RESEARCH

Association of electronic screen exposure with depression among women in early pregnancy: a cross-sectional study

Qianqian Yang[1], Qian Wang[1], Hongzhi Zhang[2], Danping Zheng[3*] and Shaidi Tang[4*]

Abstract

Background Previous studies indicated that excessive engagement in digital devices could lead to negative psychological impacts in general population. We aimed to determine the association of electronic screen exposure with depression among women in early pregnancy.

Methods A cross-sectional study was conducted from June 2021 to June 2022. A total of 665 women in early pregnancy were recruited and the information included socio-demographic characteristics, screen exposure and Patient Health Questionnaire − 9 depression scale.

Results Among the women in early pregnancy, the total daily smartphone viewing time was the longest (median [P25-P75], 5 [3–6] hours/day) in the three types of electronic screen exposure. The total daily smartphone viewing time ($P=0.015$, $OR[95\%CI]=1.09[1.11–1.18]$), smartphone ($P=0.016$, $OR[95\%CI]=1.24[1.04–1.47]$) and television viewing time ($P=0.006$, $OR[95\%CI]=1.35[1.09–1.67]$) before nocturnal sleep were significantly associated with depression among women in early pregnancy. The thresholds calculated by receiver operator characteristic curves were 7.5 h/day, 1.5 h/day and 1.5 h/day, respectively. In addition, women with higher scores of smartphone addiction were more susceptible to depression ($P<0.001$, $OR[95\%CI]=1.11[1.07–1.16]$). The top three smartphone usages in women with depression were watching videos (22.0%), listening to music (20.9%) and playing games (16.7%).

Conclusions In conclusion, electronic screen exposure, including screen viewing time, smartphone addiction and problematic smartphone use was associated with depression among women in early pregnancy. Further studies are warranted to verify the conclusions.

Keywords Depression, Maternal exposure, Pregnancy, Screen time

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Background

Nowadays, digital devices with electronic screens have become indispensable accessories in our daily life, such as computers, smartphones, televisions and so on. As the Internet and 4G/5G network is widely used, all kinds of internet service can be provided by the majority of electronic devices. People become increasingly reliant on internet social media, e-shopping, watching television series and short videos, thereby meeting growing needs and changing lifestyles. However, it is usually followed by much more viewing time on digital devices. Numerous evidences have demonstrated that

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excessive use of electronic products with screens could result in various physical symptoms among general population. Pathological or compulsive use of the internet (often conceptualized as internet addiction) were more likely to have sleep problems or reduced sleep duration [1, 2]. Besides, prolonged exposure to electronic screens were associated with elevated risks of breast cancer [3], lower birth weight [4], hypertensive disorders of pregnancy [5]. There were many mediators and moderators involved [6], such as prolonged sedentary time, shortened sleep time, social exclusion and so on.

Excessive engagement in digital devices could also lead to negative psychological impacts. In older children and youth, higher levels of television or digital media time were associated with higher levels of depression, anxiety, and inattention; higher levels of video game time were associated with higher levels of depression, irritability, inattention, and hyperactivity [7]. Additionally, higher levels of electronic learning time were associated with higher levels of depression and anxiety [7]. Similar situations existed among university students. A cross-sectional study conducted in 2019 indicated that both severities of internet gaming disorder and social media addiction were associated with depression, anxiety and stress [2]. Furthermore, not all screen time was created equal: associations with mental health varied by activity and gender. Girls generally demonstrated stronger associations between screen media time and mental health indicators than boys. Heavy internet users (≥ 5 h/day) were 166% more likely to have clinically relevant levels of depressive symptoms than low users among girls, compared to 75% more likely among boys) [8]. A recent study showed that cyberbullying, lack of sleep, and lower physical activity mediated the link between social media use and mental health among girls but not boys [9].

It is worth noting that prolonged screen viewing time not only exists in general population but also in pregnant women. A cross-sectional survey [10] conducted in 2015 indicated that 62.6% pregnant women reported prolonged mobile phone viewing (≥ 1 h/day). Moreover, pregnant women in the second pregnancy were more likely have longer screen viewing time than those in the first pregnancy [10]. A case-control study [5] carried out in 2019 showed that, the median using time of smartphone (and/or tablet computer) among healthy pregnant women was 5.5 h/day. The above researches noticed the length of screen time, but did not explore the influence on the health of pregnant women. In addition, the use of electronic products, such as internet gaming [2] and social media [11], also has varying impacts on health. However, studies examining the impact of electronic screen exposure among pregnant women are yet to be seen.

As is well-known to all, women in the first trimester of pregnancy are more prone to suffer from a variety of psychological illnesses, including depression, anxiety and hypomanic symptoms [12–15]. Importantly, the incidence of depression is particularly high, peaking at a staggering 31.4% [16]. Hence, we expected an association of screen time and usage with depression among women in the first trimester of pregnancy.

The present study aimed to determine the association of electronic screen exposure (mainly including viewing time and usages) with depression among women in early pregnancy ($\leq$ gestation week 14). If the viewing time were related to depression, we would calculate the threshold hours for the women in early pregnancy. Thus, an improved understanding of maternal health care could be provided.

Methods

Ethics approval

The present study was performed in accordance with the Declaration of Helsinki, and was approved by the ethics committee of Liyang People's Hospital (No. 2021003). In our database, the participants' information of name and telephone number was anonymized.

Study design and sample size determination

We carried out a cross-sectional study by convenience sampling in the hospitals where our team members were located from June 2021 to June 2022. The sample size was calculated by the Epicalc 2000 software. As this was a cross-sectional study, we clicked "sample-precision-single proportion" in sequence in the software based on the assumptions: Considering proportion 15%, precision 3% and confidence interval (*CI*) 95%. The sample size was determined to be 544. Taking account of the non-response rate, we added 20% more sample size and finally recruited 665 participants.

Participants

This investigation was conducted in Changzhou and Wuxi two cities, which are both located in south Jiangsu province and two of the developed areas in China. The recruited hospitals included Liyang people's hospital, Jiangxi community health service center, Shuofang community health service center, and Wuxi Hongqiao hospital. We excluded pregnant women diagnosed with diabetes mellitus, hyperthyroidism, hypothyroidism, polyembryony, hypertension during pregnancy and infectious diseases. All pregnant women were asked to fill out digital questionnaires by scanning a two-dimensional

code. To ensure all of them were voluntary to participate in, we set the first question was "Whether are you willing to join in this investigation?". If the answer were "Yes", the investigation would continue; otherwise, the process would terminate.

Questionnaire

Participants' information was collected from digital questionnaires. There were an array of variables in the questionnaire, including socio-demographic characteristics, screen exposure, Patient Health Questionnaire (PHQ) -9 depression scale. Details were displayed in Fig. 1. In the present study, products with electronic screen included personal computers, smartphones (and/or tablet computers like iPad) and televisions. Screen time was calculated as the daily average hour spent on the electronic products mentioned above in the past 12 weeks. Particularly, screen time before nocturnal sleep was recorded. The usages of personal computer involved three options: most time for entertainment, most time for work and halves for both. The usages of smartphone involved eight options: work, chatting, watching videos, playing games, social communication, shopping, listening to music and others. Every woman could choose no more than three most frequent functions among those options. The above information was self-reported by the participants through recollection. To detect the smartphone addiction among women during early pregnancy, a short version of the Smartphone Addiction Scale for Chinese Adults (SAS-CA) [17] was applied. This version consists of 11 items with a 5-point scale (1 = "strongly disagree" and 5 = "strongly agree"). The higher scores meant more serious smartphone addiction. Cronbach's alpha of the current sample was 0.878. We used PHQ-9 depression scale [18, 19], a 9-item module, to assess depression among pregnant women. The Cronbach's alpha of PHQ-9 was reported to be 0.89 [20]. If the total score ≥ 5, the woman would be diagnosed with depression [20].

Statistical analysis

IBM SPSS Statistics 25 (IBM Corp., Armonk, NY, USA) software was used to perform statistical analysis. The significance level (α) was declared at 0.05. Mean ± standard deviation (*SD*) was applied to describe the continuous data if it met the normal distribution (verified by *Kolmogorov-Smirnov* and *Shapiro-Wilk* tests); otherwise, medians and quartiles (25th – 75th percentile value) were applied. Ratios were used to describe the enumeration data. To detect the differences between two groups, the *t* test or *Mann-Whitney U* test was applied for the continuous data, depending on the normality; the $\chi2$ test was applied for the enumeration data. *Logistic* regression models were applied to multivariate analysis while controlling for the confounders. Receiver operator characteristic (*ROC*) curve, area under curve (*AUC*) and Youden Index were used to determine the best threshold hours of screen exposure time among women in early pregnancy.

Results

General characteristics

Among all early pregnant women who met the inclusion criteria, 37 declined to participate in this study. Hence, we finally recruited 665 participants. There were 108 (16.2%) women diagnosed with depression, while the other 557 (83.8%) women were not. Table 1 reported the participants' general characteristics. Of the 665 participants, 368 (55.3%) were in their first pregnancy, and 297 (44.7%) were in their second pregnancy. The average gestation week was 10.67±1.69, and the average body mass index (BMI) of pre-pregnancy was 22.72±4.08 kg/m^2.
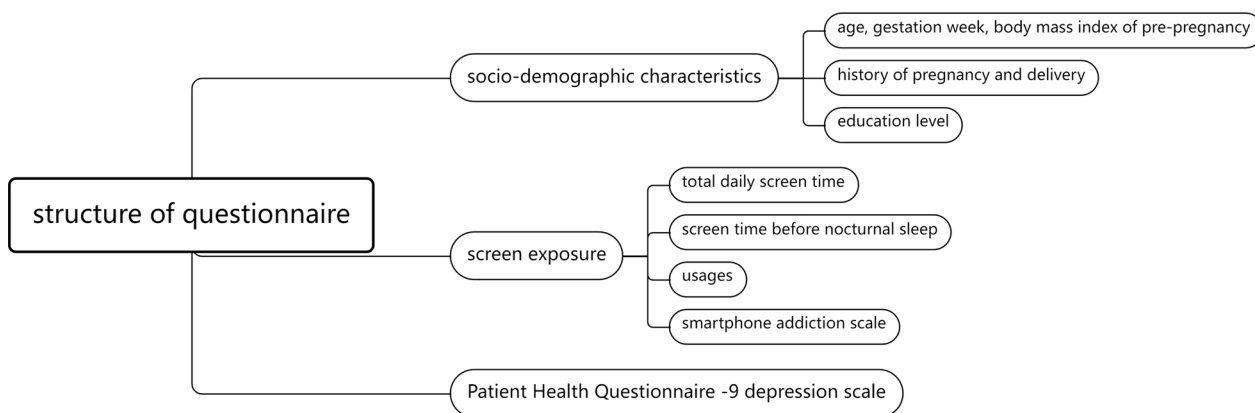

Fig. 1 The questionnaire structure of the present study

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Table 1 Characteristics of the study participants

Variable		Descriptive	Depression group	Control group	P
Age (n, %)					
	18–25 years old	118 (17.7)	16 (14.8)	102 (18.3)	0.87
	26–30 years old	315 (47.4)	58 (53.7)	257 (46.1)	
	31–40 years old	228 (34.3)	33 (30.6)	195 (35.0)	
	41–45 years old	4 (0.6)	1 (0.9)	3 (0.5)	
Education level (n, %)					
	High school degree or less	284 (42.7)	54 (50.0)	230 (41.3)	0.319
	Associate degree	179 (26.9)	21 (19.4)	158 (28.4)	
	Undergraduate degree	176 (26.5)	28 (25.9)	148 (26.6)	
	Graduate degree	26 (3.9)	5 (4.6)	21 (3.8)	
Parity (n, %)					
	First pregnancy	368 (55.3)	58 (53.7)	310 (55.7)	0.709
	Second pregnancy	297 (44.7)	50 (46.3)	247 (44.3)	
Gestation week (Mean ± SD[a])		10.67 ± 1.69	10.31 ± 1.75	10.74 ± 1.67	0.015[*]
BMI[b] (kg/m^2) of pre-pregnancy (Mean ± SD[a])		22.72 ± 4.08	22.80 ± 4.33	22.70 ± 4.03	0.818
History of abortion frequency (Median [25−75%])		0 (0–1)	0 (0–1)	0 (0–1)	0.787

[a] *SD* standard deviation, [b] *BMI* body mass index

*P<0.05

Except for the gestational week (*P* = 0.015), which was statistically significant, none of the other factors were.

Exposure of electronic screens among women in early pregnancy

The median (25−75%) total computer viewing time was 2 (0−6) hours/day, while most women did not use computers before nocturnal sleep. About half women (45.4%) used computers only for work. The median (25−75%) total smartphone viewing time was 5 [3−6] hours/day, and the viewing time before nocturnal sleep was 1 (1, 2) hours/day. Each smartphone usages had different frequencies and percentages. The top three usages were chatting (28.6%), watching videos (22.4%) and work (15.7%). The median (25−75%) total television viewing time was 1 (0−2) hours/day, and the viewing time before nocturnal sleep was 0 (0−1) hours/day. Television viewing was almost all for entertainment among participants in our study. Details were showed in Table 2.

Association of screen exposure time with depression among women in early pregnancy

Since the screen exposure hours were lack of normality, we conducted *Mann-Whitney U* tests to detect the

Table 2 Exposure of electronic screens among women in early pregnancy

Electronic product		Daily viewing hours (Median [25−75%])	Electronic product	Usage	Frequency (*n*)	Percentage (%)
Computer	Total	2 (0–6)	Computer	Work	302	45.4
	Before nocturnal sleep	0 (0–0)		Entertainment	198	29.8
				Both	165	24.8
Smartphone	Total	5 (3–6)	Smartphone	Work	239	15.7
				Chatting	435	28.6
				Watching videos	341	22.4
				Playing games	60	3.9
	Before nocturnal sleep	1 (1–2)		Social communication	183	12.0
				Shopping	137	9.0
				Listening to music	86	5.6
				Others	42	2.8
Television	Total	1 (0–2)	Television	Almost all for entertainment		
	Before nocturnal sleep	0 (0–1)				

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differences of screen exposure time between women with and without depression. Then, we performed *Logistic* regression by adjusting the gestation week. Table 3 indicated that total daily smartphone viewing time ($P = 0.015$, *OR*[95%*CI*]=1.09[1.11−1.18]), smartphone ($P = 0.016$, *OR*[95%*CI*]=1.24[1.04−1.47]) and television viewing time ($P = 0.006$, *OR*[95%*CI*]=1.35[1.09−1.67]) before nocturnal sleep were significantly associated with depression among women in early pregnancy. The exposure hours were longer in women with depression than those in women without depression. In addition, women with higher scores of smartphone addiction were more susceptible to depression ($P<0.001$, *OR*[95%*CI*]=1.11[1.07−1.16]). Total daily computer and television viewing time, and computer viewing time before nocturnal sleep were not significantly related to depression among women in early pregnancy (all $P>0.05$).

Association of electronic products' usages with depression among women in early pregnancy

We conducted a *χ2* test to analyze the difference of computer usages among women with and without depression, but no statistically significance was found ($P>0.05$). The top three smartphone usages (excluding "Others") in women with depression were watching videos (22.0%), listening to music (20.9%) and playing games (16.7%). Please see Additional file 1 and Fig. 2. Since there were too many categories of smartphone usages, the statistical analysis was not applicable.

Threshold hours of screen exposure time among women in early pregnancy

Based on the results in Table 3, we carried out *ROC* curves and calculated *Youden* Indexes to determine the best threshold hours of screen exposure time among women in early pregnancy (see Table 4 and Additional files 2–4). The threshold of total smartphone viewing time was

7.5 h/day, with the sensitivity 0.315 and specificity 0.795 (*AUC*=0.567, $P = 0.026$). The threshold of smartphone viewing time before nocturnal sleep was 1.5 h/day, with the sensitivity 0.537 and specificity 0.553 (*AUC*=0.571, $P = 0.019$). The threshold of television viewing time before nocturnal sleep was 1.5 h/day, with the sensitivity 0.250 and specificity 0.882 (*AUC*=0.571, $P = 0.020$).

Discussion

Among the women in early pregnancy, the total daily smartphone viewing time was the longest in the three types of electronic screen exposure. Moreover, we suggested that total daily smartphone viewing time, smartphone and television viewing time before nocturnal sleep were associated with depression among women in early pregnancy, and the thresholds were 7.5 h/day, 1.5 h/day and 1.5 h/day, respectively. Women with higher scores of smartphone addiction were more susceptible to depression.

According to the previous and current studies, the exposure time of smartphone screen has been getting longer among pregnant women in China. A cross-sectional survey [10] conducted in 2015 indicated that 62.6% pregnant women reported mobile phone viewing time ≥ 1 h/day. However, our previous study [5] carried out in 2019 showed that, the median using time of smartphones among healthy pregnant women was 5.5 h/day. The present study was conducted in 2022, and indicated the median viewing time of smartphone among women in early pregnancy was 5 h/day. The longer exposure time of smartphone might result from the widely use of 4G/5G network and various applications (APPs) with plural functions. Nevertheless, our studies were all located in south Jiangsu province, which could not represent all the districts in China.

It has been well demonstrated that overuse of smartphone or smartphone addiction is significantly related

Table 3 Differences of screen exposure time between women with and without depression

Variable	Women with depression (Median [25−75%])	Women without depression (Median [25−75%])	*P*	*P*adj	OR [a]adj (95%*CI*[b])
Total daily computer viewing hours	1 (0–6)	2 (0–6)	0.522	0.636	0.99 (0.93–1.05)
Computer viewing hours before nocturnal sleep	0 (0–1)	0 (0–0)	0.119	0.175	1.10 (0.96–1.26)
Total daily smartphone viewing hours	5 (3–8)	4 (3–6)	0.025[*]	0.015[*]	1.09 (1.11–1.18)
Smartphone viewing hours before nocturnal sleep	2 (1–2)	1 (1–2)	0.013[*]	0.016[*]	1.24 (1.04–1.47)
Scores of smartphone addiction	1 (0–2)	1 (0–2)	<0.001[**]	<0.001[**]	1.11 (1.07–1.16)
Total daily television viewing hours	0.5 (0–1.75)	0 (0–1)	0.513	0.497	1.04 (0.93–1.16)
Television viewing hours before nocturnal sleep	22 (17.25–26)	18 (14–22)	0.008[**]	0.006[**]	1.35 (1.09–1,67)

[a] *OR* Odds Ratio, [b]*CI* Confidence interval

*$P<0.05$; **$P<0.01$

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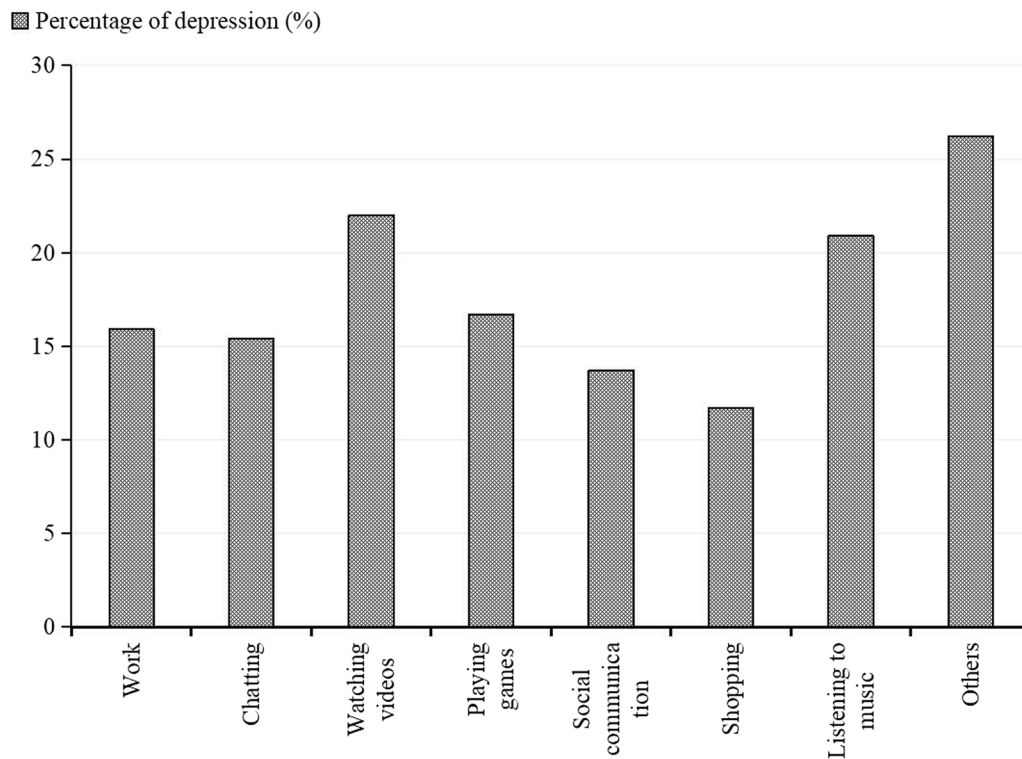
☒ Percentage of depression (%)

Fig. 2 Depression percentages of different smartphone usages

Table 4 Threshold hours of screen exposure time determined by *ROC*[a] curves

Variable	Area under curve	*P*	OR [b] (95%CI[c])	Threshold (hours)	Sensitivity	Specificity	Youden index
Total daily smartphone viewing hours	0.567	0.026*	0.51–0.63	7.5	0.315	0.795	0.110
Smartphone viewing hours before nocturnal sleep	0.571	0.019*	0.51–0.63	1.5	0.537	0.553	0.090
Television viewing hours before nocturnal sleep	0.571	0.020*	0.51–0.63	1.5	0.250	0.882	0.132

[a] *ROC* receiver operator characteristic, [b]*OR* Odds Ratio, [c]*CI* Confidence interval

*$P < 0.05$

to depression among university students [21–23] and adults [24], which is consistent with the results of present study. The accurate mechanisms remained unclear, whereas the prolonged sedentary time might play an important role in the relationship between smartphone overuse and depression. As sitting hours increased, university students' stress, anxiety, and depression significantly increased despite controlling for sex, economic level, body mass index, underlying disease, and health self-management [25]. A meta-analysis indicated that screen time accounted for 57.2% of total sedentary time in adults during the COVID-19 pandemic, and increases in sedentary time were negatively correlated with global mental health, depression, anxiety and quality of life,

irrespective of age [26]. Therefore, total daily smartphone screen time and sedentary time should be kept within reasonable limits.

Exposure to electronic screens before nocturnal sleep was particularly related to depression among women in early pregnancy, which should be paid more attention to. People with smartphone addiction were inclined to postpone their bedtime [22]. If individuals use smartphones in low light conditions, the blue light generated from smartphones would significantly decrease sleepiness and confusion-bewilderment [27]. However, short sleep duration was established as a risk factor of depression [22, 28] in adults. Hence, screen time before nocturnal sleep should be strictly controlled.

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In spite of the hazardous effects of prolonged screen time, electronic devices are irreplaceable in modern life, and it is necessary to determine the appropriate threshold time for the target population. In our study, the thresholds of total smartphone viewing time, smartphone and television viewing time before nocturnal sleep were calculated as 7.5 h/day, 1.5 h/day and 1.5 h/day, respectively. Although the *AUC*s were all less than 0.6 and *Youden* Indexes were around 0.1, the specificity of total smartphone viewing time and television viewing time before nocturnal sleep was 0.795 and 0.882, respectively. In other words, women with screen time below those thresholds might not be depressed. Still, the conformation of thresholds should be warranted by more large scale and multi-center studies.

Besides the exposure time of smartphone, the usages might be also correlated with depression in women during early pregnancy. The top three smartphone usages (excluding "Others") in women with depression were watching videos (22.0%), listening to music (20.9%) and playing games (16.7%). Although these results were concluded from descriptive analyses but not statistical inferences, it could be supported by other researches. Among Korean middle school students, the order of the usage types with the highest influence on smartphone addiction was: enjoying music/videos, social network service, and study [29]. A large-scale cross-sectional study suggested that social media and video games was related to the symptoms of psychiatric disorders, including anxiety and depression [30]. Nonetheless, the mechanism of the relationships between different smartphone usages and depression were unknown.

Finally, we didn't find any statistical significance of computer screen exposure. Since a variety of computer functions can be replaced by smartphones, people tend to use smartphones more frequently. As a result, computers were used mainly for work by most women, whereas only 29.8% were only for entertainment. Then, the exposure hours of computer were fewer than those of smartphone, especially before nocturnal sleep. So, the computer screen exposure might not be a risk factor for women in early pregnancy.

Limitations were also existed in our study. Firstly, the electronic screen time was self-reported by participants, resulting in the inaccuracy hours of screen time. Secondly, the present study was a cross-sectional study, so we could not determine whether the depression caused the high screen time or the raised screen time caused the depression. Thirdly, the thresholds were calculated for depression, which might not be suitable for other disorders. Finally, there was a lack of generalizability due to the specific sample characteristics defined by the inclusion criteria in the current study. Given this, a multi-center, follow-up, cohort study should be conducted.

Conclusions

In conclusion, electronic screen exposure, including total daily smartphone viewing time, smartphone and television viewing time before nocturnal sleep, were associated with depression among women in early pregnancy; the maximum exposure time we recommended was less than 7.5 h/day, 1.5 h/day and 1.5 h/day, respectively. Pregnant women should also refrain from smartphone addiction. Lastly, further studies are warranted to verify the conclusions.

Abbreviations

CI	Confidence interval
PHQ	Patient Health Questionnaire
SAS-CA	Smartphone Addiction Scale for Chinese Adults
SD	Standard deviation
ROC	Receiver operator characteristic
AUC	Area under curve
BMI	Body mass index
APP	Application

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12978-024-01869-z.

Supplementary Material 1.

Supplementary Material 2.

Supplementary Material 3.

Supplementary Material 4.

Supplementary Material 5.

Data availability
All data generated or analysed during this study are included in this published article and Additional file 5.

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Declarations

Ethics approval and consent to participate
The present study was performed in accordance with the Declaration of Helsinki, and was approved by the ethics committee of Liyang People's Hospital (No. 2021003). Informed consent was obtained from digital questionnaire, of which the first question was set as "Whether are you willing to join in this investigation?". If the answer were "Yes", the investigation would continue; otherwise, the process would terminate. The Ethics Committee approved the procedure for consent of our study, and the Department of Science and Education permitted the access and use of the medical records described in our study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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