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Associations between smartphone addiction, parenting styles, and mental well-being among adolescents aged 15–19 years in Gujarat, India

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Abstract

Background The pervasive use of smartphones among adolescents has raised concerns about addiction and its impact on mental well-being. This study investigates the prevalence of smartphone addiction and its associations with socio-demographic factors, parenting styles, and mental health among Indian adolescents.

Methods A cross-sectional study was conducted among 560 school-going adolescents (aged 15–19) in Gujarat, India, from January to October 2023. Data was collected using validated scales: the Smartphone Addiction Scale-Short Version (SAS-SV), the Parenting Styles and Dimensions Questionnaire (PSDQ), and the Depression Anxiety Stress Scale-21 (DASS-21). Bivariate and multivariate logistic regression analyses were performed to identify factors associated with smartphone addiction.

Results The prevalence of smartphone addiction was 64.6%. Urban residence (AOR: 2.4, 95% CI: 1.8–3.3), higher parental education (AOR: 3.3, 95% CI: 1.7–4.3 for graduate fathers), longer smartphone use (AOR: 2.08, 95% CI: 1.7–3.6 for > 3 years), and higher socioeconomic status (AOR: 1.9, 95% CI: 1.5–3.51) were associated with increased odds of addiction. Authoritarian and permissive parenting styles in both parents were positively associated with smartphone addiction, while authoritative parenting was negatively associated. Smartphone addiction was strongly associated with mental health issues, particularly with severe stress (AOR: 10.82, 95% CI: 5.11–22.88, $p < 0.001$).

Conclusion Smartphone addiction is highly prevalent among Indian adolescents and is significantly associated with urban living, higher socioeconomic status, non-authoritative parenting styles, and poor mental health. These findings underscore the need for digital literacy programs, parenting interventions promoting authoritative styles, and mental health support to foster healthy smartphone use among adolescents.

Keywords Smartphone addiction, Adolescents, Parenting styles, Mental health, Digital literacy, India

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Introduction

The proliferation of smartphones has dramatically reshaped the landscape of adolescent communication, learning, and entertainment globally. As of 2021, smartphone penetration reached 75% worldwide, with India experiencing a rapid surge to 54% despite significant urban-rural disparities [1]. While smartphones offer unprecedented access to information and social connectivity, concerns about their excessive use, particularly among adolescents, have grown exponentially.

Smartphone addiction, characterized by compulsive use, tolerance, and withdrawal symptoms, has emerged as a significant public health concern. A recent meta-analysis reported a global prevalence of 16% among adolescents, with rates varying substantially across regions [2]. In India, studies have found prevalence rates ranging from 39 to 44% among urban adolescents, underscoring the issue's magnitude in this rapidly digitalizing nation [3].

The impact of smartphone addiction on adolescent well-being is multifaceted and concerning. Research has consistently linked excessive smartphone use to mental health issues, including increased rates of depression and anxiety [4]. Moreover, smartphone addiction has been correlated with decreased academic performance and sleep disturbances, highlighting its potential to affect multiple domains of adolescent life [5].

Parenting styles are crucial in shaping adolescent behavior, including technology use. Recent research has shown that authoritative parenting, characterized by high warmth and firm control, is associated with lower risks of smartphone addiction among adolescents [6]. However, the influence of parenting styles on adolescent smartphone use may vary across cultural contexts, necessitating culture-specific investigations.

The Indian context presents unique challenges and opportunities in addressing adolescent smartphone addiction. India's rapid digital transformation, driven by affordable smartphones and data plans, has created a generation of digital natives [7]. However, this digital revolution intersects with traditional family structures, intense academic pressures, and evolving social norms, creating a complex environment for adolescent smartphone use.

Despite the growing concern, there is limited research examining the interplay between smartphone addiction, parenting styles, and mental health among Indian adolescents. Understanding these relationships is crucial for developing culturally appropriate interventions, guiding family-based prevention strategies, and supporting early identification of at-risk adolescents.

Given this context, our study aims to investigate the prevalence of smartphone addiction among adolescents aged 15–19 years in Gujarat, India, and its associations with socio-demographic factors, parenting styles, and mental well-being. By examining these relationships, we seek to contribute to the growing literature on adolescent smartphone use in non-Western contexts and provide valuable insights for policymakers, educators, and mental health professionals working with Indian adolescents [8, 9].

Methodology

Study design and setting

This institutional-based Cross-sectional study which aimed to determine the prevalence of smartphone addiction and its association with the parenting style and Mental well-being of adolescents was conducted among school-going adolescents aged 15–19 years in Gujarat, India between January 2023 and October 2023. The age range of 15–19 years was selected based on both developmental considerations and previous research findings: Developmental Stage: This age range corresponds to the period of middle to late adolescence, a critical developmental stage characterized by: - Increased autonomy and independence in decision-making, including technology use. Advanced cognitive development, allowing for a more nuanced understanding of smartphone usage patterns and potential consequences. Heightened peer influence and identity formation, which can significantly impact smartphone use behaviors, and also Previous Research - Sohn et al. (2019) conducted a meta-analysis on smartphone addiction in children and adolescents, finding that the 17–19 age group showed the highest prevalence rates [8].

Sample size and sampling technique

The sample size was calculated using the formula $N=Z^2 PQ/L^2$ considering the $P=0.27$ (based on a pilot study conducted in Gujarat among 100 adolescents aged 15–19 years) with an absolute precision of 5% at a 95% confidence interval and design effect of 2. The calculated minimum sample size of 524 was rounded to 560. We rounded this up to 560 to account for potential non-responses and to ensure adequate representation across age groups and clusters. For the logistic regression analysis examining the association between smartphone addiction and mental health outcomes: Effect size: We used an odds ratio of 1.5, which is considered a small to medium effect size in epidemiological studies. α error probability: 0.05, Sample size: 560. Number of predictors: 10 (including socio-demographic variables, parenting styles, and mental health indicators).

The post-hoc power analysis revealed that with our sample size of 560, we achieved a power of 0.92 (92%) to detect an odds ratio of 1.5 at a 0.05 significance level. This exceeds the conventionally accepted power of 80%, indicating that our study was adequately powered to detect

meaningful associations between smartphone addiction and our variables of interest.

Cluster sampling was chosen over other methods (such as simple random sampling or stratified sampling) for several reasons: Geographical Efficiency: Given the wide distribution of schools across Gujarat, cluster sampling allowed us to concentrate our data collection efforts in selected areas, reducing travel time and costs. Administrative Feasibility: Working with entire schools as clusters simplified the logistics of obtaining permissions and conducting the study. Reduced Sampling Frame Requirements: We only needed a list of schools rather than a complete list of all eligible students in Gujarat. Potential for School-Level Interventions: This method allows for future interventions to be designed at the school level if needed.

Selection of Clusters (Schools):

a) A comprehensive list of all secondary and higher secondary schools in Gujarat was obtained from the state education department.
b) Schools were stratified by urban/rural location to ensure representation.
c) 28 schools were randomly selected using a computer-generated random number sequence, with the number of schools from each stratum proportional to the urban/rural population distribution in Gujarat.

3. Selection of Participants within Clusters:

a) In each selected school, we aimed to recruit 20 participants (4 from each age group: 15, 16, 17, 18, and 19 years).
b) Class rosters for grades 9–12 were obtained from each school.
c) Students were stratified by age, and within each age group, participants were selected using systematic random sampling (every nth name on the alphabetically ordered class list, where n was determined by the total number of eligible students in that age group).
d) If a selected student was absent or declined to participate, the next student on the list was approached.

Eligibility criteria

The study included adolescents aged 15–19 years who were willing to participate. Exclusion criteria encompassed those who were unable to read or write the questionnaire, those diagnosed with any mental or cognitive disorder that impaired understanding and providing informed consent, those who had not received parental consent if under 18 years old, and those who were absent or unwilling to participate on the day of data collection.

Study tools

Data was collected via a pre-tested, structured questionnaire adapted from prior studies and validated scales. The study employed four primary tools for data collection. First, a structured socio-demographic questionnaire was used to gather information on participants' age, gender, school, residence (urban/rural), parent's education and occupation, socioeconomic status, smartphone usage patterns (including duration, frequency, purpose, and applications used), and perceived impact of smartphone use on daily life, social relationships, academics, and sleep.

The Smartphone Addiction Scale - Short Version (SAS-SV) was utilized to measure smartphone addiction. This 10-item scale, rated on a 6-point Likert scale, has demonstrated high internal consistency (Cronbach's alpha: 0.91), good concurrent validity (r=0.70) with the original SAS, and high test-retest reliability (r=0.88). The SAS-SV has been validated across various cultures, including among Indian adolescents. For this study, smartphone addiction was operationally defined as a score of ≥31 for boys and ≥33 for girls on the SAS-SV [4, 10, 11].

To assess parenting styles, the study used the Parenting Styles and Dimensions Questionnaire (PSDQ). This 32-item scale measures three parenting styles: authoritarian, authoritative, and permissive, using a 5-point Likert scale. The PSDQ has shown high internal consistency (Cronbach's alpha ranging from 0.64 to 0.86 for different subscales), good construct validity, and test-retest reliability ranging from 0.79 to 0.93. It has been validated in diverse cultural contexts, including Asian populations and specifically in India. Operationally, authoritarian parenting was defined as strict, punitive, and demanding unquestioning obedience; authoritative parenting as warm, nurturing, and setting reasonable limits with open communication; and permissive parenting as indulgent, non-demanding, and exerting minimal control over children's behavior [12].

Finally, the Depression Anxiety Stress Scale-21 (DASS-21) was employed to measure symptoms of depression, anxiety, and stress. This 21-item scale, with 7 items per subscale rated on a 4-point scale, has demonstrated excellent internal consistency (Cronbach's alpha ranging from 0.87 to 0.94 for different subscales), good convergent and discriminant validity, and high test-retest reliability (r=0.71 to 0.81). The DASS-21 has been validated in diverse populations, including Indian adolescents. For each subscale, scores were categorized as normal, mild, moderate, severe, or extremely severe, with specific cut-off points for each category. For instance, depression scores were categorized as normal (0–9), mild [10, 11,

13], moderate [12, 14–20], severe (21–27), and extremely severe (28–42). Similar categorizations were applied for anxiety and stress subscales, with their respective cut-off points [14, 15].

Data collection

The questionnaire was distributed to students in their classrooms after obtaining written informed consent from school authorities, parents, and permission from students. Respondents were given 30 min to complete the questionnaire which was then collected back. The investigators clarified any doubts or queries during filling.

Statistical analysis

Data was coded and cleaned in MS Excel and then transferred to SPSS v25.0 for analysis. Descriptive statistics were computed to summarize the socio-demographic characteristics of the participants, the prevalence of smartphone addiction, parenting styles, and mental well-being scores using measures of central tendency (mean, median) and variability (standard deviation, range) for continuous variables, and frequencies and percentages for categorical variables.

To assess the associations between smartphone addiction (dependent variable) and the independent variables, including socio-demographic factors, parenting styles, and mental well-being, bivariate analyses were performed initially. For categorical independent variables, the chi-square test or Fisher's exact test (for small expected cell counts) was used to examine the differences in smartphone addiction prevalence across the categories. For continuous independent variables, independent sample t-tests/one-way ANOVA were employed to compare the mean scores of smartphone addiction across the groups.

Variables with a p-value < 0.2 in the bivariate analyses were considered for inclusion in the multivariate analysis. Multivariate logistic regression was performed to identify independent predictors of smartphone addiction while adjusting for potential confounders. The dependent variable, smartphone addiction, was dichotomized based on the cut-off scores of the Smartphone Addiction Scale-Short Version (SAS-SV). Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated to estimate the strength of association between the independent variables and smartphone addiction.

The assumptions of logistic regression were rigorously assessed:

1. Linearity of continuous variables with the logit was checked using the Box-Tidwell test.
2. Multicollinearity was assessed using variance inflation factors (VIF), with a threshold of VIF > 5 indicating problematic multicollinearity.
3. The presence of influential outliers was evaluated using Cook's distance, with values > 4/n (where n is the sample size) flagged for further investigation.

To assess the association between smartphone addiction and mental well-being, multinomial logistic regression was performed, depending on the nature of the mental well-being variables (DASS-21 scores for depression, anxiety, and stress).

Correlation analyses (Pearson's correlation) examined the relationships between parenting styles, smartphone addiction, and mental well-being scores. All statistical tests were two-tailed, and a p-value of < 0.05 was considered statistically significant.

To ensure the robustness of our findings, we conducted several sensitivity analyses:

1. We ran models with and without potential outliers (identified using Cook's distance) to assess their impact on the results.
2. We performed bootstrapping with 1000 resamples to obtain bias-corrected confidence intervals for our main effect estimates.
3. We conducted stratified analyses by age groups to check if the associations differed across different adolescent age brackets.

Ethical considerations

Ethics approval was obtained from the Institutional Review Board of M.P. Shah Government Medical College, Jamnagar, Gujarat. [REF.No:110/02/2023]. Participation was voluntary and informed written consent and permission were taken. Confidentiality was maintained using unique identifiers and data access was restricted to study investigators.

Results

Table 1 presents the distribution of respondents according to their smartphone usage patterns across various socio-demographic factors

Among the 560 participants, smartphone usage was high across all age groups, ranging from 84.82% (95 out of 112) for 16-year-olds to 91.96% (103 out of 112) for 19-year-olds. Gender-wise, a slightly higher proportion of females (90.8%, 217 out of 239) used smartphones compared to males (89.1%, 286 out of 321). Urban residents had a higher smartphone usage (90.95%, 382 out of 420) compared to rural residents (86.42%, 121 out of 140). Interestingly, the use of hands-free kits didn't significantly influence smartphone usage, with 89.7% (366 out of 408) of those using hands-free kits and 90.13% (137 out of 152) of those not using them being smartphone users. Parental education, particularly higher education

Table 1 Distribution of respondents according to smartphone use (*N* = 560)

Characteristic	Category	Total *N* (%)	Smartphone Users *N* (%)	Non-Smartphone Users *N* (%)
Age				
	15	112 (20.0%)	102 (91.1%)	10 (8.9%)
	16	112 (20.0%)	95 (84.8%)	17 (15.2%)
	17	112 (20.0%)	102 (91.1%)	10 (8.9%)
	18	112 (20.0%)	101 (90.2%)	11 (9.8%)
	19	112 (20.0%)	103 (92.0%)	9 (8.0%)
Gender				
	Male	321 (57.3%)	286 (89.1%)	35 (10.9%)
	Female	239 (42.7%)	217 (90.8%)	22 (9.2%)
Area of Residence				
	Urban	420 (75.0%)	382 (91.0%)	38 (9.0%)
	Rural	140 (25.0%)	121 (86.4%)	19 (13.6%)
Father's Education				
	Illiterate	23 (4.1%)	18 (78.3%)	5 (21.7%)
	Primary/Secondary	125 (22.3%)	110 (88.0%)	15 (12.0%)
	Higher Secondary	111 (19.8%)	102 (91.9%)	9 (8.1%)
	Graduate and Higher	301 (53.8%)	273 (90.7%)	28 (9.3%)
Mother's Education				
	Illiterate	64 (11.4%)	55 (85.9%)	9 (14.1%)
	Primary/Secondary	171 (30.5%)	149 (87.1%)	22 (12.9%)
	Higher Secondary	107 (19.1%)	95 (88.8%)	12 (11.2%)
	Graduate and Higher	218 (39.0%)	204 (93.6%)	14 (6.4%)
Years of Usage				
	< 3 years	372 (66.4%)	336 (90.3%)	36 (9.7%)
	> 3 years	188 (33.6%)	167 (88.8%)	21 (11.2%)
Duration of use (hours/day)				
	< 2 h/day	365 (65.2%)	325 (89.0%)	40 (11.0%)
	> 2 h/day	195 (34.8%)	178 (91.3%)	17 (8.7%)
Socioeconomic Status (SES)				
	Upper (Class 1 & 2)	396 (70.7%)	354 (89.4%)	42 (10.6%)
	Lower (Class 3,4,5)	164 (29.3%)	149 (90.9%)	15 (9.1%)

Note: Percentages in the "Total N (%)" column are calculated out of the total sample size (*N* = 560). Percentages in the "Smartphone Users N (%)" and "Non-Smartphone Users N (%)" columns are calculated within each category

levels, seemed to correlate with higher smartphone usage among adolescents. For instance, 93.57% (204 out of 218) of adolescents whose mothers were graduates or higher used smartphones. Duration and years of usage didn't show substantial differences in usage patterns. Notably, 90.34% (393 out of 435) of those who perceived smartphone use as harmful were still users. Lastly, smartphone usage was high across all perceived academic performance levels and socioeconomic statuses.

Table 2 presents the prevalence of smartphone addiction, parenting styles, and DASS gradings

The table reveals that a significant portion of the participants, 64.6% (362 out of 560), were classified as smartphone addicts. The table also presents the average scores for different parenting styles. The mean score for authoritarian parenting was 31 ± 9.12, for authoritative parenting was 29.9 ± 9.32, and for permissive parenting was 27.8 ± 9.23. These scores suggest that, on average, parents in the study exhibited slightly higher levels of authoritarian parenting behaviors compared to authoritative and permissive styles. However, the similar standard deviations indicate considerable variation in parenting styles across families. The table also presents the mental well-being of the participants using the DASS scale. For depression, 55.7% (312 out of 560) were normal, while 15.7% (88 out of 560) had mild, 15.4% (86 out of 560) had moderate, 8% (45 out of 560) had severe, and 5.2% (29 out of 560) had extremely severe symptoms. For anxiety, 52.3% (293 out of 560) were normal, with 15.5% (87 out of 560) mild, 16.4% (92 out of 560) moderate, 11.3% (63 out of 560) severe, and 4.5% (25 out of 560) extremely severe. Stress levels were more concerning, with only 42.5% (238 out of 560) being normal, 18.2% (102 out of 560) mild, 22.5% (126 out of 560) moderate, 14.6% (82 out of 560) severe, and 2.1% (12 out of 560) extremely severe.

Table 2 Prevalence of smartphone addiction, parenting styles, and DASS gradings

Characteristic	Category	*n*	%
Smartphone Addiction	Addicted	362	64.6%
	Non-addicted	198	35.4%
Father Parenting Style	Authoritarian, mean ± SD	31 ± 9.12	
	Authoritative, mean ± SD	29.9 ± 9.32	
	Permissive, mean ± SD	27.8 ± 9.23	
Mother parenting style	Authoritarian, mean ± SD	35 ± 9.22	
	Authoritative, mean ± SD	30.2 ± 8.90	
	Permissive, mean ± SD	29.9 ± 9.92	
Depression (DASS)	Normal	312	55.7%
	Mild	88	15.7%
	Moderate	86	15.4%
	Severe	45	8.0%
	Extremely Severe	29	5.2%
Anxiety (DASS)	Normal	293	52.3%
	Mild	87	15.5%
	Moderate	92	16.4%
	Severe	63	11.3%
	Extremely Severe	25	4.5%
Stress (DASS)	Normal	238	42.5%
	Mild	102	18.2%
	Moderate	126	22.5%
	Severe	82	14.6%
	Extremely Severe	12	2.1%

Correlation heatmap (Fig. 1)

The correlation heatmap in Fig. 1 visually represents the strength and direction of the relationships between parental styles, smartphone addiction, and DASS (Depression, Anxiety, and Stress Scale) scores. The heatmap displays Pearson's correlation coefficients, with darker shades indicating stronger positive correlations and lighter shades indicating stronger negative correlations.

The heatmap is divided into two sections, one for the father's parenting style and another for the mother's parenting style.

For father's parenting style:

- Authoritarian style is positively correlated with smartphone addiction ($r = 0.16$), depression ($r = 0.19$), anxiety ($r = 0.22$), and stress ($r = 0.27$) scores, indicating that higher levels of authoritarian parenting by fathers are associated with higher smartphone addiction and poorer mental health.
- Authoritative style is negatively correlated with smartphone addiction (r = -0.12), depression (r = -0.16), anxiety (r = -0.14), and stress (r = -0.18) scores, suggesting that higher levels of authoritative parenting by fathers are associated with lower smartphone addiction and better mental health.
- Permissive style is positively correlated with smartphone addiction ($r = 0.14$), depression ($r = 0.17$), anxiety ($r = 0.20$), and stress ($r = 0.24$) scores, indicating that higher levels of permissive parenting by fathers are associated with higher smartphone addiction and poorer mental health.

For mother's parenting style:

- Authoritarian style is positively correlated with smartphone addiction ($r = 0.20$), depression ($r = 0.25$), anxiety ($r = 0.28$), and stress ($r = 0.33$) scores, indicating that higher levels of authoritarian parenting by mothers are associated with higher smartphone addiction and poorer mental health.
- Authoritative style is negatively correlated with smartphone addiction (r = -0.16), depression (r = -0.22), anxiety (r = -0.20), and stress (r = -0.24) scores, suggesting that higher levels of authoritative parenting by mothers are associated with lower smartphone addiction and better mental health.
- Permissive style is positively correlated with smartphone addiction ($r = 0.18$), depression ($r = 0.23$), anxiety ($r = 0.26$), and stress ($r = 0.30$) scores, indicating that higher levels of permissive parenting by mothers are associated with higher smartphone addiction and poorer mental health.

The separation of parenting styles by father and mother in the correlation heatmap allows for a more nuanced understanding of the differential impact of paternal and maternal parenting styles on adolescent smartphone addiction and mental health outcomes.

Table 3 explores factors associated with smartphone addiction through bivariate and multivariate logistic regression

Urban residents were 2.4 times (AOR: 2.4, 95% CI: 1.8–3.3) more likely to be smartphone addicts compared to rural residents. Using hands-free kits increased the odds of addiction by 2.5 times (AOR: 2.5, 95% CI: 1.8–3.6). Higher paternal and maternal education levels were associated with increased odds of addiction, with the highest being 3.3 times (AOR: 3.3, 95% CI: 1.7–4.3) for fathers with graduate or higher education. Using smartphones for more than 3 years (AOR: 2.08, 95% CI: 1.7–3.6) and using them for more than 2 h daily (AOR: 2.6, 95% CI: 1.6–4.1) also increased addiction odds. Interestingly, perceiving smartphone use as not harmful increased addiction odds by 2.4 times (AOR: 2.4, 95% CI: 1.9–4.2). Lower perceived academic performance was associated with higher addiction odds, with those perceiving their performance as poor being 3.7 times (AOR: 3.7, 95% CI: 1.1–12) more likely to be addicted. Higher socioeconomic status (AOR: 1.9, 95% CI: 1.5–3.51) also increased addiction odds. Regarding the father's parenting style:

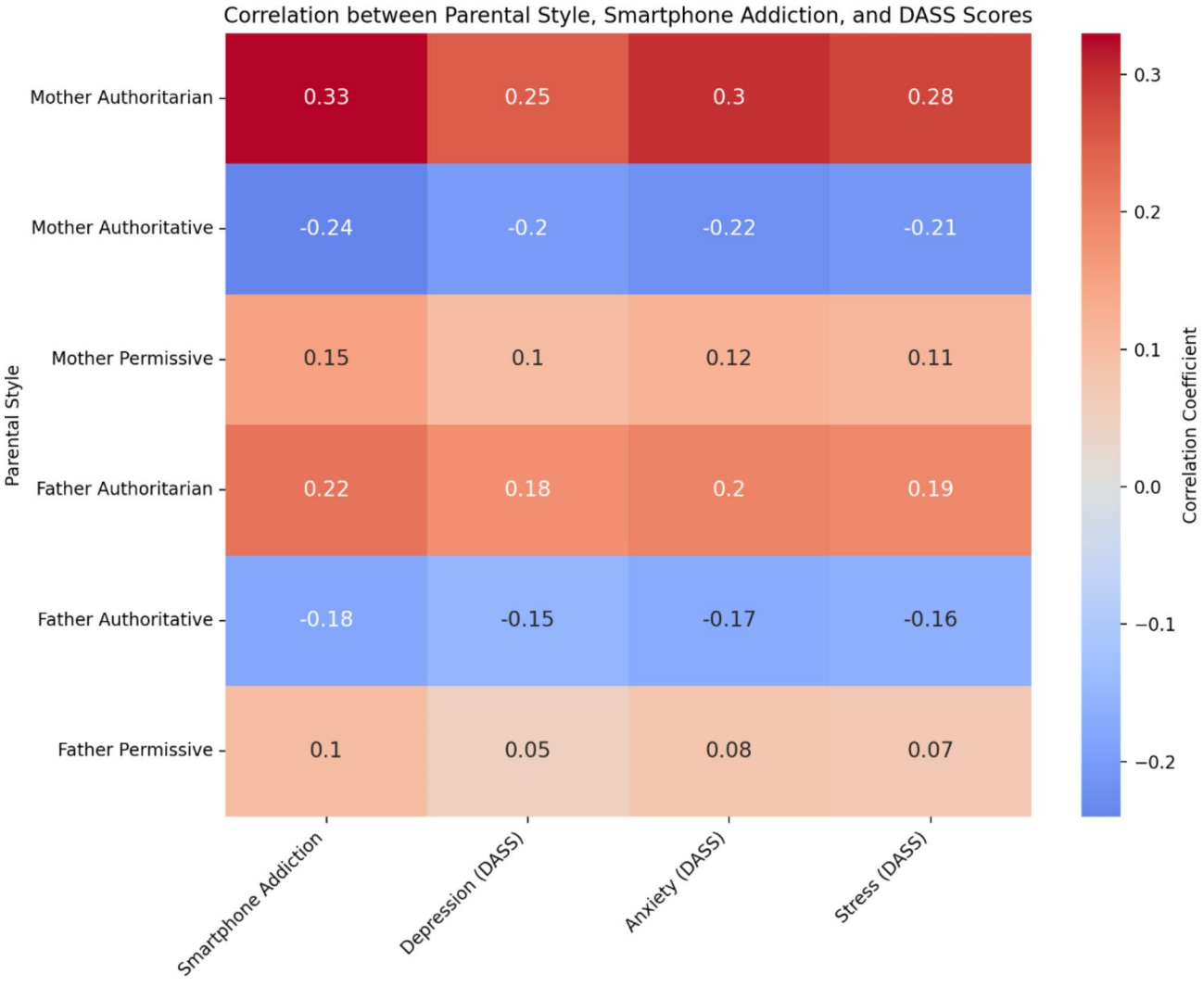

Fig. 1 shows the correlation between parental style, Smartphone addiction, and DASS score

- Authoritarian: For every one-unit increase, the odds of smartphone addiction increase by 4% (AOR: 1.04, 95% CI: 1.02–1.06).
- Authoritative: For every one-unit increase, the odds of smartphone addiction decrease slightly by 3% (AOR: 0.97, 95% CI: 0.95–0.99).
- Permissive: For every one-unit increase, the odds of smartphone addiction increase by 3% (AOR: 1.03, 95% CI: 1.01–1.05).

For mother's parenting style:

- Authoritarian: For every one-unit increase, the odds of smartphone addiction increase by 5% (AOR: 1.05, 95% CI: 1.03–1.07).
- Authoritative: For every one-unit increase, the odds of smartphone addiction decrease by 4% (AOR: 0.96, 95% CI: 0.94–0.98).
- Permissive: For every one-unit increase, the odds of smartphone addiction increase by 4% (AOR: 1.04, 95% CI: 1.02–1.06).

Table 4 demonstrates a strong association between smartphone addiction and mental well-being

For depression, compared to those with normal scores, those with moderate depression were 2.17 times (AOR: 2.17, 95% CI: 1.31–3.59, $p=0.003$) and those with severe depression were 3.95 times (AOR: 3.95, 95% CI: 2.05–7.61, $p<0.001$) more likely to be smartphone addicts. For anxiety, the odds increased from 2.11 (AOR: 2.11, 95% CI: 1.31–3.41, $p=0.002$) for mild anxiety to 6.28 (AOR: 6.28, 95% CI: 3.09–12.78, $p<0.001$) for severe anxiety. The most striking association was with stress levels. Compared to those with normal stress, those with mild stress were 2.21 times (AOR: 2.21, 95% CI: 1.29–3.79, $p=0.004$), those with moderate stress were 4.63 times (AOR: 4.63,

Table 3 Factors associated with smartphone addiction bivariate and multivariate logistic regression analysis ($N=362$)

Variable	Categories	COR	AOR
Age	15	[1]	-
	16	0.958(0.5–1.6)	-
	17	0.7(0.4–1.3)	-
	18	1.08(0.6–1.9)	-
	19	0.8(0.4–1.5)	-
Gender	Female	1.27(0.87–1.83)	-
	Male	[1]	[1]
Area of Residence	Urban	2.1(1.9–3.5)*	2.4(1.8–3.3)*
	Rural	[1]	[1]
Use of Hands-free kit	Yes	2.6(1.9–3.4)*	2.5(1.8–3.6)*
	No	[1]	[1]
Father's Education	Illiterate	[1]	[1]
	Primary/ Secondary	2.247(1.39–3.98)*	2.7(1.4–6.2)*
	Higher Secondary	2.60(1.5–5.11)*	2.4(1.7–3.8)*
	Graduate and Higher	3.8(2.8–7.3)*	3.3(1.7–4.3)*
Mother's Education	Illiterate	[1]	[1]
	Primary/ Secondary	1.046(0.5–2.1)	-
	Higher Secondary	1.8(0.87–3.8)	-
	Graduate and Higher	2.14(1.09–4.15)*	2.7(1.9-4)*
Years of Usage	< 3 years	[1]	[1]
	> 3 years	2.1(1.7–3.7)*	2.08(1.7–3.6)*
Duration of use (hours/day)	< 2 h	[1]	[1]
	> 2 h	2.89(1.8–4.4)*	2.6(1.6–4.1)*
The perception that smartphone use is harmful	Yes	[1]	[1]
	No	2.01(1.127–2.61) *	2.4(1.9–4.2) **
Current Academic Performance According to you	Excellent	[1]	[1]
	Good	1.64(0.95–2.81)	-
	Average	3.8(2.1–6.7) *	3.1(1.7–5.7)*
	Poor	4.99(1.5–16) *	3.7(1.1–12)*
Socioeconomic Status (SES)	Upper (Class 1 &2)	2.4(1.9–3.2) *	1.9(1.5–3.51*)
	Lower (Class 3, 4 &5)	[1]	[1]
Father Parenting Style	Authoritarian	1.05 (1.03–1.07) *	1.04 (1.02–1.06)*
	Authoritative	0.96 (0.94–0.98) *	0.97 (0.95–0.99) *
	Permissive	1.04 (1.02–1.06) *	1.03 (1.01–1.05)*
Mother Parenting Style	Authoritarian	1.06 (1.04–1.08) *	1.05 (1.03–1.07) *
	Authoritative	0.95 (0.93–0.97) *	0.96 (0.94–0.98) *
	Permissive	1.05 (1.03–1.07) *	1.04 (1.02–1.06) *

COR-crude odds ratio, AOR-adjusted odds ratio, p-value < 0.05*-significant, $p < 0.001$**-highly significant

95% CI: 2.66–8.07, $p<0.001$), and those with severe stress were 10.82 times (AOR: 10.82, 95% CI: 5.11–22.88, $p<0.001$) more likely to be smartphone addicts. These findings underscore the significant impact of smartphone addiction on mental health, particularly stress levels.

Discussion

This cross-sectional study among school-going adolescents in Gujarat, India, revealed a high prevalence of smartphone addiction (64.6%) and its significant associations with various socio-demographic factors, parenting styles, and mental well-being. These findings underscore the pervasive nature of smartphone use among adolescents and its potentially detrimental effects on their mental health.

The prevalence of smartphone addiction in our study (64.6%) is notably higher than previous reports. For instance, while comparing with previous study found a 33.6% prevalence among Indian teenagers [16]. This disparity could be attributed to the increasing smartphone penetration in India, evolving social norms around technology use, or the impact of the COVID-19 pandemic, which has accelerated digital adoption for education and socialization [17].

Our study found that urban residence, higher parental education, longer duration of smartphone use, and higher socioeconomic status were associated with increased

Table 4 Association between smartphone addiction and mental well-being (adjusted odds Ratios)

Mental Well-being	COR (95% CI)	AOR (95% CI)	*p*-value
Depression			
Normal	Reference	Reference	-
Mild	1.62 (1.08–2.42)	1.32 (0.84–2.08)	0.228
Moderate	3.00 (1.92–4.69)	2.17 (1.31–3.59)	0.003
Severe	5.67 (3.11–10.33)	3.95 (2.05–7.61)	< 0.001 ***
Anxiety			
Normal	Reference	Reference	-
Mild	2.67 (1.73–4.12)	2.11 (1.31–3.41)	0.002 *
Moderate	4.92 (3.02–8.01)	3.47 (2.01–5.99)	< 0.001 **
Severe	9.33 (4.81–18.10)	6.28 (3.09–12.78)	< 0.001 **
Stress			
Normal	Reference	Reference	-
Mild	3.04 (1.88–4.92)	2.21 (1.29–3.79)	0.004 *
Moderate	6.92 (4.20-11.42)	4.63 (2.66–8.07)	< 0.001 **
Severe	17.50 (8.75-35.00)	10.82 (5.11–22.88)	< 0.001 **

Note: The adjusted odds ratios (AOR) are obtained in the model that controls for potentially confounding variables such as age, gender, socioeconomic status, use of hand-free kit, residence, parents education, years of usage, duration of use, academic performance, perception that smartphone use is harmful, and parenting styles. p-value < 0.05*-significant, p < 0.001**-highly significant

odds of smartphone addiction. These findings align with previous research [4, 10, 16]. The association between higher parental education and socioeconomic status might reflect greater affordability and access to smartphones in these households. However, it also suggests that educated parents might not fully recognize or mitigate the risks of excessive smartphone use, underscoring the need for awareness programs targeting all socioeconomic strata. The significant association between hands-free kit use and smartphone addiction (AOR: 2.5, 95% CI: 1.8–3.6) may suggest that increased accessibility to smartphone functions correlates with higher addiction risk.

Interestingly, our study found that adolescents who perceived their academic performance as average or poor were more likely to be smartphone addicts. This finding is consistent with previous research that has reported a negative correlation between smartphone addiction and academic performance. For instance, a study by Boumosleh and Jaalouk found that smartphone addiction was associated with lower academic performance among university students [18]. Another study by Kamaluddin et al. also reported a significant correlation between smartphone addiction and declined academic performance, including reduced study habits, difficulty in concentration, and increased absenteeism [19]. Additionally, a study by Zeng also found that high levels of smartphone addiction were linked to lower academic achievement and reduced motivation to learn [20]. This could be a bidirectional relationship: addiction might lead to decreased academic focus or poor academic performance might drive adolescents to seek escape or validation through smartphones. Either way, it highlights the need for interventions that promote healthy smartphone use and academic engagement.

Our findings on parenting styles are particularly noteworthy. Both authoritarian and permissive parenting styles were associated with higher odds of smartphone addiction compared to authoritative parenting. This is consistent with Bae's study in South Korea, which found that authoritative parenting was protective against internet addiction [21]. Authoritarian parenting, characterized by strict rules and limited warmth, has been linked to increased aggression and lower self-esteem in children. This style of parenting can also lead to children feeling anxious and insecure, which may contribute to their susceptibility to smartphone addiction. Conversely, Permissive parenting, marked by high warmth and low control, can result in children lacking self-regulation and exhibiting more behavioral problems. This style of parenting can also lead to children feeling overindulged and lacking boundaries, which may contribute to their addiction to smartphones. Authoritative parenting, which balances warmth and control, has been linked to better social and emotional development, including higher self-esteem and better self-regulation. This style of parenting can also help children develop healthy habits and boundaries, reducing their likelihood of smartphone addiction. These findings underscore the importance of parenting programs that promote open communication, reasonable limits, and digital literacy [22, 23].

The most alarming findings relate to the association between smartphone addiction and mental well-being. Adolescents with severe levels of depression, anxiety, and particularly stress had significantly higher odds of smartphone addiction. These findings echo those of Twenge et al., who reported links between increased screen time and higher rates of depression and suicide among U.S. adolescents [5, 24]. The strongest association in our study was with stress, with severely stressed adolescents being nearly 11 times more likely to be smartphone addicts. This could be due to the use of smartphones as a coping mechanism for stress, or the stress induced by constant connectivity, fear of missing out (FOMO), or cyberbullying [25]. These findings call for urgent integration of mental health support and digital wellness programs in schools.

The findings of this study have significant implications for parents, educators, policymakers, and mental health professionals. They underscore the need for a balanced approach to smartphone use, one that harnesses its educational and social benefits while mitigating its risks. Moreover, they highlight the critical role of authoritative parenting - characterized by warmth, open communication, and reasonable limits - in promoting digital wellness and mental health among adolescents.

Limitations

Despite these strengths, our study has certain limitations. The cross-sectional design precludes the establishment of causality, making it impossible to determine whether smartphone addiction leads to mental health issues or vice versa; longitudinal studies are needed to clarify these causal pathways. The reliance on self-reported data may introduce biases such as social desirability or recall bias, as adolescents might underreport smartphone use or overreport positive parenting behaviors. Our exclusion criteria, which omit adolescents with pre-existing mental disorders or language barriers, may miss critical insights into how smartphone addiction interacts with these vulnerabilities, limiting the generalizability of our findings to these subpopulations. Non-response bias is another concern, as adolescents who were absent or unwilling to participate may have different smartphone usage patterns or mental health issues, potentially leading to an underestimation of smartphone addiction prevalence or its mental health impacts. The focus on a limited age range of 15–19 years also restricts our understanding of smartphone addiction in younger adolescents or its progression from childhood, possibly missing opportunities for early intervention. Additionally, cultural nuances specific to Gujarat may limit the generalizability of our findings to other regions in India or globally. Finally, the reliance on self-reported measures of smartphone use, rather than objective measures such as screen time data from smartphones, may not fully capture accurate usage patterns.

Recommendations

Several recommendations are proposed to address these limitations and build on our findings. Future research should employ longitudinal designs to track changes in smartphone use, parenting styles, and mental health over time, helping to establish causal relationships and identify critical periods for intervention. Incorporating objective measures of smartphone use, such as app usage data or wearable sensors, could provide a more accurate picture of usage patterns. Qualitative research, including in-depth interviews or focus groups with adolescents, parents, and teachers, can help understand the lived experiences and cultural nuances behind smartphone use, parenting, and mental health. Inclusive studies that encompass adolescents with pre-existing mental health conditions or language barriers will provide insights into how smartphone addiction interacts with these vulnerabilities and inform targeted interventions. Extending the study to include younger adolescents (10–14 years) and following them into late adolescence will help understand the developmental trajectory of smartphone addiction and identify early risk factors. Based on our findings, digital literacy programs should be developed and evaluated to promote healthy smartphone use, digital well-being, and effective digital parenting strategies, targeting both adolescents and parents. Integrating mental health screenings and services into schools, with a focus on the links between digital behaviors and mental health, can help address these issues proactively. Developing culturally sensitive parenting programs that promote authoritative parenting styles, emphasizing open communication about digital use, setting reasonable limits, and modeling healthy digital behaviors, is also crucial. Advocacy for policies that protect adolescent digital well-being, such as regulations on smartphone advertising to minors, mandatory digital wellness curricula in schools, and funding for research on technology's impact on child development, is essential. Replicating this study in different Indian states and internationally can provide a broader understanding of how cultural, economic, and technological contexts shape the relationships between smartphone use, parenting, and mental health. Engaging with tech companies to design smartphone features that promote mindful use, such as more sophisticated screen time controls, nudges for physical activity, or AI-driven algorithms that detect and respond to addictive usage patterns, can also be beneficial.

Conclusion

The present study reveals a high prevalence of smartphone addiction among Indian adolescents and its significant associations with socio-demographic factors, parenting styles, and mental health. These findings call for a multi-pronged approach involving digital literacy programs, parenting interventions, mental health support, and policy measures to promote healthy smartphone use. Future longitudinal studies are needed to understand the causal pathways and long-term impacts of smartphone addiction on adolescent development. As smartphones become increasingly integral to adolescents' lives, balancing their benefits with mitigating their risks is crucial for fostering healthy, resilient future generations.

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Author contributions

YM contributed to the conceptualization, data curation, formal analysis, investigation, methodology, resources, supervision, validation, writing (original draft), and writing (review and editing). YM, HL, and DP contributed to conceptualization, data curation, formal analysis, investigation, writing (original draft), and writing (review and editing). YM, HL, and DP contributed to the methodology, resources, supervision, validation, and writing (review and editing). YM, HL, and DP contributed to the formal analysis, investigation, writing (original draft), and writing (review and editing). All the authors read and approved the final manuscript.

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Data availability
The datasets generated and/or analyzed during the current study are not publicly available to protect the privacy of the study participants but are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
Good clinical care guidelines were followed, and the guidelines were established as per the Helsinki Declaration 2008. All the participants were given clear instructions about the study before the start of the study. Written informed consent was obtained from the patients in their vernacular language for study participation, and no identifying information or images were included in the original article, which was submitted for publication in an online open-access publication. The entire methodology and protocol were approved by the Institutional Ethical Committee of Shri M P Shah Government Medical College, Jamnagar, Gujarat, India.

Ethics approval
Ethics approval was obtained from the Institutional Review Board of M.P. Shah Government Medical College, Jamnagar, Gujarat. [REF.No:110/02/2023].

Consent for publication
Not Applicable.

Competing interests
The authors declare no competing interests.

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