assessment were used to test for the normality of the distribution of quantitative data (Table 1).

The Mann-Whitney U test was used to compare data that were not normally distributed between the two groups, a Kruskal-Wallis test was used to compare three or more groups without normal distribution, and a Bonferroni-Dunn test was used for paired comparisons. Spearman's correlation analysis was used to evaluate the relationship between variables. In a multivariate analysis, the effect of other risk factors on PSU scores was evaluated with a linear regression analysis. The level of statistical significance was set at an alpha less than 0.05.

DATA COLLECTION TOOLS

1. Sociodemographic Data Collection Form: The Sociodemographic data collection form was used to garner sociodemographic information about the study participants and was prepared by the authors in accordance with the objectives of the study.

TABLE 1: Normality of distribution analysis.

	$\bar{X}\pm SE$	Median	Skewness/SE	Kurtosis/SE	Kolmogorov-Smirnov Sig.(n=85)
Anxiety score	7.482±0.482	7.000	1.616	-1.087	0.000
Depression score	6.670±0.397	6.000	1.153	-1.087	0.008
PSQI score	8.094±0.348	8.000	2.007	0.729	0.000
Smartphone addiction scale	18.847±1.099	16.000	7.084*	0.006	0.001*

* $p>0.05$; SE: Standard error; PSQI: Pittsburgh Sleep Quality Index.

2. **Informed Consent Form:** The informed consent form explains the title, objectives, and scope of the study in detail, and garners data on the contact details of the participant and the interviewer. It is to be read and signed by the participants.
3. **HADS:** This form was developed for the evaluation of the risk of anxiety and depression, and to measure the level and change in the severity of anxiety and depression in patients with bodily disease and in those presenting to primary healthcare departments.¹⁸ The validity and reliability of the Turkish version of the scale have been studied.¹⁹ The scale comprises a total of 14 items and the two domains of anxiety (HAD-A) and depression (HAD-D). The minimum and maximum scores are 0 and 21 in this scale. The scale is not meant to diagnose a condition, but rather to rapidly determine at-risk groups by screening the subjects for anxiety and depression as a result of the reliability analysis of the anxiety scale, Cronbach's alpha value was found to be 0.772, and the Cronbach's alpha value of the depression scale was found to be 0.786. The scale has been found appropriate for the study of samples without bodily diseases; and it can also be used in the healthy population.²⁰
4. **PSQI:** The scale was developed for the evaluation of sleep quality and disturbances; and the Turkish version of the scale has been validated.^{21,22} This self-report scale which consists of 19 items assesses the sleep quality and sleep disorders of the respondent over the previous month. Total possible scores are in the range of 0 to 21 and the poor sleep quality score is higher than 5. As a result of the reliability analysis of the PSQI, Cronbach's alpha value was found to be 0.786.
5. **SAS-SV:** This scale was developed for the assessment of the risk of smartphone addiction in adolescents. The scale includes 10 items that are rated on a 6-point Likert scale, with possible scores ranging from 10 to 60 and higher scores indicating an increased risk of addiction. The Cronbach's alpha coefficient for internal consistency and concurrent validity of the scale has been calculated as 0.91 and the validity and reliability of the Turkish version have been evaluated.^{23,24} As a

result of the reliability analysis of the smartphone addiction scale, Cronbach's alpha value was found to be 0.932.

RESULTS

Included in the study were 85 pregnant women who attended a family health center. The age of the participants ranged from 18 to 41 years, with a mean age of 29.13 ± 5.78 years, while the gestational age ranged from 5 to 40 weeks, with a mean of 21.79 ± 10.13 weeks. All of the respondents were married ($n=85$), 41.2% ($n=35$) had no child, 29.4% ($n=25$) had one child, 21.2% ($n=18$) had two children and 8.2% ($n=7$) had three children or more.

Of the respondents, 41.2% ($n=35$) were primary school graduates, 24.7% ($n=21$) were high school graduates, 34.1% ($n=29$) were university graduates or higher; and 24.7% ($n=21$) were employed and 75.3% ($n=64$) were unemployed. Demographic characteristics are shown in Table 2.

The anxiety scores ranged between 0 and 16 points, with a mean score of 7.48 ± 3.91 points; the depression scores ranged between 0 and 16 points, with a mean of 6.67 ± 3.67 points; the PSQI score ranged between 1 and 17 points, with a mean of 8.09 ± 3.22 points; and the smartphone addiction scale scores ranged between 10 and 57 points, with a mean of 18.85 ± 10.41 points.

TABLE 2: Distribution of demographic characteristics.

		Minimum-maximum	
		(Median)	$\bar{X} \pm SD$
Age (years)		18-41 (28)	29.13 ± 5.78
Gestational age (week)		5-40 (22)	21.79 ± 10.13
		n	%
Marital status	Married	85	100.0
Number of Children	None	35	41.2
	One	25	29.4
	Two	18	21.2
	Three or more	7	8.2
Educational level	Primary school	35	41.2
	High school	21	24.7
	University or higher	29	34.1
Employment Status	Employed	21	24.7
	Unemployed	64	75.3

SD: Standard deviation.

Normality of distribution analyzes were applied to all scales of the study. Initially, the numerical value proximity of the mode and median results of the scales was analyzed, and then the Skewness and Kurtosis results were also evaluated to ensure verification. Since the values of the Smartphone Addiction Scale were not distributed normally in the Skewness and Kurtosis analysis, and the sample number was larger than 30, a more advanced test, Kolmogorov-Smirnov analysis, was applied. As a result of the relevant analysis, the significance value of the scale was found to be normally distributed, as it was 0.001 and close to 0.05.

The smartphone addiction scale scores of pregnant women did not vary significantly according to the number of children and employment status ($p>0.05$).

The smartphone addiction scale scores of the respondents were differed significantly by education status ($p=0.009$; $p<0.01$). Paired comparisons carried out to identify the source of significance in the difference revealed significantly higher smartphone addiction scale scores among pregnant women with a university or higher education level than among high school graduates ($p=0.036$ and $p=0.003$, respectively; $p<0.05$). There was no significant difference in the smartphone addiction scale scores of the high school and primary school graduates among the pregnant women ($p>0.05$). Evaluation of smartphone Addiction Scale Scores by Demographic Characteristics is shown in Table 3 and the use of mobile phones according to the educational status of the pregnant women is given in Figure 1.

TABLE 3: Evaluation of Addiction Scale scores according to participants' demographic characteristics.

		Smartphone Addiction Scale-short form score			
		n	Median (Minimum-maximum)	$\bar{X}\pm SD$	p value
Number of children	None	35	18 (10-47)	19.80±8.72	^a 0.305
	One	25	14 (10-55)	18.32±11.00	
	Two	18	15 (10-57)	19.44±12.97	
	Three or more	7	13 (10-21)	14.43±4.28	
Educational level	Primary school	35	14 (10-47)	16.17±8.15	^a 0.009**
	High school	21	14 (10-36)	17.00±7.27	
	University or higher	29	19 (10-57)	23.41±12.53	
Employment status	Employed	21	17 (10-57)	21.57±13.50	^b 0.280
	Unemployed	64	15 (10-47)	17.95±8.72	

^aKruskal-Wallis Test; ^bMann-Whitney U Test; ** $p<0.01$; SD: Standard deviation.

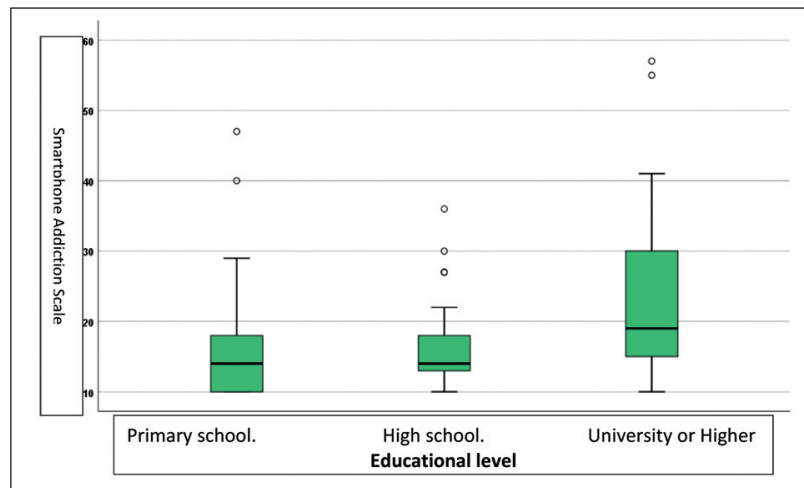


FIGURE 1: Distribution of smartphone addiction scores of pregnant women based on educational status.

TABLE 4: Correlation between the short version of the Smartphone Addiction Scale Score and the demographic characteristics and other scale scores.

	Smartphone Addiction Scale score	
	r	p value
Age (years)	-0.256	0.018*
Gestational age (week)	0.051	0.643
Anxiety score	0.097	0.375
Depression score	0.094	0.394
PSQI score	0.059	0.593

*p<0.05; r: Spearman's correlation coefficient; PSQI: Pittsburgh Sleep Quality Index.

The study identified a significant weak negative correlation between age and the smartphone addiction scale scores of the respondents (According to the results of the related analysis, it was observed that the smartphone addiction scale scores decreased as the pregnant women got older.) (r: -0.256; p=0.018; p<0.05). No significant correlation was found between gestational week and smartphone addiction scale score (p>0.05). The study found no statistically significant relationship between the smartphone usage addiction score and the anxiety, depression and PSQI scores (p>0.05). The Relationship between Smartphone Addiction Scale Scores and Demographic and Scale Scores is given in Table 4.

The study found no statistically significant relationship between the smartphone addiction scores of

primary school graduates and their anxiety, depression and PSQI scores (p>0.05).

The study found no statistically significant relationship between the smartphone addiction scores of high school-graduates and the anxiety, depression and PSQI scores (p>0.05).

The study found no statistically significant relationship between the smartphone addiction scores of the respondents with a university degree or higher, and their anxiety, depression and PSQI scores (p>0.05), although a weak positive correlation was identified between the smartphone addiction scale and depression scores of these pregnant women (r: -0.416; p=0.025; p<0.05). The relationship between smartphone addiction scale scores in education groups shown in Table 5.

As a result of the Kruskal Wallis analysis, a significant difference was seen in Anxiety, Depression, PSQI values and Smartphone Addiction scores according to the education level of pregnant women. This indicates that at least one of the groups is distinguishable from the others. In this case, the Mann-Whitney U test, which provides the opportunity to explore the differences between groups in detail, was utilized. Through the Mann-Whitney U test, it was found that pregnant women differ most between primary school and university graduates in terms of anxiety, depression, PSQI and smartphone addiction.

TABLE 5: Comparison of participants according to their anxiety, depression, PSQI and smartphone addiction scores according to their education levels.

Kruskal-Wallis Analysis		n	Chi-Square	Sig.	Mann-Whitney Test	Sig.
Anxiety s.	Primary school	35	6.314	0.043*	Primary school	0.023*
	High school	21			University or higher	
	University or higher	29				
Depression s.	Primary school	35	11.458	0.003*	Primary school	0.001*
	High school	21			University or higher	
	University or higher	29				
PSQI s.	Primary school	35	0.372	0.830	Primary school	0.003*
	High school	21			University or higher	
	University or higher	29				
Smartphone addiction s.	Primary school	35	9.513	0.009*	Primary school	0.734
	High school	21			University or higher	
	University or higher	29				

*p<0.05 Mann-Whitney; PSQI: Pittsburgh Sleep Quality Index.

DISCUSSION

The present study investigating the relationship between smartphone addiction and anxiety, depression and sleep quality in pregnant women found no significant relationship between smartphone addiction and the studied variables. Smartphone addiction has been strongly linked to increased anxiety and depression levels, as well as such negative mental health effects as stress.²⁵ A study has been reported a relationship between general anxiety levels and smartphone use.²⁶ One review of literature reported a low-to-moderate relationship between PSU and anxiety levels while another study reported a relationship between smartphone use and the female sex, high anxiety levels and insomnia.^{27,28} In a study conducted during the COVID-19 pandemic, an association was identified between anxiety and intense smartphone use and depression.²⁹ PSU can contribute to the development of depression, and it has been reported in another study that problematic or general smartphone use often occurs as a result of depression, anxiety and mental health problems such as stress, and the same study reported a consistent relationship between depression severity and smartphone addiction.^{27,30} In a study of university students, a significant positive correlation was reported between depression and anxiety scale scores and problematic smartphone use.¹¹ To the best of our knowledge, the present study is the first to evaluate the relationship between smartphone use and study variables associated with pregnant women. In contrast to the studies in literature involving different populations, the present study revealed no significant correlation between depression and anxiety levels and smartphone addiction. Pregnant women may develop a controlled attitude towards smartphone use, considering the potentially harmful effects of smartphone use on the developing fetus. The current results may have also differed by the number of participants. Results may vary with the number of patient, as the study universe was composed of individuals registered with a single family health center, and the similar smartphone use patterns of individuals with similar sociocultural backgrounds can be regarded as a factor changing the study results. During the literature review phase, a study found that

the degree of PSU increased depression levels, in line with the results of our study.⁹ Additionally, a meta-analysis study stated that there was a significant relationship between PSU and increased levels of depression.¹⁰ This finding can be attributed to the probability of more intense smartphone use and the probability of being employed in an environment requiring more intense smartphone use with increasing education levels and social status. There may be a bidirectional relationship between depressive mood and PSU. The decrease in socialization and energy that can be seen in depression may increase PSU levels in these pregnant women.

It has been previously emphasized that people with a high income are more likely to engage in digital networking but whether those with higher educational statuses are less likely to engage in PSU during pregnancy requires further research.³¹ The findings of previous studies indicate that nighttime smartphone use is linked to lower sleep quality, waking up at late hours and more pronounced sleep disturbances.³² A further study suggested that the blue light emitted by smartphones could affect sleep quality, another reported a relationship between PSU and low sleep quality and yet another reported a similarly strong relationship between intense smartphone use and sleep quality, sleep disturbances and daytime dysfunction in healthy individuals.^{9,33,34} The relationship between the use of electronic media and low sleep quality, as well as the relationship between the use of electronic media and cognitive, emotional and physiological stimulation were attributed to the action of keeping one's smartphone in the bedroom at night and the frequent interruptions to sleep by unexpected text messages and phone calls.³⁵ Another study highlighted that the blue light emitted by smartphones could affect sleep quality and that staying digitally connected due to increasing work demands could lead to disturbed sleep patterns associated with stress and burnout syndrome.²⁷ To the best of our knowledge there is no data could be found on the effect of smartphone use in pregnant women on sleep quality. In our study, no significant relationship was found between smartphone addiction and sleep quality in pregnant women. Different physiological and anatomical variables specific to the trimester of preg-

nancy may have led to restriction of smartphone use at night.

STUDY LIMITATIONS

The various physiological and anatomical changes that occur during pregnancy that are specific to particular pregnancy periods may limit nighttime smartphone use, and may play a role in the observed relationship with sleep, although the small sample size in the present study may have affected this result. Although the sample size was sufficient to draw the present conclusions, it is likely that studies involving larger samples would produce more significant results. One of the limitations of the present study is the potential bias associated with the self-reporting style of the scales used. Furthermore, the study's exclusive focus on only one family health center may have resulted in a sample of people with similar sociocultural characteristics, potentially impacting the observed findings. It is not possible to speculate on the causal relationship between variables due to cross-sectional study design, and the lack of a control group in the study. Prospective studies involving a larger number of participants and including a control group may yield valuable insights into the use of smartphones among the pregnant population.

CONCLUSION

Although the present study revealed no relationship between smartphone addiction and anxiety, depression and sleep quality in pregnant women, available findings must be re-examined on a larger sample size using different study designs. The findings of the pre-

sent study differ from those observed in the general population, indicating a need for prospective studies exploring the causal relationship between factors, specifically in pregnant women. Smartphone addiction and other behavioral addictions studied in literature require further investigation to elucidate their impact on both the physical and psychological well-being of expectant mothers and the developing fetus. Nurses have an important role in the routine control of pregnant women. In pregnancy follow-up, the pattern and frequency of smartphone use in the context of exposure to harmful substances, environments and situations should also be among the routine monitoring items of health professionals.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

This study is entirely author's own work and no other author contribution.

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