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Influence of maternal and infant technology use and other family factors on infant development

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Abstract

Background Digital technology is ubiquitous in the lives of many children and parents. To better understand any influence of technology use by infants, and mothers, on child development, technology use should be considered within the broader family system context in which children develop. This study aimed to investigate associations between infant and maternal technology use and infant 12-month development, taking into consideration other family factors.

Methods This cross-sectional study used data from ORIGINS participants, collected at 12-months of age: maternal and child technology use (TechU-Q), sociodemographic factors (e.g. child sex, household income), parental mental health (DASS-21), and child development (Ages and Stages Questionnaire). Linear regression was used for analyses.

Results When family factors were considered, higher infant mobile touchscreen device (MTSD) use was associated with poorer infant development for gross motor, problem-solving, and total ASQ-3 scores. In contrast there were no associations between infant television (TV) watching or maternal technology use and total ASQ-3 scores. Higher maternal technology use was associated with higher infant technology use. Poorer maternal and paternal mental health were associated with poorer infant development. Poorer maternal mental health was also associated with higher infant TV watching and higher maternal MTSD use.

Conclusion There is a complex relationship between technology use, parental mental health and other family factors that together influence infant development. To improve infant development outcomes, less focus should be on infant or maternal technology use, and more on supporting the family as a whole, and parental mental health in particular.

Keywords Infant, Child development, Digital technology, ORIGINS

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Background

Digital technologies are now ubiquitous in the lives of many children and parents, with homes in the USA having on average five internet-connected devices (e.g., computer, smartphone, tablet, television (TV), etc.) [1]. Australian data from 2017 showed that 75% of children under the age of 6 years use mobile touchscreen devices (MTSD) regularly, and over a third of pre-schoolers owned their own MTSD [2]. The rise of MTSD use has enabled more young children to access the internet [3], with a third of pre-schoolers in the United Kingdom going online, and an even higher percentages in other countries such as in Sweden (70%) and Netherlands (78%) [4]. Mothers are also reported to be very active technology users, for example averaging 6.1 h per day on smartphones alone in the USA [5]. Growing up in this digital technology environment has been reported to influence infant development [6–8].

Increases in child screen time have been associated with poorer child development in pre-school aged children [6], including lower scores in communication, problem-solving, and personal-social domains [7, 9], and weaker language skills [10]. However, there is limited research on children under 3 years of age [11]. Further, the evidence on associations between maternal and child screen use and child development is complicated, with inconsistent findings across studies, and inconsistent reported effects for different technologies and on different aspects of development. For example, greater tablet use was negatively associated with preschool children's fine motor development in one study [12], but positively in another [13]. A recent systematic review reported that the use of digital technology by children aged 7 years or younger was negatively associated or unrelated to motor development but positively associated with receptive language and executive function, with increased use of digital technology associated with better receptive language and executive function [11]. Contemporary devices, such as MTSD, have not only increased potential for exposure but appear to have different influences on children's health and development [9, 11]. Children are reported to begin regularly engaging with these devices at a younger age, shifting from preschool to infancy in the USA [14]. Overall, there is very limited published research on the impact of digital technology use, particularly contemporary devices, on infant development [11, 15]. It is important to consider infant development, as early development can track into later development, and behaviour patterns can start at a young age [16–18].

One potential reason for the inconsistent current evidence is that the contextual factors (including maternal technology use and a range of family factors such as parental mental health and sociodemographic factors) that may influence the relationship between digital technology use and child development have not been adequately considered [11]. Increased maternal screen time has been associated with poorer development in children 2 years and older including poorer self-regulation, lower executive functioning and higher behavioural problems [19], as well as weaker language skills [10]. Maternal digital technology use may thus also influence development in infancy, potentially through an impact on the interactions between family members [20, 21]. Other family factors previously shown to be associated with child development include parental mental health and sociodemographic factors. Poorer parental mental health has been related to poorer child development in infancy [22]. Maternal depression in particular has been associated with lower levels of language development, conduct and depressive symptoms and disorders, delay and disruption to social and emotional competence, sleeping problems, and poorer physical health [23]. Like maternal technology use, maternal mental health may influence development through disturbances in the parent/child relationships [23]. Other family factors such as parental education, family socioeconomic status, and ethnicity have been found to be associated with infant development [24, 25], with lower maternal education, and lower socioeconomic status associated with poorer infant development [24]. Overall, there is scant evidence on whether maternal technology use is associated with infant development, nor on how digital technology use is related to other elements within a family system.

To better understand any influence of technology use by infants and mothers on infant development, technology use should be considered within the broader family system context in which a child develops. Figure 1 illustrates how the contextual factors in the family system may be linked to infant development in various ways.

Therefore, the primary aim of this study was to investigate the associations between maternal and infant digital technology use and infant development at 12 months (aim 1). Secondary aims included: to investigate the associations between family factors and infant development at 12 months (aim 2), to investigate the associations between maternal technology use and infant technology use at 12 months (aim 3); and to investigate the associations between maternal mental health and maternal and infant technology use at 12 months (aim 4).

Methods

Study design and population

This study is a sub-project of ORIGINS. This unique long-term study, a collaboration between The Kids Research Institute Australia and Joondalup Health Campus, is one of the most comprehensive studies of pregnant women and their families in Australia to date. ORIGINS recruited 3,708 families from the Joondalup

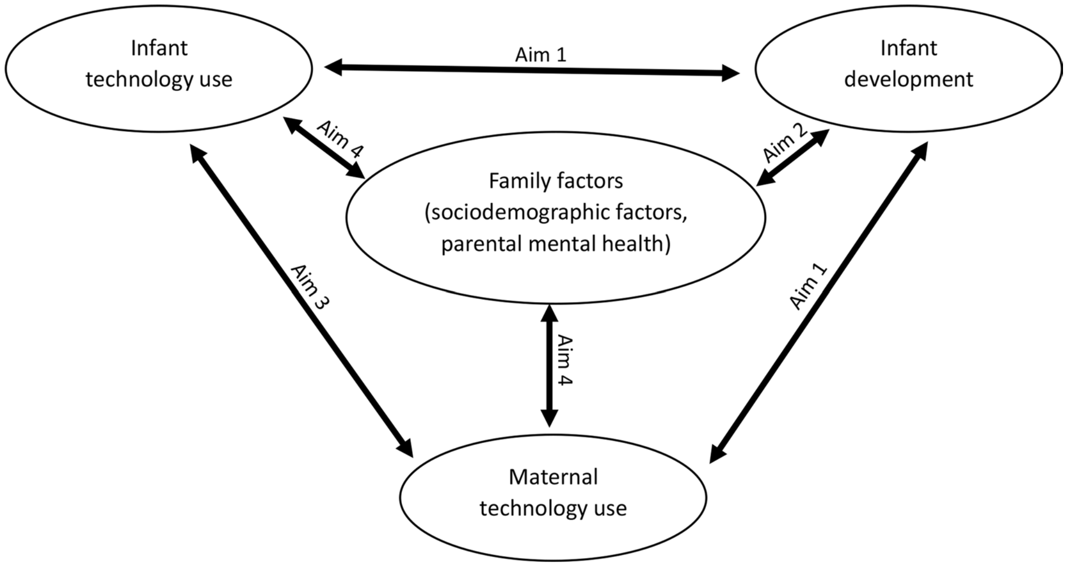

Fig. 1 Potential relationships between infant and maternal technology use, family factors, and infant development

and Wanneroo communities of Western Australia between 2017 and 2023 [26]. This cross-sectional analysis examined the associations between infant and maternal technology use and 12-month infant development data from ORIGINS, taking into consideration other family factors. Participation was voluntary, with informed consent, and ethical approval and oversight governed by REGGS HREC (2017/ETH/1728) and Curtin Human Research Ethics Committee (HRE2018-0064).

Infant and maternal technology use (12-month assessment)

The Technology Use Questionnaire (TechU-Q) was completed by the mother when the infant was 12 months of age via online questionnaire. The TechU-Q has been found to be a reliable and valid tool for measuring both young children's and parents' technology use [27]. The TechU-Q includes questions on the frequency and duration of weekday and weekend electronic device use including mobile phone and tablet use (MTSD), and TV. The mother completed the questionnaire for their own use, which was followed by asking if the infant was allowed to use the device. If the mother reported the infant was allowed to use the device, the same questions on frequency and duration of weekday and weekend electronic device use were asked for the infant use. We calculated the average minutes per day of use of MTSD and TV (7-day daily average in minutes) at 12 months of age for infants and mothers.

Infant development (12-months assessment)

The 12-month Ages and Stages Questionnaire, version 3 (ASQ-3) was completed by the mother when the infant was 12 months of age via online questionnaire [28]. The ASQ-3 is an accurate, cost-effective, and parent-friendly instrument for screening and monitoring of young children [29–33] with high concurrent validity [28]. The ASQ-3 contains 30 questions across 5 domains: communication, gross motor, fine motor, problem-solving, and personal-social. Scoring of each question is based on whether a child can complete an item (if not yet =0, sometimes=5 and yes=10), providing a score of 0–60 for each domain. We calculated mean (standard deviation (SD)) of each domain and a total overall score (0-300), with higher scores indicating more positive outcomes.

Family factors

We considered potential covariates based on previous literature investigating factors associated with infant development [22–25]. Some sociodemographic factors were collected antenatally (parental education, number of children in the household, postcode of residence, and ethnicity) with the others collected at 12 months. The potential covariates included: infant's sex, infant's height and weight, maternal age, maternal body mass index, number of children in the household, parental mental health, parental education, family socioeconomic status, and ethnicity. Except for infant's height and weight, which were collected by the ORIGINS Project team at a clinical visit, all other factors were collected via online questionnaire, completed by the mother.

Parental mental health was assessed using the Depression, Anxiety and Stress Scale 21 (DASS-21) [34, 35] with an overall symptom score (out of 126) and depression, anxiety and stress subscale scores (out of 42). Parental education was assessed as the highest level of education that the mother and father completed (high school or less, trade/apprenticeship, or university degree). Parental employment status included categories of full time (work, student or volunteer), part time (work, student or volunteer), and home duties/unemployed. Household income was assessed as combined household income over the last 12 months (up to $25,000, $25,001 to $50,000, $50001 to $75000, $75001 to $100000, $100001 to $150000, and more than $150000 a year). Family socioeconomic status was assessed on the residence postcode-based Index of Relative Socio-economic Advantage and Disadvantage (IRSAD) [36], collapsed into quintiles for this analysis with higher quintiles representing more relative socioeconomic advantage. Parental ethnicity was categorised on the Australian Standard Classification of Cultural and Ethnic Groups and reported as Oceanian, European and Other.

Statistical analysis

Descriptive statistics were reported as mean (standard deviation, SD) for continuous variables, and as counts and percentages for categorical variables. The 7-day daily average of use of MTSD and TV, in minutes per day, for the infant and mother were used. The ASQ-3 domains (0–60) and total scores (0-300) were calculated according to the standard scoring guide [28] and used in the analysis. Infant sex was coded as male or female. Infant age (in months), infant weight (kg), infant height (cm), and maternal body mass index (kg/m^2) were continuous variables collected when the infant attended the 12-month clinical assessment. Parental mental health (DASS-21) included continuous separate variables for depression, anxiety and stress subscale scores, as well as total score within the univariate analysis, but only continuous total DASS-21 scores (maternal and paternal) were included within the multivariable analysis due to collinearity between the DASS-21 subscale scores. Parental education was coded as high school or less, trade/apprenticeship, and university degree. Parental employment status was coded as full time (work, student or volunteer), part time (work, student or volunteer), and home duties/unemployed. Parental ethnicity was coded as Oceanian, European and other. The number of children in the household was dichotomised into 0 (i.e. first child) and 1 or more children. Household income was coded as up to $25,000, $25,001 to $50,000, $50,001 to $75,000, $75,001 to $100,000, $100,001 to $150,000, and more than $150,000 a year. The Index of Relative Socio-economic Advantage and Disadvantage (IRSAD), based on the household postcode, was collapsed into quintiles for this analysis with higher quintiles representing greater relative socio-economic advantage.

All analyses were completed using data of participants that had completed maternal and infant technology use and infant development measures ($n=466$) (based on the primary aim). For the primary aim, we investigated the association between infant and maternal digital technology use and infant development at 12 months by using univariate and multivariable linear regression. For the secondary aims, we also individually investigated the association between family factors (e.g., sociodemographic and parental mental health) and infant development at 12 months, the association between maternal technology use and infant technology use at 12 months, and the association between maternal mental health and maternal and infant technology use at 12 months by using univariate linear regression. For each multivariable linear regression model, model assumptions were checked including: linearity, homoskedasticity, independence of errors, normality, and independence of independent variables. For the multivariable analyses the mean variance inflation factor (VIF) was 1.33 with a VIF for each variable no greater than 1.6. The covariates that were found to be significantly associated with the total ASQ-3 score in the univariate analyses (infant sex, maternal ethnicity, paternal education, and maternal and paternal DASS-21 total scores), were introduced into the multivariable linear regression model. For both univariable and multivariable linear regression, results are reported as standardised coefficients, and parametric bootstrap sampling (with 1000 reps) was used to obtain the 95% confidence intervals. Data were analysed using Stata/BE version 17. Statistical significance was set at a p-value of <0.05.

Results

Participants

By March 2023, 1157 ORIGINS participants had completed the 12-month assessment. Of these, 466 participants had completed the 12-month ASQ-3 and maternal and infant TechU-Q and were included in the reported analyses. Infants were aged from 11 to 14 months and almost equal numbers of both sexes. Over half of the infants had mothers who completed a university degree. Most mothers were either working part time or had home duties, and most fathers were working full time. A smaller proportion of mothers with a university degree reported being unemployed or on home duties (29.8%) compared to mothers with other education levels (high school or less (53.5%), or trade/apprenticeship (52.8%). Over half the infants were the first child in the household. Most of the cohort were from more advantaged socioeconomic backgrounds and had a European or Oceanian ethnicity. Participant characteristics are presented in Supplementary Table S1.

Just under half the infants were allowed to watch TV (51.5%), but only 14.7% and 9.1% were allowed to use tablets and mobile phones, respectively. Table 1 describes infant and maternal digital technology use and infant development.

Table 1 Infant and maternal digital technology use and infant development

	Mean (SD)	Range (min, max)
Digital technology use (TechU-Q, average daily use in minutes)		
Infant MTSD	4.64 (15.87)	0, 150
Infant TV	33.37 (56.85)	0, 411.43
Maternal MTSD	167.46 (114.06)	0, 720
Maternal TV	145.82 (100.05)	0, 720
Infant development (ASQ-3)		
Communication	48.13 (11.36)	0, 60
Gross motor	41.78 (16.83)	0, 60
Fine motor	53.17 (7.71)	15, 60
Problem solving	47.54 (11.45)	0, 60
Personal social	44.37 (11.58)	10, 60
Total	234.89 (11.58)	85, 300

ASQ-3: Ages and Stages Questionnaire, version 3; MTSD: Mobile touchscreen device; TechU-Q: Technology Use Questionnaire; TV: television. $n = 466$

Aim 1: associations between infant and maternal technology use and infant development

When considering the association between infant technology use and infant development univariately, higher infant MTSD use was associated with poorer infant development for gross motor, fine motor, and personal social domains, as well as total ASQ-3 scores. However, in contrast to MTSD use, there was no association between infant TV watching and infant development (Supplementary Table S2).

When considering family factors in the analysis between infant technology use and infant development in the multivariable analysis, higher infant MTSD use was associated with poorer infant development for gross motor, problem-solving, and total ASQ-3 scores. Based on the standardised coefficients, a 16-minute increase in infant MTSD use (1 SD) was associated with a decrease of 5 out of 300 points (0.40 SD) in the total ASQ-3 score. Similarly to the univariate analysis, no association between infant TV watching and total ASQ-3 score was found in the multivariable analysis (Table 2).

When considering the association between maternal technology use and infant development univariately, higher maternal MTSD use was associated with poorer infant development for the fine motor domain. There was no association between maternal TV watching and infant development (Supplementary Table S2).

When considering family factors in the analysis between maternal technology use and infant development in the multivariable analysis maternal MTSD use was no longer associated with infant development. Maternal TV watching was associated with poorer infant development in the problem solving domain (Table 2).

Aim 2: associations between family factors and infant development

When considering the association between family factors and infant development univariately, some family factors were associated with infant development (Supplementary Table S3). Infant male sex was associated with poorer infant development for total ASQ-3 scores. Higher maternal age was associated with poorer infant development for gross motor and problem solving domains, but not total ASQ-3 score. Poorer maternal mental health (higher DASS-21 stress, anxiety, depression, and total scores) was associated with poorer infant development in all domains except gross motor. Worse paternal mental health (higher DASS-21 stress, anxiety, depression, and/or total scores) was associated with poorer infant development in all domains except gross motor. Paternal high school or less education (compared to trade or apprenticeship), and maternal European ethnicity (compared to Oceanian ethnicity) were associated with poorer infant development for total ASQ-3 scores.

When the association between family factors and infant development was investigated in the multivariable analysis only infant male sex, and maternal and paternal mental healthremained significantly associated with at least one domain of the ASQ-3. Infant male sex was associated with lower communication and personal social domain scores. Higher maternal DASS-21 total score was associated with lower fine motor and problem-solving, and total ASQ-3 scores. Worse paternal mental health (DASS-21 total score) was associated with lower communication and personal-social domains, and total ASQ-3 scores (Table 2). Based on the standardised coefficients, a 17 out of 126 points increase in maternal total DASS-21 score (1 SD) was associated with a decrease of 2 out of 300 points (0.21 SD) in the total ASQ-3 score, and a 15 out of 126 points increase in paternal total DASS-21 score (1 SD) was associated with a decrease of 2 out of 300 points (0.18 SD) in the total ASQ-3 score.

Aim 3: association between maternal and infant technology use

Higher maternal MTSD use and TV watching were associated with higher infant MTSD use and TV watching (Table 3). Based on the standardised coefficients, a 114-minute increase in maternal MTSD use (1 SD) was associated with an increase of 2.5-minutes (0.16 SD) in infant MTSD use, and a 100-minute increase in maternal TV watching (1 SD) was associated with an increase of 17-minutes (0.30 SD) in infant TV use.

Aim 4: association between maternal mental health and maternal and infant technology use

Higher maternal anxiety and depression subscale scores at 12 months were associated with higher infant MTSD

Table 2 Associations between infant and maternal technology use and family factors with infant development

	Infant development (ASQ-3, standardised coefficient (95% CI))					
	ASQ-3 Communication	ASQ-3 Gross Motor	ASQ-3 Fine Motor	ASQ-3 Problem Solving	ASQ-3 Personal social	ASQ-3 Total
Infant and maternal technology use (TechU-Q, average daily use in minutes)						
Infant MTSD	-0.21 (-0.51, 0.10) $p=0.181$	**-0.35 (-0.63, -0.07)** $p=0.015$	-0.20 (-0.54, 0.13) $p=0.232$	**-0.42 (-0.77, -0.06)** $p=0.022$	-0.17 (-0.44, 0.10) $p=0.223$	**-0.40 (-0.76, -0.04)** $p=0.031$
Infant TV	-0.02 (-0.21, 0.17) $p=0.803$	0.13 (-0.08, 0.35) $p=0.221$	-0.07 (-0.22, 0.08) $p=0.347$	**0.16 (0.02, 0.30)** $p=0.026$	-0.09 (-0.26, 0.09) $p=0.319$	0.05 (-0.14, 0.24) $p=0.591$
Maternal MTSD	0.01 (-0.31, 0.05) $p=0.895$	0.00 (-0.20, 0.20) $p=0.999$	-0.05 (-0.23, 0.13) $p=0.583$	-0.04 (-0.19, 0.11) $p=0.607$	0.03 (-0.15, 0.22) $p=0.731$	-0.01 (-0.20, 0.18) $p=0.931$
Maternal TV	-0.13 (-0.31, 0.05) $p=0.156$	-0.05 (-0.21, 0.11) $p=0.558$	-0.12 (-0.27, 0.03) $p=0.118$	**-0.16 (-0.33, -0.00)** $p=0.045$	-0.16 (-0.33, 0.00) $p=0.050$	-0.17 (-0.34, 0.00) $p=0.051$
Other family factors						
Infant sex: Female (Male (reference))	**0.37 (0.08, 0.66)** $p=0.013$	0.24 (-0.04, 0.52) $p=0.095$	0.05 (-0.16, 0.26) $p=0.624$	0.09 (-0.17, 0.36) $p=0.489$	**0.37 (0.08, 0.67)** $p=0.014$	0.33 (0.07, 0.60) $p=0.014$
Maternal Ethnicity (Oceanian (reference))						
European	-0.11 (-0.44, 0.22) $p=0.519$	-0.01 (-0.38, 0.41) $p=0.944$	-0.13 (-0.42, 0.17) $p=0.406$	-0.12 (-0.43, 0.19) $p=0.456$	-0.29 (-0.65, 0.06) $p=0.102$	-0.16 (-0.55, 0.22) $p=0.406$
Other	-0.10 (-0.63, 0.43) $p=0.704$	0.28 (-0.19, 0.75) $p=0.245$	-0.22 (-0.65, 0.21) $p=0.322$	-0.11 (-0.56, 0.34) $p=0.626$	-0.32 (-0.82, 0.18) $p=0.206$	-0.08 (-0.59, 0.43) $p=0.753$
Paternal education (High school or less (reference))						
Trade/Apprenticeship	0.08 (-0.27, 0.43) $p=0.655$	0.14 (-0.20, 0.49) $p=0.421$	0.23 (-0.08, 0.53) $p=0.144$	0.21 (-0.11, 0.53) $p=0.200$	-0.20 (-0.56, 0.15) $p=0.265$	0.13 (-0.21, 0.47) $p=0.465$
University degree	0.06 (-0.28, 0.40) $p=0.748$	-0.15 (-0.52, 0.22) $p=0.421$	0.21 (-0.11, 0.53) $p=0.197$	0.29 (-0.04, 0.63) $p=0.085$	0.15 (-0.16, 0.47) $p=0.265$	0.12 (-0.21, 0.45) $p=0.325$
Maternal DASS-21 total score	-0.05 (-0.26, 0.15) $p=0.600$	-0.10 (-0.28, 0.08) $p=0.294$	**-0.26 (-0.43, -0.10)** $p=0.002$	**-0.21 (-0.38, -0.03)** $p=0.020$	-0.15 (-0.33, 0.03) $p=0.096$	**-0.21 (-0.40, -0.01)** $p=0.035$
Paternal DASS-21 total score	**-0.22 (-0.42, 0.02)** $p=0.031$	-0.05 (-0.16, 0.06) $p=0.340$	-0.12 (-0.24, 0.00) $p=0.056$	-0.13 (-0.27, 0.01) $p=0.062$	**-0.14 (-0.26, -0.02)** $p=0.017$	**-0.18 (-0.30, -0.05)** $p=0.004$

Multivariable linear regression analysis adjusted for sociodemographic and other family factors based if there were statistically associated with infant development (total ASQ-3 score) in the univariate analysis. ASQ-3: Ages and Stages Questionnaire, version 3; DASS-21: Depression, Anxiety and Stress Scales; MTSD: Mobile touchscreen device; TechU-Q: Technology Use Questionnaire; TV: television. Bolded values indicate statistically significant result with $p<0.05$. $n=215$

Table 3 Association between maternal and infant technology use

Technology use (TechU-Q, average daily use in minutes)	Standardised coefficient (95% CI)	
	Maternal MTSD	Maternal TV
Infant MTSD	**0.16 (0.33, 0.29)** $p=0.014$	**0.14 (0.01, 0.27)** $p=0.043$
Infant TV	**0.15 (0.06, 0.23)** $p=0.001$	**0.30 (0.22, 0.39)** $p<0.001$

Univariate linear regression analysis. MTSD: Mobile touchscreen device; TechU-Q: Technology Use Questionnaire; TV: television. Bolded values indicate statistically significant result with $p<0.05$. $n=466$

use, but there were no associations found between maternal stress scale and total DASS-21 scores and infant MTSD use. Poorer maternal mental health (higher stress, anxiety, depression, and total DASS-21 scores) at 12 months was associated with higher infant TV watching (Table 4).

Poorer maternal mental health (higher anxiety, depression, and total DASS-21 scores) at 12 months was associated with higher maternal MTSD use but not TV watching (Table 4).

Discussion

Overall, when investigated in isolation, there were associations between technology use and infant development, with higher infant MTSD use and higher maternal MTSD use associated with poorer infant development. However, when family factors were considered in the analysis, only infant MTSD use remained associated with infant development. (Aim 1). When considering the family factors, poorer maternal and paternal mental health were associated with poorer infant development (Aim 2). Higher maternal technology use was associated with higher

Table 4 Association between maternal mental health and maternal and infant technology use

	Maternal mental health (DASS-21, standardised coefficient (95% CI))			
	DASS-21 stress	**DASS-21 anxiety**	**DASS-21 depression**	**DASS-21 total**
Technology use (TechU-Q, average daily use in minutes)				
Infant MTSD	0.08 (-0.01, 0.17) $p=0.075$	**0.02 (0.01, 0.04)** $p=0.033$	**0.13 (0.01, 0.26)** $p=0.040$	0.11 (-0.00, 0.23) $p=0.057$
Infant TV	**0.10 (0.02, 0.18)** $p=0.010$	**0.02 (0.01, 0.04)** $p=0.003$	**0.15 (0.05, 0.24)** $p=0.001$	**0.12 (0.04, 0.19)** $p=0.002$
Maternal MTSD	0.07 (-0.00, 0.15) $p=0.060$	**0.03 (0.01, 0.05)** $p=0.017$	**0.11 (0.01, 0.20)** $p=0.022$	**0.11 (0.02, 0.20)** $p=0.013$
Maternal TV	0.01 (-0.07, 0.10) $p=0.788$	0.01 (-0.01, 0.04) $p=0.207$	0.05 (-0.03, 0.14) $p=0.195$	0.05 (-0.06, 0.17) $p=0.380$

Univariate linear regression analysis. MTSD: Mobile touchscreen device; TV: television. Bolded values indicate statistically significant result with $p<0.05$. $n=466$

infant technology use (Aim 3). Finally, poorer maternal mental health was associated with higher infant TV watching and higher maternal MTSD use (Aim 4). Figure 2 shows a summary of the findings. Overall, technology use appears to be part of the family system in which many behaviours and factors are interrelated.

Digital technology use and infant development

Interestingly, in this study a small infant daily exposure to MTSD (5 min) was related to poorer infant development, while substantially higher TV daily exposure (33 min) was not. Much of the previous literature has either focused on TV watching or considered screen time as a whole [6, 7, 9, 10], yet the results from this analysis highlight the importance of considering different devices separately when investigating the relationship between technology use and infant development. Given only a small proportion of children were using MTSD, and even then, with a small daily exposure, it may be that the content or context of use could be influencing infant development, or that MTSD use could be a marker of other elements in the family that are actually influencing infant development. Based on the multivariable regression model, an increase of 16 min in daily infant MTSD use would be associated with a decrease of 5 out of 300 points in the total ASQ-3 score suggesting that a substantial increase in MTSD use would be required to have small potential impact on infant development. It is unclear if this difference is clinically meaningful, particularly in a non-clinical population, but it could be trivial.

In this study at infancy, although an association between higher maternal MTSD use and poorer infant development was found in univariate analysis, this relationship was no longer significant when considering other family factors in multivariable analysis. This finding is contrary to previous studies of pre-school aged children, which found that increases in maternal screen time were associated with poorer development, including poorer self-regulation, lower executive functioning, higher behavioural problems [19], as well as weaker language skills [10], even after considering a range of family factors such as children's age, sex, race/ethnicity, maternal education level, and birth order within the analysis [10, 19]. That maternal screen use has been related to development of children aged 2 years and older [10, 19]

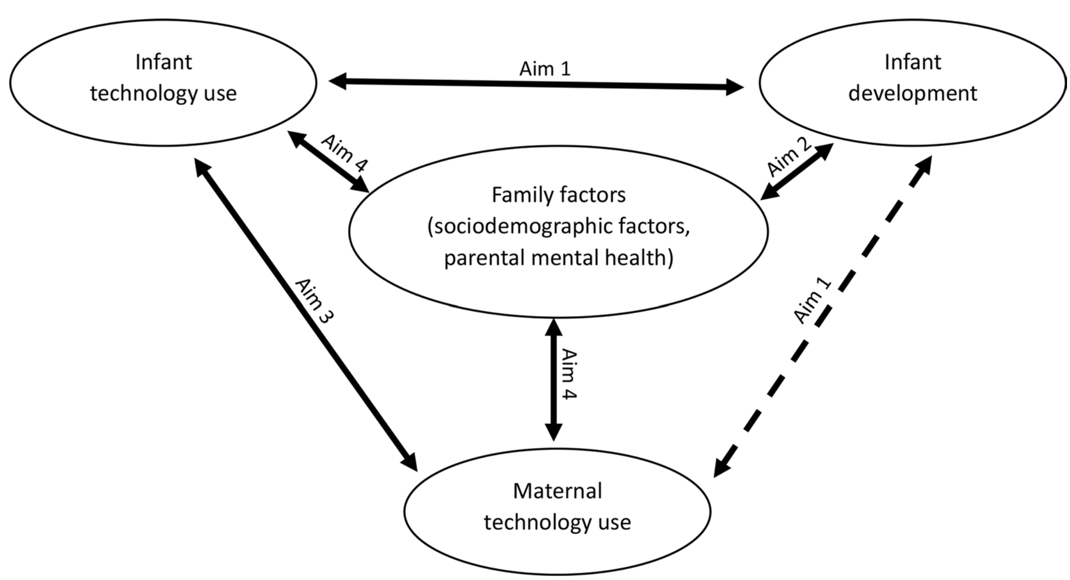

Fig. 2 Relationships between infant and maternal technology use, family factors, and infant development. (Solid lines represent associations found between variables, dashed line represented association found in univariate analysis but not in multivariable analysis)

but was not observed in the current study of 12-month old children may suggest the impact of technology use takes time to have an observable effect on development.

Overall, the association between infant and maternal technology use and infant development is likely complex, with prior evidence showing that not all screen use negatively influences child development. High quality screen time (e.g. interactive media use) with parental participation has been associated with favourable child development outcomes amongst children aged 2 to 3.5 years [37]. Similarly, passive screen use (e.g., TV watching) has been associated with worse developmental outcomes in older children whereas interactive screen use (e.g., video games) has been associated with better educational outcomes [38]. Based on a systematic review of 42 studies including children aged 12 years or younger ($n=18{,}905$), greater quantity of screen use was associated with lower child language skills, however better quality screen use (such as educational programs and co-viewing) was associated with higher child language skills [39].

Family factors and infant development

The finding that poorer maternal mental health was associated with poorer infant development in this study is consistent with previous literature [22, 23]. This study provided the additional contribution that it is important to consider family factors when investigating associations between infant and maternal technology use and infant development. However, it is worth noting that family factors are likely not just environmental, but other factors such as genetics could also be important. For example, a previous study found that genetic confounding plays a significant role in the association between child screen time and psychiatric problems in children aged 9 to 11 years [40].

Digital technology use as part of the family system

Separately, infant and maternal technology use and family factors can be associated with infant development, but it is important to consider how these factors could be co-related in the family system. Poorer maternal mental health was associated with higher infant TV watching and higher maternal MTSD use. Further, higher maternal technology use was associated with higher infant technology use. Thus, infant technology use, maternal technology use and parental mental health are interconnected and together associated with infant development. All three factors could influence infant development through a web of mechanisms including impacts on interactions and relationships between family members [20, 21, 23, 41], differences in co-viewing and monitoring of technology use by children, and differences in the quality of technology use [41]. Overall, technology use is likely part of the family system in which many behaviours and factors are interrelated (Fig. 2). This relationship between technology use, family factors and child development may also change and develop as the child grows. For example, parental mental health may be most important during infancy but technology use may be more important in later life stages.

Strengths and limitations

Strengths of this study include the focus on infancy where there was a paucity of evidence as well as with a comprehensive approach considering both the infant and maternal technology use, along with many different family factors. This study also considered both TV watching and MTSD use separately, which highlighted the difference in associations with different types of devices. Limitations include that the analysis was cross-sectional and can only determine association rather than directional or causal evidence. Although the number of variables considered and univariate analyses completed could impact the power of the study, parametric bootstrap was used to ensure robust estimates. Given the data used in this study were collected between 2017 and 2023, the potential influence of the COVID-19 pandemic on the participants technology use is unclear. Technology use was measured using participant self- and proxy- (for the infants) report. Although parent report of technology use is likely to have both random (e.g. recall bias) and systematic errors (e.g. desirability bias) [42, 43], the questionnaire used has been shown to be valid and reliable tool, and to our knowledge, there is no objective measurement system that is suited to large scale cohort studies of families with young children, such as the ORIGINS Project. The technology use measure did not capture co-use of electronic devices, which is likely important for infants. This study also did not consider father's screen time and the context and content of screen use was unknown. A recent umbrella review has found that when considering more nuanced components of screen use (content, context or device), there was a complex picture, with meta-analyses of associations between screen use and outcomes showing overall small-to-moderate effects, with mixed results [44]. Further, the generalisability is limited by being a cohort of Western Australians with mainly socio-economically advantaged families.

Future research direction and clinical significance

This study attempted to view digital technology use as a part of the family system in a cross-sectional analysis, but this could be part of a life course, therefore it would be important to consider the role of technology within the family system prior to birth and after 12 months with longitudinal studies. When considering technology use in future research it would be important to consider device specific use, particularly MTSD use, instead of just

TV or total screen use. To improve infant development outcomes, less focus should be placed on child or maternal technology use, and more on supporting the family as a whole, and maternal and paternal mental health in particular.

Conclusion

Digital technology is ubiquitous in the lives of many children. Its increased use by younger children and multiple family members is reforming and reshaping the developmental environments of our youngest children as well as their siblings, parents, carers, and wider social networks. This study highlights that there appears to be a complex relationship between technology use, parental mental health and other family factors that together influence infant development. Considering how parents and children use digital technology within the family system context could provide better information to support targeted guidance for families and professionals caring for children around technology use and address this community concern.

Abbreviations

ASQ-3	12-month Ages and Stages Questionnaire, version 3
DASS-21	Depression, Anxiety and Stress Scale 21
MTSD	Mobile touchscreen devices
SD	Standard deviation
TechU-Q	Technology Use Questionnaire
TV	Television

Supplementary Information

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Supplementary Material 1

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Author contributions

AMB, LMS, DS, JZ conceived the study, and participated in the design of the study. All authors contributed to the analysis and interpretation of data, drafting and revising of the manuscript, and have approved the final version to be published.

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Data availability

The data that support the findings of this study are available from ORIGINS, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available upon reasonable request and with permission of ORIGINS Management Group and Scientific Committee.

Declarations

Ethics approval and consent to participate

Participation was voluntary, with informed consent, with ethical approval and oversight governed by REGGS HREC (2017/ETH/1728) and Curtin Human Research Ethics Committee (HRE2018-0064).

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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