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BRIEF REPORT

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Associations between maternal smartphone use and mother-infant responsiveness: A cluster analysis of potential risk and protective factors

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Abstract

Contradictory results in the extant literature suggests that additional risk factors should be considered when exploring the impacts of maternal smartphone use on mother-infant relationships. This study used cluster analysis to explore whether certain risk factors were implicated in mother-infant dyads with high smartphone use and low mother-infant responsiveness. A cross-sectional survey of 450 participants in the UK measured infant social-emotional development, maternal depressive, anxiety and stress symptoms, wellbeing, social support, smartphone use, and mother-infant responsiveness. Participants were predominantly White (95.3%) and living with a partner (95.2%), with infants who were born full-term (88.9%). Cluster analysis identified three clusters characterized as; cluster (1) "infant at risk" showing high infant development concerns, high maternal smartphone use, and low mother-infant responsiveness; cluster (2) "mother at risk" showing high maternal depressive, anxiety, and stress scores, low social support, high maternal smartphone use, and low mother-infant responsiveness, and cluster (3) "low risk" showing low maternal smartphone use and high mother-infant responsiveness. Significant differences were found between all risk factors, except for maternal smartphone use and mother-infant responsiveness between clusters 1 and 2 suggesting that both clusters require early intervention, although interventions should be tailored towards the different risk factors they are presenting with.

KEYWORDS
dyadic responsiveness, mother-infant interactions, perinatal mental health, technoference

1 | INTRODUCTION

Smartphones have changed the way that we connect with the world, and while they have simplified many elements of our lives, they are also intrusive and habit-forming which could ultimately impact our most proximal relationships (Rotondi et al., 2017). It has been suggested that while parents use their smartphones to maintain a

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connection with their adolescent children, parents with younger children are more likely to use their device to disconnect from their offspring and connect with other adults through social media platforms (Kildare & Middlesmiss, 2017), particularly in instances where they find parenting to be isolating or frustrating (Radesky et al., 2016). This, however, is likely to create multiple instances of "technoference" within the caregiver-child relationship. Technoference is a concept which refers to the everyday interruptions that are experienced within interpersonal interactions due to the use of mobile technology devices (McDaniel, 2015; McDaniel & Coyne, 2016). In young children under 5 years old, mother-child technoference has been associated with parental perceptions of child internalizing and externalizing behaviors (McDaniel & Radesky, 2018a). Further work by Radesky et al. (2018) support these findings, suggesting that a mother's perceptions of her child are affected by maternal smartphone use during parenting domains such as mealtimes. However, to date, minimal research has yet been undertaken to explore the effects of technoference on caregiver-infant interactions (Braune-Krickau et al., 2021).

While the body of literature is currently still small, there is some evidence to suggest that maternal smartphone use can have a negative effect on mother-infant interactions, causing heightened negative affect in infants who appear to perceive their mother as non-responsive (Myruski et al., 2018; Stockdale et al., 2020), and increasing infant stress and physiological discomfort (Rozenblatt-Perkal et al., 2022; Tidemann & Melinder; 2022). Additionally, maternal smartphone use during feeding has been shown to cause a decrease in levels of responsiveness to interactive cues for both mother and infant (Ventura et al, 2019). Conversely, evidence has also been reported suggesting no adverse effects on the development of mother-infant interactions. Longitudinal studies of mother-infant dyads have reported data that suggests that maternal phone use while feeding is not associated with attachment or bonding issues over time and can instead provide a source of support for mothers to counteract the difficulties of caring for an infant (Coyne et al., 2021; Inoue et al., 2021).

Such sparse and contradictory data suggests that additional risk and protective factors must be considered when exploring the impact of caregiver smartphone use on mother-infant dyad interactions. Additionally, the risk factors for a suboptimal dyadic relationship are often the same risk factors present in the lives of those displaying problematic smartphone use behaviors. These risk factors include maternal depression and/or stress (Newsham et al., 2018; Uzundağ et al., 2022), perceived problems with infant temperament and development (Alvarez Gutierrez & Ventura, 2021), and access to appropriate social support in the face of isolation, which many mothers have reported when raising a small child (McDaniel, 2019; Radesky et al., 2016).

Consequently, the current study aimed to identify risk and protective factors associated with both problematic smartphone use and mother-infant responsiveness, and to investigate whether subgroups of mother-infant dyads can be identified via these factors using a cluster analysis. A cluster analysis approach was used as it places emphasis on a person-centered approach to data, potentially enabling identification of associations which may have been missed or omitted when only using linear regression modelling (von Eye & Bogat, 2006). Considering previous research on the development of mother-infant interactions, we hypothesized that (i) mothers with poorer mental health, and (ii) those that reported higher levels of infant social-emotional developmental concerns, would be more likely to use their phones more regularly in the presence of their child, and are more likely to demonstrate lower levels of responsiveness with their infant.

Key Findings

- Analysis identified three clusters of mother-infant dyads with significantly different risk and protective profiles.
- Clusters can be characterized as "infant at risk", "mother at risk", and "low risk".
- Early support for problematic smartphone use as well as risks to mother-infant interactions should be tailored accordingly.

STATEMENT OF RELEVANCE

This cluster analysis is the first to explore a number of risk factors identified as associated with both mother-infant responsiveness and problematic smartphone use. By accurately identifying and understanding the risk factors that influence both problematic smartphone use and mother-infant responsiveness, it may be possible to develop resources and support for at-risk mother-infant dyads. Tailoring early support intervention including education programs for mothers' and infants' individual needs is crucial to ensure that both mother and infant receives the psychological support they need in the first years of life.

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2 | METHODS

2.1 | Design

This cluster analysis was part of a larger study focused on the associations between maternal smartphone use, infant development, maternal mental health, and mother-infant interaction outcomes (Golds et al., under review). Ethical approval for the study was granted by the University of Edinburgh Clinical Psychology Ethics Committee. A cross-sectional survey design was employed. Due to social distancing precautions put in place during the COVID-19 pandemic, recruitment was limited to online recruitment methods, and so the survey was shared across social media platforms (i.e., Facebook and Twitter), as well as a research recruitment website (MQMentalHealth.org) to increase recruitment potential. All participants received detailed information regarding the survey and signed an informed consent form before taking part in the study. All responses were anonymous and stored in an encrypted data storage platform.

2.2 | Participants

Inclusion criteria for the study comprised mothers who were (i) older than 16 years old, (ii) lived in the UK, and (iii) had a baby aged between 3 and 9 months old. In total, 450 surveys were analyzed for the cluster analysis. The mean age of participating mothers was 32.49 (SD = 4.22, range = 19–42) years. The mean age of the participants' infants was 5.86 (SD = 1.69, range = 3–9) months. For full demographic data, see Table 1.

2.3 | Measures

2.3.1 | Demographic questionnaire

Demographic data were collected comprising maternal age, ethnicity, country of residence, level of education, employment status, whether the mother was on maternity leave, whether the mother lived with a partner, and if there were other children in the household.

2.3.2 | Maternal smartphone use

The Technology Interference with Parenting Scale (TIPS; McDaniel & Coyne, 2016) records situations in which caregiver smartphone use is likely to interfere with parenting. An adapted TIPS was introduced through a question stem reading, "There are often times when parents have to use their smartphone when spending time with their child. How likely are you to use your phone (e.g., to make calls, text, check email, check social media, watch a video)?" Participants can then report how likely they are to use their phone in different contexts and parenting domains (such as bedtime, mealtimes, bathtime, etc…) in the presence of their infant. Items are rated on a 5-point Likert scale ranging from 0 (Never) to 4 (Very Often). Higher scores indicate that mothers are using their smartphone more often in the presence of their infant. In the current sample, Cronbach's $\alpha = .78$.

2.3.3 | Infant social and emotional development

The Ages and Stages Questionnaire: Social-Emotional (ASQ:SE-2; Squires et al., 2015) 6 Month Questionnaire is a 23-item measure for use with infants aged 3–9 months. This self-report scale for parents measures the perceived social and emotional development of the infant. Items are rated on a 3-point Likert scale as 0 (Often or always), 5 (Sometimes), or 10 (Rarely or never), with reverse scoring attributed to some items. In areas where the parent feels particular concern, an additional five points can be added to the item. Questions are predominantly linked to social and emotional development, such as emotion regulation (e.g., is your baby able to calm herself down?) and social affect (e.g., does your baby stiffen and arch her back when picked up?). Additionally, within this age range, a number of questions are related to eating and sleeping concerns (e.g., does your baby have trouble sucking from a breast or bottle?; Does your baby have trouble falling asleep at nighttime?), which are associated with social-emotional development in this age range (Squires et al., 2015). Higher scores on the scale indicate that the mother perceives that her infant is experiencing more social emotional development issues. Due to the large number of developmental milestones typically achieved within this age range (Leach, 2017), stratification checks were conducted. An independent samples *t*-test suggested that there was a significant difference ($p < .001$) between the mean scores for infants aged 3–6 months and infants aged 6–9 months. However, the mean scores were 30 (SD = 19.6) and 24 (SD = 15.6), respectively, indicating that both age groups' mean scores were within the no/low risk cut off range in the ASQ. While some infants aged 3–6 months may have scored slightly higher on average, the mean scores suggest that this was predominantly within the normal range of behavior for the age group 3–9 months as specified by the ASQ-SE:2. In the current sample $\alpha = .69$, which has been deemed acceptable for exploratory research (Nunally & Bernstein, 1994).

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TABLE 1 Demographic information for all participants.

Maternal age (years)	***N***	**On maternity leave**	***N* (%)**
	299		**450**
(Mean)	32.49	Yes	376 (83.6)
(SD)	4.22	No	54 (12)
(Range)	19–42	NA	20 (4.4)
Ethnicity	***N* (%)**	**Household composition**	***N* (%)**
	450		**450**
African, Caribbean, or Black British	1 (.2)	Lone parent household	20 (4.4)
Asian or Asian British	9 (2)	Couple household	428 (95.2)
White	429 (95.3)	Other	2 (.4)
Mixed / multiple ethnicity	7 (1.6)		
Another ethnic group	4 (.9)	**Any other children**	***N* (%)**
			450
Country of residence	***N* (%)**	No	282 (62.7)
	448	Yes	168 (37.3)
England	290 (64.4)		
Scotland	124 (27.6)	**Infant age (months)**	***N* (%)**
Wales	18 (4)		**450**
Northern Ireland	16 (3.5)	(Mean)	5.86
		(SD)	1.69
Level of education	***N* (%)**	(Range)	3–9
	450		
Secondary school	16 (3.6)	**Infant sex**	***N* (%)**
College / Vocational	66 (14.6)		**450**
Undergraduate degree	177 (39.3)	Male	214 (47.6)
Postgraduate degree	179 (39.8)	Female	236 (52.4)
Other	12 (2.7)		
		Premature	***N* (%)**
Employment status	***N* (%)**		**450**
	447	No	400 (88.9)
Full-time employee	286 (63.5)	Yes	50 (11.1)
Part-time employee	82 (18.2)		
Self-employed	24 (5.3)	**Concerns eating/sleeping**	***N* (%)**
Student	5 (1.1)		**443**
Stay-at-home mother	47 (10.4)	No	370 (82.2)
Other	3 (.7)	Yes	73 (16.2)
		Concerns in general	***N* (%)**
			442
		No	378 (84)
		Yes	64 (14.2)

2.3.4 | Maternal mental health

The shortened version of the Depression, Anxiety, and Stress Scale has 21 items (DASS-21; Lovibond & Lovibond, 1995) and measures depressive symptoms, anxiety, and stress. The scale records which symptoms participants have been feeling over a timeframe of the last week and items are rated on a 4-point Likert scale ranging from 0 (Never) to 3 (Almost always). Higher scores on the depression, anxiety, and stress subscales indicate higher feelings

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of stress, anxiety, and/or depressive symptoms. For individual subscales, $\alpha = .87$ for depression, .76 for anxiety, and .84 for stress.

The WHO (Five) Well-Being Index (WHO-5; WHO, 1998) is a 5-item measuring feelings of wellbeing over a timeframe of the past 2 weeks. Items are rated on a 6-point Likert scale ranging from 0 (At no time) to 5 (All the time). A score is calculated by totaling the five answers. Scores range from 0 to 25, with 0 representing lowest feelings of well-being and 25 representing highest feelings of well-being. Within this sample population, $\alpha = .86$.

2.3.5 | Social support

The Interpersonal Support Evaluation List – shortened version 12 items (ISEL-12; Cohen et al., 1985) is a 12-item measure of perceived social support. Three subscales exist within the measure comprising "appraisal support" (i.e., feeling as though you have someone to talk to about your problems, and receiving constructive feedback), "belonging support" (feeling as though you have someone to spend time with), and "tangible support" (feeling as though you have someone who will help with material aid). Each subscale contains four items which are rated on a 4-point Likert scale ranging from 1 (Definitely False) to 4 (Definitely True) with reverse scoring attributed to some items. Higher scores on the scale indicate that participants perceive themselves to have higher levels of social support. For individual subscales, $\alpha = .80$ for appraisal, .81 for belonging, and .72 for tangible support.

2.3.6 | Mother-infant responsiveness

The Maternal Infant Responsiveness Instrument (MIRI; Amankwaa & Pickler, 2007) is a 22-item measure used to capture representations of the mother-infant relationship. The scale asks participants to reflect on the responsiveness within the dyadic relationship with a 5-point Likert scale ranging from 5 (Strongly agree) to 1 (Strongly disagree) with reverse scoring attributed to some items. Both the mother's and infant's responsiveness are measured through statements such as "I believe I know when my baby wants to play" and "I have seen my baby respond to my playing with him/her". Higher scores in this scale indicate that respondents feel the dyad is more responsive to one another. In the current sample, $\alpha = .84$.

2.4 | Data analysis

All data analysis was carried out in R 4.3.0 using packages "VIM" (Kowarik & Templ, 2016), "dplyr" (Wickham et al., 2023), "factoextra" (Kassambara & Mundt, 2020), "cluster" (Maechler et al., 2022), and "ggplot2" (Wickham, 2016). First, incomplete responses within the data were analyzed for data imputation options. All variables had missing data points with values ranging from 3.6% to 12.9% (See Table 3 for full details). A *t*-test of missingness reported similar means in present and missing cases for all variables. Little's Missing Completely at Random (MCAR) Test suggested that missing data were MCAR ($X^2 = 7370.778$, df = 8076, $p = 1.00$). K-nearest neighbor (kNN) imputation (k = 10) was selected as an appropriate method of data imputation for cluster analysis, as it has been demonstrated to outperform other forms of similar imputation methods (Jadhav et al., 2019). All variables were then standardized using a z-score transformation, and an analysis of descriptive statistics and correlation was performed. No collinearity was identified between measured variables and as such, all variables were entered into the statistical analysis.

Cluster analyses were used to identify patterns of association between the measured variables (i.e., mother-infant responsiveness, maternal smartphone use, infant social emotional development, maternal depressive symptoms, anxiety symptoms, stress symptoms, feelings of well-being, and perceived levels of social support including appraisal support, belonging support, and tangible support). First, hierarchical cluster analysis using Ward's method, including a visual inspection of the dendrogram and agglomeration coefficients, was used to identify the appropriate number of clusters. Additionally, it was ensured that each cluster contained more than 10% of the overall sample to reduce the likelihood of extremely small clusters (Hair et al., 2010). These methods indicated a three-cluster analysis would be appropriate for analysis. Second, K-means cluster analysis was used to identify similarity within clusters and dissimilarity between clusters (Balijepally et al., 2011). The stability of the cluster structure was confirmed by determining the agreement between the Ward's method and the K-means method using a cross-tabulation with Cramer's V test (Cramer's $V = .571$, $p < .001$), suggesting moderately stable cluster structures. Finally, analysis of variance (ANOVA) was performed to enable cluster profiling, followed by a post-hoc Tukey test to explore significant differences between clusters.

3 | RESULTS

The K-means cluster analysis identified three clusters of mother-infant dyads, based on the identified risk and protective factors. The profiles of the three clusters are represented by variable distribution in Figure 1 and final cluster centers (means) in Figure 2, and a summary of variable

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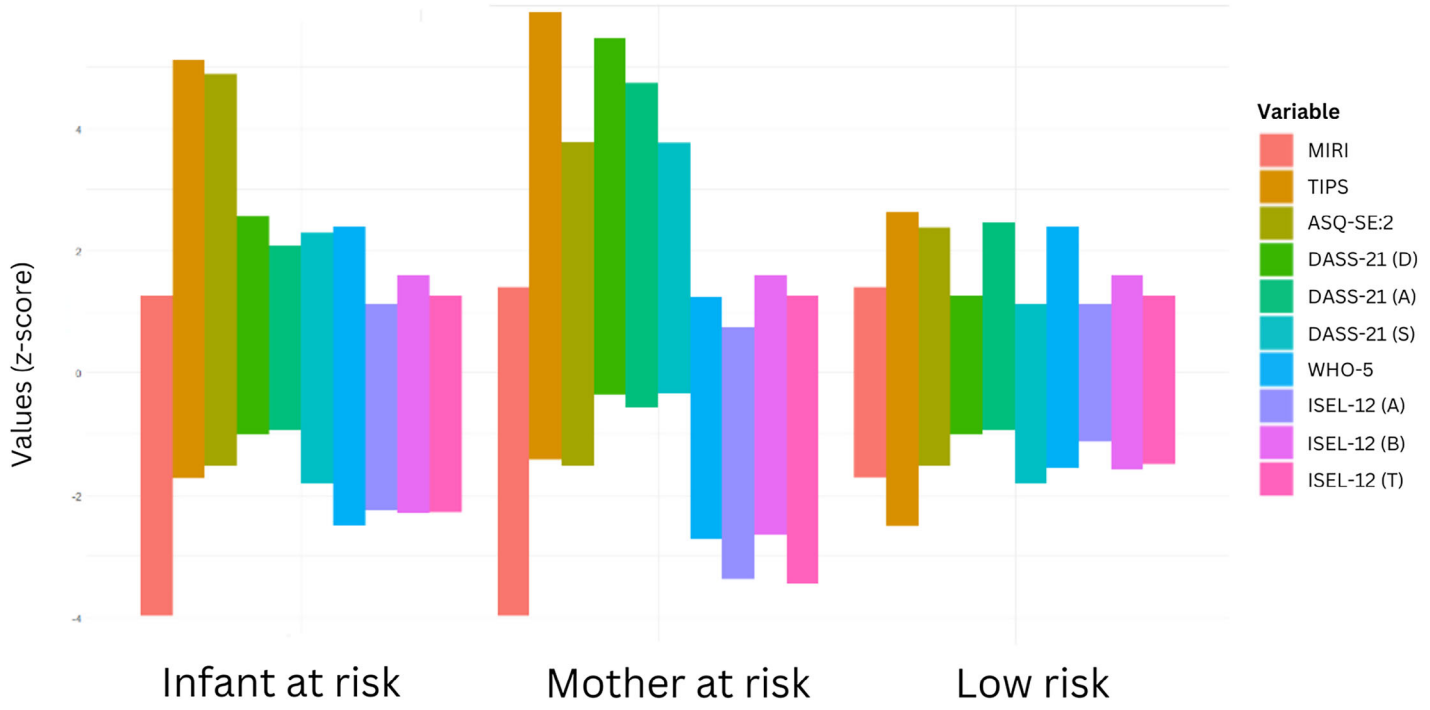

FIGURE 1 Variable distribution within cluster profiles. *Note*: ASQ-SE:2, Ages and Stages Questionnaire; DASS-21 (D), Depression, Anxiety and Stress Scale Depression subscale; DASS-21 (A), Depression, Anxiety and Stress Scale Anxiety subscale; DASS-21 (S), Depression, Anxiety and Stress Scale Stress subscale; ISEL-12 (A), Interpersonal Support Evaluation List Appraisal subscale; ISEL-12 (B), Interpersonal Support Evaluation List Belonging subscale; ISEL (T), Interpersonal Support Evaluation List Tangible subscale; MIRI, Mother-Infant Responsiveness Instrument; TIPS, Technology Interference with Parenting Scale; WHO-5, WHO (Five) Well-Being Index.

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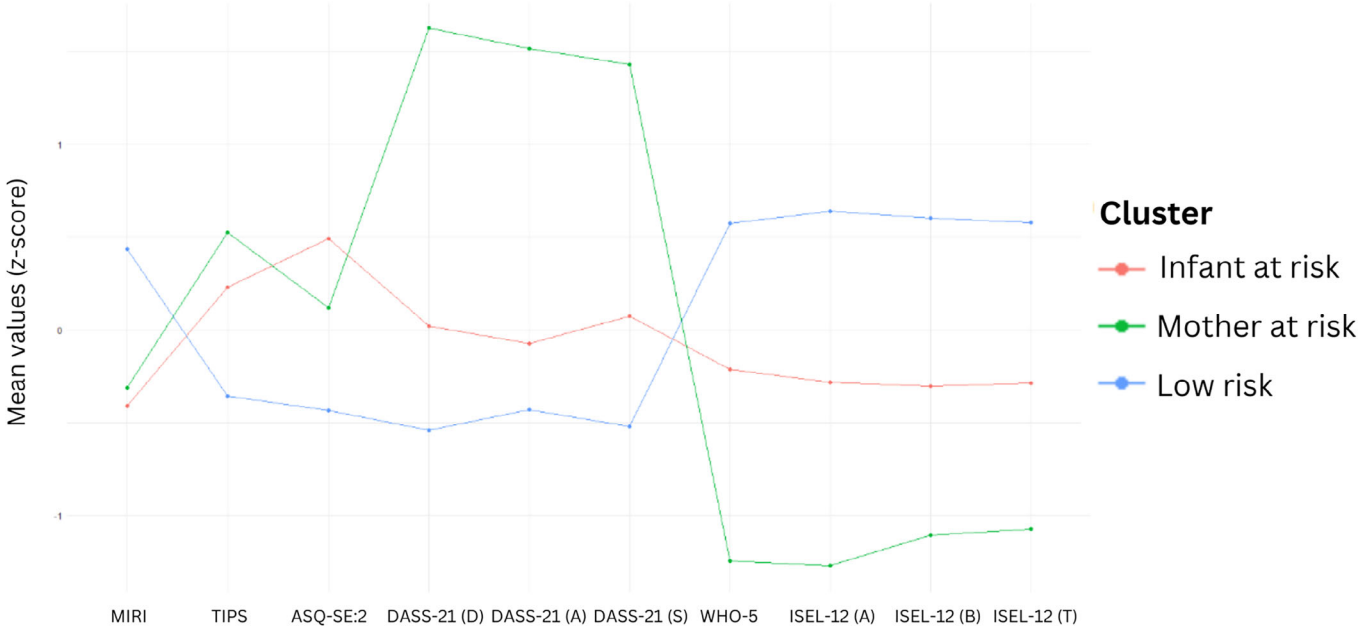

FIGURE 2 Final cluster centers (means with z-score transformation) across cluster profiles. *Note*: ASQ-SE:2, Ages and Stages Questionnaire; DASS-21 (D), Depression, Anxiety and Stress Scale Depression subscale; DASS-21 (A), Depression, Anxiety and Stress Scale Anxiety subscale; DASS-21 (S), Depression, Anxiety and Stress Scale Stress subscale; ISEL-12 (A), Interpersonal Support Evaluation List Appraisal subscale; ISEL-12 (B), Interpersonal Support Evaluation List Belonging subscale; ISEL (T), Interpersonal Support Evaluation List Tangible subscale; MIRI, Mother-Infant Responsiveness Instrument; TIPS, Technology Interference with Parenting Scale; WHO-5, WHO (Five) Well-Being Index.

TABLE 2 Summary of variable measures and cluster profile characteristics

	Variable measured	Cluster 1	Cluster 2	Cluster 3
MIRI	Mother-Infant responsiveness	Low[a]	Low	High
TIPS	Technology interference with parenting	High[c]	High	Low
ASQ-SE:2	Infant social-emotional development (3–9 months)	High	Medium	Low
DASS-21 (D)	Maternal depression	Medium[b]	High	Low
DASS-21 (A)	Maternal anxiety	Medium	High	Low
DASS-21 (S)	Maternal stress	Medium	High	Low
WHO-5	Maternal wellbeing	Medium	Low	High
ISEL-12 (A)	Social support (appraisal)	Medium	Low	High
ISEL-12 (B)	Social support (belonging)	Medium	Low	High
ISEL-12 (T)	Social support (tangible)	Medium	Low	High

Abbreviations: ASQ-SE:2, Ages and Stages Questionnaire; DASS-21 (D), Depression, Anxiety and Stress Scale Depression subscale; DASS-21 (A), Depression, Anxiety and Stress Scale Anxiety subscale; DASS-21 (S), Depression, Anxiety and Stress Scale Stress subscale; ISEL-12 (A), Interpersonal Support Evaluation List Appraisal subscale; ISEL-12 (B), Interpersonal Support Evaluation List Belonging subscale; ISEL (T), Interpersonal Support Evaluation List Tangible subscale; MIRI, Mother-Infant Responsiveness Instrument; TIPS, Technology Interference with Parenting Scale; WHO-5, WHO (Five) Well-Being Index.

[a]Low – mean (z score) $< -.3$

[b]Medium – mean (z score) $-.3 \leq$ Medium $\geq +.3$

[c]High – mean (z-score) $> +.3$

measures and cluster profile characteristics are reported in Table 2. A one-way ANOVA found no significant mean differences between the cluster groups in relation to any of the measured demographic characteristics.

Cluster 1 was characterized by high levels of maternal smartphone use in the presence of the infant, high scores for infant social and emotional developmental concerns, medium levels of maternal depressive, anxiety and stress scores, medium levels of wellbeing and perceived social support, and low mother-infant responsiveness. This cluster was labelled "infant at risk" ($N = 171$, 38% of the total sample).

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TABLE 3 Descriptive statistics, ANOVAs, and post-hoc tests for cluster profiles

		Cluster 1 ($N = 171$)	Cluster 2 ($N = 68$)	Cluster 3 ($N = 211$)		
	% missing data	Infant at risk	Mother at risk	Low risk		
		M (z-score)	*M (z-score)*	*M (z-score)*	*F*	*p*
MIRI	12.9	−.410[c]	−.311[c]	.433[ab]	44.71	<.001
TIPS	11.8	.321[c]	.526[c]	−.356[ab]	30.94	<.001
ASQ-SE:2	8.2	.491[bc]	.118[ac]	−.436[ab]	50.14	<.001
DASS-21 (D)	6.2	−.020[bc]	1.628[ac]	−.541[ab]	261.2	<.001
DASS-21 (A)	7.6	−.073[bc]	1.517[ac]	−.430[ab]	173.9	<.001
DASS-21 (S)	3.8	.075[bc]	1.429[ac]	−.522[ab]	175.2	<.001
WHO-5	3.6	−.214[bc]	−1.247[ac]	.575[ab]	154.2	<.001
ISEL-12 (A)	5.6	−.282[bc]	−1.270[ac]	.637[ab]	194.5	<.001
ISEL-12 (B)	5.1	−.300[bc]	−1.107[ac]	.603[ab]	143.9	<.001
ISEL-12 (T)	5.1	−.289[bc]	−1.072[ac]	.579[ab]	127.7	<.001

Abbreviations: ANOVA, Analysis of Variance; ASQ-SE:2, Ages and Stages Questionnaire; DASS-21 (D), Depression, Anxiety and Stress Scale Depression subscale; DASS-21 (A), Depression, Anxiety and Stress Scale Anxiety subscale; DASS-21 (S), Depression, Anxiety and Stress Scale Stress subscale; ISEL-12 (A), Interpersonal Support Evaluation List Appraisal subscale; ISEL-12 (B), Interpersonal Support Evaluation List Belonging subscale; ISEL (T), Interpersonal Support Evaluation List Tangible subscale; MIRI, Mother-Infant Responsiveness Instrument; TIPS, Technology Interference with Parenting Scale; WHO-5, WHO (Five) Well-Being Index.

[a]Statistically significant in comparison to Cluster 1.

[b]Statistically significant in comparison to Cluster 2.

[c]Statistically significant in comparison to Cluster 3.

Cluster 2 was characterized by high levels of maternal smartphone use in the presence of the infant, medium scores for infant social and emotional developmental concerns, high levels of maternal depressive, anxiety, and stress scores, low levels of wellbeing and perceived social support, and low mother-infant responsiveness. This cluster was labelled "mother at risk" ($N = 68$, 15.1% of the total sample).

Cluster 3 was characterized by low levels of maternal smartphone use in the presence of the infant, low scores for infant social and emotional developmental concerns, low levels of maternal depressive, anxiety, and stress scores, high levels of wellbeing and perceived social support and high mother-infant responsiveness. This cluster was labelled "low risk" ($N = 211$, 46.9% of the total sample).

ANOVAs on the clusters reported significant effects for all risk and protective factors measured. Post-hoc Tukey tests also showed that significance between clusters was evident for almost all variables except for mother-infant responsiveness and maternal smartphone use between clusters 1 and 2. Descriptive statistics for each cluster, ANOVAs, and post-hoc analyses are recorded in Table 3.

4 | DISCUSSION

To our knowledge, this was the first study aiming to determine whether reliable cluster profiles of risk and protective factors for problematic smartphone use and mother-infant responsiveness could be identified amongst mothers with infants aged between 3 and 9 months old. Analysis identified three distinct clusters with different risk and protective profiles.

Cluster 1 ("infant at risk") comprised 38% of the sample and was characterized by high levels of maternal smartphone use in the presence of their infant and low mother-infant responsiveness. This cluster displayed medium levels of depressive, stress, and anxiety symptoms, and correspondingly, medium levels of wellbeing and perceived social support. They did, however, report higher levels of infant social emotional development concerns (ergo, mothers perceived their infants to have suboptimal development). Alvarez Gutierrez and Ventura (2021) reported that maternal technology use was positively associated with perceived infant negative affectivity. It could be suggested that mothers who feel distressed about the relationship they have with their infant, due to perceived suboptimal infant development, may turn to their smartphone as a way to alleviate negative feelings, as research suggests that absorption in smartphone use is one way that mothers may attempt to find stress relief (McDaniel & Radesky, 2018a; Uzundağ et al., 2022). It is, however, difficult to ascertain directionality when studies have shown that maternal problematic phone use may influence increased perceived externalizing problems in children (McDaniel & Radesky, 2018b) yet at the same

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time, externalizing behaviors may lead to an increase in maternal smartphone use (McDaniel & Radesky, 2018a). This of course has the potential to create a cascading bidirectional effect in both maternal and infant affect and behavior. Due to the minimal research thus far undertaken with infants, these extant studies do pertain to toddlers and young children, however, it is arguable that parents of infants are likely to respond in a similar manner and therefore the results of such studies can be extrapolated to parents and infants under the age of 1-year-old.

It is also important to note that mothers within this cluster were characterized by medium levels of depressive symptoms. While these mothers were not demonstrating the highest level of risk for depression, an elevated symptomology may still influence these mothers' perceptions of their infants (Field et al., 1993; Lefkovics et al., 2018) potentially causing them to perceive the child as having more development issues. In addition to using their device to alleviate negative feelings, mothers who perceive their infants as having suboptimal social emotional development may use their smartphones more regularly for looking up answers to parenting questions (Baker & Yang, 2018). This may be one way in which mothers are trying to seek help around parenting challenges – by trying to understand whether there is an issue with their infant's development. It would, nonetheless, cause mothers to spend more time on their phones in the presence of their child.

Cluster 2 ("mother at risk") was the smallest cluster comprising 15.1% of the sample. Similar to cluster 1, these mothers were characterized by high levels of technoference and low mother-infant responsiveness. However, in contrast to cluster 1, these mothers reported significantly lower (i.e., medium) levels of infant development concerns, but high depressive, stress, and anxiety symptoms and correspondingly low levels of wellbeing and social support. Research suggests that maternal depression is positively associated with problematic phone use as well as higher levels of technoference (Newsham et al., 2018). It may be that mothers in this cluster are employing their smartphones to seek support from their friends and family. Coyne et al. (2021) suggested that using a smartphone to connect with others while carrying out caring responsibilities such as feeding could be a positive tool to prevent frustration and isolation. Baker and Yang (2018) also argue that social media platforms are a useful tool for mothers to receive the social support that they need to counteract the isolation of motherhood, particularly when raising younger children. However, smartphones are not only used for reaching out to others and are often used as an escape mechanism when caregivers need to self-regulate their own negative emotions (Uzundağ et al., 2022). Paradoxically, non-social uses of smartphones, such as entertainment consumption or playing games, are considered to be more passive forms of smartphone use and have been positively associated with higher levels of anxiety and depression, as well increased problematic smartphone use (Elhai et al., 2017).

When considering this cluster, it is also important to note the potential dyadic risk. While mothers within this cluster reported lower (i.e., medium) levels of infant social-emotional concerns, this may be due to the fact that the mother's withdrawal into the smartphone affects her sensitivity to the infant's cues. Maternal smartphone use during feeding has been shown to reduce a mother's responsiveness to her infant's satiety cues (Inoue et al., 2022; Ventura et al., 2019) and maternal sensitivity overall has been shown to be reduced when using a smartphone in the presence of a child (Beamish et al., 2019). This again suggests potential for bidirectional causation, in which mothers with higher depressive symptoms are using their smartphones more regularly in an attempt to regulate their negative affect, in turn unwittingly creating increasingly poorer mental health outcomes for both partners within the dyad.

Cluster 3 ("low risk") was the largest cluster accounting for 46.9% of the sample. Mother-infant responsiveness was high within these dyads. Mothers were characterized as reporting low levels of smartphone use, low levels of depressive, stress, and anxiety symptoms as well as high levels of wellbeing and social support. They also reported low levels of infant social emotional development concerns. It can be concluded that the mother-infant dyads within this cluster experience, in general, high levels of protective factors within their daily lives.

4.1 | Implications for early support

While it is encouraging to note that nearly 50% of the mothers who responded to this survey have high levels of mother-infant responsiveness with their infant, low scores for mental health issues, and high levels of social support, the cluster analysis suggests that many of the dyads within this community sample could benefit from early support interventions, albeit for different reasons. The results of the cluster analysis support and extend upon our initial hypothesis by demonstrating two groups of mother-infant dyads who may need early intervention support. In cluster 1, we can see that mothers may need support for the developmental issues which they perceive their infants to have, whereas in cluster 2, mothers may also need critical support for their own mental health pathways. However, while the root cause of these two clusters appears to be different, it is also important to consider the likely potential for bidirectional influences on both mother and infant,

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and we argue that whether it is the infant or mother who is seemingly at risk, this will inevitably cause risk to both partners within the dyad, creating a need for dyadic support, early education, and potentially clinical intervention for some families. For many mothers, in-person support is often difficult to access, and smartphones may provide a simple method to gain support through virtual platforms (Archer & Kao, 2018). Research suggests that social media, which is often accessed through smartphone use for support, has both benefits and drawbacks for mothers of young children. Smartphone use provides social support, whilst at the same time often causing feelings of guilt around smartphone use in the presence of infants, and in some cases potentially increasing feelings of anxiety and depression (Archer & Kao, 2018; Elhai et al., 2017). In order to prevent problematic smartphone use habits, early education and support would be advised, and this could take the form of education support throughout the perinatal period related to smartphone use in the presence of infants and children (e.g., McCaleb, 2020). For this reason, it may be critical to design education programs that are readily available and at a whole population level, potentially through devices such as a smartphone, but with features that allow mothers to still be present with their infant.

4.2 | Limitations

We acknowledge that this study relies on cross-sectional (as well as self-report) data, limiting inferences of causality or directionality regarding the included variables. A longitudinal study would be preferential to further reinforce the validity of the cluster profiles. Self-report data are highly subject to bias, particularly when considering concepts such as personal smartphone use (Andrews et al., 2015); however, it has been suggested that asking people about their general smartphone use will return moderately reliable data (Andrews et al., 2015). Secondly, the current sample composition is almost entirely White (95.3%) women who are living with a partner, and as such the experience of these mothers is not necessarily generalizable to mothers of other ethnicities, or to lone parent households. The homogeneity of the sample may be due, in part, to online recruitment methods which have created a sample that is highly self-selected. Self-selection biases have been observed in psychological studies (e.g., Kaźmierczak et al., 2023) suggesting that participants have an intrinsic motivation to take part in the studies they have chosen, and as such, the results of this analysis should be considered with care in terms of their generalizability to the population as a whole. Thirdly, and crucially, this study was undertaken during the COVID-19 pandemic, at a time where many people were relying solely on technology to access social support and often as the primary method of seeing friends and family (David & Roberts, 2021). We would therefore suggest that further studies are undertaken to see if this had a direct impact on the psychological profiles of mothers at that time, and how this may change longitudinally after social distancing measures were lifted.

4.3 | Implications for future research

As discussed, the COVID-19 pandemic created a necessity for online recruitment for this study. This is turn creates a self-selection of participants. It would be useful, therefore, to further this work by recruiting mothers from a wider demographic, and to consider using population-wide recruitment methods designed to generate a sample that is more representative of the intended population. Due to the high levels of social mobility that can be observed in the modern world, it may also be pertinent to explore whether the participants, while all based in the UK, are native to the country or had migrated. This may shed light on cultural differences in a more salient way than looking at ethnicity only. Additionally, the age range of the infants in the study is relatively large, with infants in this age range typically reaching multiple developmental milestones (Leach, 2017). Future research may be improved by recruiting dyads within a smaller age range, for example, 3–6 months or 6–9 months. Due to the nature of cross-sectional surveys, some of the implications that have been drawn out within this discussion are inferential, as there are likely missing risk variables which could have been measured within the sample. While the cluster analysis here infers that mothers may be using their smartphones for differential reasons, for example, escape versus support seeking, it is difficult to make that assertion without measuring variables such as resilience or coping skills. Future work in this area could therefore concentrate on maternal coping strategies to understand if this is a driving factor for maternal smartphone use. Further, while mental health outcomes such as depression, anxiety, and stress are salient features to measure in this population, it may also be useful to consider societal expectations, such as mental load, emotional burden, and cognitive labor, which mothers often assume as part of their caring responsibilities (Delaney et al., 2023). Such additional pressures may have a direct association with maternal mental health outcomes and should therefore be highlighted as an important risk factor at the population level. Another construct that mothers report high levels of is loneliness, which while not a mental health outcome per se, can contribute directly to depression, anxiety, and stress (e.g., Luoma et al., 2019; Nowland et al., 2021), and could therefore be explored in terms of elevated problematic smartphone use. In terms of

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measuring smartphone use in an effective manner, asking participants to record the type of apps that they are engaging with each day would make it easier to measure whether mothers are using their phones for passive consumption or social support seeking behaviors, as this could potentially make a difference to the mental health outcomes of the smartphone user. Further, using quantitative methods of measurement can only provide a small part of the picture, and it would be advisable to also engage new mothers in more qualitative discussion about why and how they are using their smartphones, as this information could be crucial in terms of delivering effective early intervention.

5 | CONCLUSION

In conclusion, this study has demonstrated distinct clusters of mothers in regard to smartphone use while parenting, dyadic risk factors, and mother-infant responsiveness. While a number of the mothers in the sample were reporting high levels of technoference, it is only when using the cluster analysis that some of the differential risk and protective factors for this behavior become more apparent. Escape versus support seeking behaviors are coping strategies which many new mothers will employ while raising their infants (Radesky et al., 2016), and in knowing why these strategies are employed at different times, and for what reasons, may be useful in designing effective support interventions for mothers. Infant development and maternal mental health pathways are both risk factors to the dyad and so it is necessary to determine which forms of support are best offered to mothers, early and effectively (Choi et al., 2020; Hazell Raine et al., 2019). While there are a number of additional variables that would be useful to include in this research, this study suggests that clustering of risk and protective factors in new mothers is a useful method of understanding the needs of the mother-infant dyad in terms of early education, intervention, and support.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DATA AVAILABILITY STATEMENT

This research was not pre-registered. The data used in the research cannot be publicly shared but are available upon request. The data can be obtained via email.

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