Association between mobile phone use in young children and caregiver-rated health

Noriko Kojimahara, Mariko Matsushita and Yasuto Sato

1 Research Support Center, Shizuoka General Hospital, Shizuoka, Japan
2 Department of Public Health, Tokyo Women’s Medical University, Tokyo, Japan
E-mail: nkojimah@outlook.jp

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Abstract
The association between mobile phone or tablet use and children’s health remains unclear. The main aim of this study was to examine whether caregiver-rated health and children’s mental disorders were related to their mobile phone use. We conducted a multistage sampling Internet survey of 1535 caregivers living with children aged 0–14 years in Japan. Using this cross-sectional data, multiple regression models were used to test for relationships among factors related to mobile phone use, caregiver-rated child health, and mental disorders. Total mobile phone use time was related to age, number of siblings, availability of Wi-Fi at home, and the child’s ownership of a mobile phone. Age and availability of Wi-Fi at home were positively related to tablet use, but neither the number of siblings nor the child’s ownership of a tablet were related to tablet use. In addition, we examined that tablet use (Odds ratio 0.62, 95% CI 0.39–1.00) and Wi-Fi use (Odds ratio 0.66, 95% CI 0.47–0.93) were related to low caregiver-rated child health among preschool students. It was newly pointed out that tablet and Wi-Fi use were related to low caregiver-rated child health among preschool students. As young children are likely to be exposed to internet for the purpose of babysitting, this study suggested that parents should be aware of mental influence for tablets and Wi-Fi use.

1. Introduction
Along with the popularization of smartphones and tablets, the use of information and communication technology (ICT) by children worldwide has increased dramatically. According to the World Telecommunication/ICT Indicators 2019–2020 [1], the highest mobile phone subscriber rate per 100 people was 178 in Kuwait, following to 164 in Lithuania, and 139 in Japan in 2018. In fact, rapid increase of communication terminals, such as smartphones, tablets, personal computers, and game consoles usage have been concerned, particularly among children in Japan [2]. Results from the Cabinet Office of Japan’s (CAO) [3] 2017 young children’s Internet environment survey showed that 39.2% of children under age nine had used the Internet within the last year, including 3.1% of children younger than one year old.

Several studies reported that mobile phone use addiction was related to adolescent depression [4], insomnia [5], and brain tumors [6, 7]. Revisions of the current International Commission on Non-ionizing Radiation Protection (ICNIRP) guidelines [8] for radiofrequencies in the range of 100 kHz–300 GHz published in 2020; however, Belyaev et al [9] and Hardel et al [10] suggested that exposure below the thermal threshold might be possible to be linked to worse health. The purposes of this study were to clarify Japanese young children’s use of communication terminals, such as mobile phones and tablets, especially in light of the increasing availability of Wi-Fi, and to assess whether children’s Internet use was associated with caregiver-rated child’s health and mental health disorders.

2. Materials and methods
This study was approved by the ethics committee of Tokyo Women’s Medical University on April 19, 2018 (approval number: 4761). We obtained informed consent from all participants via the Internet. Employing an
existing panel provided by a Japanese Internet research company, we conducted a one-week, multistage sampling Internet survey in March 2017. Using this nationwide commercial panel, consisting of approximately 1.2 million persons, women who lived with children were screened. A total of 1545 female caregivers living with their children age 0–14 years were selected from the Tokyo metropolitan area, which were approximately 32 million of the total population in 2017. Samples extracted using two-stage stratified random sampling, were asked 50-item structured questionnaire for caregivers developed to explore mobile phone or tablet use and children’s health.

The participants responded to an internet questionnaire regarding their oldest child. The items asked about age, gender, family structure, caregiver-rated children’s health and neurological symptoms, and the children’s use of mobile phones, tablets Wi-Fi. The questionnaire items were applicable to any of the target ages, 0 to 14, so the same questionnaire was used with all caregiver participants, regardless of their child’s age. Regularly using a mobile phone or a tablet was defined as using it at least once a week for three months. Socioeconomic status (SES) was defined by the caregivers’ education level: high school or less, technical school or college, and university or higher. Caregiver-rated health was assessed by the question ‘In general, would you say your child’s health is: Excellent, very good, good, poor, or very poor?’ based on the SF-36 questionnaire on general health [12]. Lorem et al. was reported that self-reported health which was widely used as an epidemiological instrument given the changes in public health since the 1980s, was associated with mortality [13]. Responses to this item were re-coded into a dichotomous measure, ‘High’ (Excellent and very good) and ‘Low’ (good, poor, and very poor). Mental disorders as medical history was also taken, to gather information on whether the child had been diagnosed with epilepsy, attention-deficit hyperactivity disorder (ADHD), depression, bipolar disorder, schizophrenia, anxiety neurosis, adjustment disorder, developmental disorder, sleep disorder, or other mental disorders.

Continuous variables were tested for statistical significance using the t-test and categorical variables were tested for statistical significance using the chi-squared test, with the significance level set at $p < 0.05$. Logistic regression models were run to calculate the odds ratios (ORs) and 95% confidence intervals (CIs) for regular use of mobile phones and tablets using IBM SPSS Statistics version 23 (IBM Corp., Armonk, NY, USA).

3. Results

Out of 1545, ten caregivers were excluded because one or more of their responses were either missing or inappropriate, leaving 1535 caregivers and their children in the analysis, as shown in figure 1. Among the female caregivers, 99.7% responded mothers ranging in age from 19 to 59 years (table 1). Table 2 shows the children’s characteristics and their communication device use. The children were divided into three groups: preschool students aged 0–5 years, including children cared for at home ($n = 703$), elementary school students ($n = 597$), and junior high school students ($n = 235$). The mean age and SD were $3.0 \pm 1.9$ years for the preschool students, $9.3 \pm 1.7$ years for the elementary school students, and $13.5 \pm 0.6$ years for the junior high school students. In all groups, the ratio of males to females was approximately equal, although approximately half was unknown in gender. Regarding siblings, 62.4% of preschool students, 34.3% of elementary school students, and 28.9% of junior high school students were reported as an only one child. A household income of 4 to 8 million yen was the most common ($41.9\%$ to $47.3\%$) in all three age groups, 15.1% of preschool students, 46.2% of elementary school students, and 71.9% of junior high school students regularly used mobile phones, while 12.9%, 30.3%, and 38.7% of the children regularly used tablets, respectively. The rates of regular use of mobile phones increased more steeply with age than the regular use of tablets. The regular use of mobile phones or tablets among the preschool students was to access the Internet, $52.8\%$ and $69.2\%$, respectively, followed by downloading videos or music, $38.7\%$ and $47.3\%$, respectively. Use of both mobile phones and tablets increased with age, although this finding was not significant.

Table 3 illustrated that among the preschool and the elementary school students, the duration of regular use and the age of starting regular use of mobile phones and tablets were similar. However, for the junior high school students, the regular use of tablets duration was approximately one year shorter than that of mobile phones, and the age of starting the regular use of tablets was approximately one year older than that of mobile phones. The current starting age for regular use of mobile phones or tablets in the preschool and elementary groups has decreased compared to the starting age for the junior high school group. The most common purpose for mobile phones or tablets among the preschool students was to access the Internet, $52.8\%$ and $69.2\%$, respectively, followed by downloading videos or music, $38.7\%$ and $47.3\%$, respectively. Use of both mobile phones and tablets increased with age, although this finding was not significant.

For children in all age groups, low caregiver-rated child health was significantly associated with regular use of mobile phones (OR 0.78, 95% CI 0.62–0.99), tablets (OR 0.76, 95% CI 0.59–0.98) and Wi-Fi (OR 0.66, 95% CI 0.52–0.83) (table 4). When divided into the preschool, elementary school, and junior high school groups, low caregiver-rated child health was associated with regular tablet use (OR 0.62, 95% CI 0.39–1.00) and Wi-Fi use (OR 0.66, 95% CI 0.47–0.93) only in the preschool students. According to the point estimates in the logistic
regression analysis, low caregiver-rated child health was not related to Internet use among junior high school students. In addition, the percentage who had diagnosed mental disorders was slightly higher in children who regularly used mobile phones, tablets, or Wi-Fi compared to non-regular users, but this association was not significant. Although each age category included small numbers of children with diagnosed mental disorders, no significant associations were observed between mental health disorders and regular mobile phone, tablet, or Wi-Fi use.

4. Discussion

Our results suggested that current mobile phone and tablet use among children was associated with low caregiver-rated child health in Japanese preschool students. Since gender was answered only half of responders in our study, we did not present results of adjustment for gender and SES. After adjusted for these, the association between low caregiver-rated child health and regular use of mobile phones and tablets did not change much (data not shown).

This study is the first large-scale study in Japan which examined the association internet environment of children in detail with the semiquantitative healthy measurements. the Internet and
Regular use of codeless phone

| Children | Preschool students | Elementary school students | Junior high school students | p values |
|---|---|---|---|---|
| Age (years), mean±SD | 3.0 ± 1.9 | 9.3 ± 1.7 | 13.5 ± 0.6 | - |
| Gender | | | | |
| Male | 139 (19.7) | 145 (24.3) | 79 (33.6) | 0.301 |
| Female | 132 (18.8) | 158 (26.5) | 63 (26.8) | - |
| Unknown | 432 (61.5) | 294 (49.2) | 93 (39.6) | - |
| No. of siblings | | | | |
| None | 439 (62.4) | 205 (34.3) | 68 (28.9) | 0.000 |
| One | 230 (32.7) | 291 (48.7) | 134 (57.0) | - |
| Two or more | 34 (4.8) | 101 (16.9) | 33 (14.0) | - |
| Regular use of mobile phones | 106 (15.1) | 276 (46.2) | 169 (71.9) | 0.000 |
| Regular use of tablets | 91 (12.9) | 181 (30.3) | 91 (38.7) | 0.000 |
| Regular use of Wi-Fi | 272 (38.7) | 367 (61.5) | 191 (81.3) | 0.000 |
| At home | 264 (97.1) | 360 (98.1) | 186 (97.4) | 0.000 |
| At school | 39 (14.3) | 61 (16.6) | 22 (11.5) | 0.008 |
| Other | 26 (9.6) | 51 (13.9) | 36 (18.8) | 0.000 |
| Regular use of codeless phone | 15 (2.1) | 45 (7.5) | 27 (11.5) | 0.000 |

**Caregiver-rated health for children**

| Health status | Preschool students | Elementary school students | Junior high school students |
|---|---|---|---|
| Excellent | 275 (39.1) | 174 (29.2) | 61 (26.1) |
| Very good | 245 (36.1) | 268 (43.5) | 77 (32.9) |
| Good | 164 (23.3) | 151 (25.3) | 87 (37.2) |
| Poor | 7 (1.1) | 10 (1.7) | 8 (3.4) |
| Very poor | 3 (0.4) | 3 (0.5) | 1 (0.4) |
| Medical history | | | |
| Mental disorders | 12 (1.7) | 18 (3.0) | 17 (7.2) |

**SD, standard deviation**

* Total number may exceed the sample size, when multiple answers allowed in the question.

size using an internet panel was the strength of the study, we have some limitations. First, self-reported health is widely adopted epidemiological studies validity to measure health-related Quality of Life, however rated by caregiver might include non-differential error, such as caregivers’ values. Notably, it is difficult to gather directly young children’s health status in this setting where preschool students aged 0 to 5, started regular mobile phone use at age 2.4 ± 1.4 years, and regular tablet use at age 2.9 ± 1.5 years. Second, the high proportion of missing data for child’s gender and the low percentage of older child caregivers among the participants might have introduced bias.

Internet device use appears to be starting at younger ages in Japan, which may result in health issues, particularly mental health disorders, surfacing when cumulative use reaches a threshold in adolescence or early adulthood. Since use of the Internet both at home and in schools is now widespread, the Ministry of Education of Israel has restricted Internet use by children in educational environments [13]. Parents should be aware of the growing concern about the possible negative influences of radiofrequency from mobile devices on cognitive development, language acquisition, vision [14], physical ability [15], and family communication [16]. In studies of socioeconomic determinants of health [17, 18]. Moreover, low socioeconomic status has also been shown to negatively affect health [19, 20]. The effects of regular Internet use on general health have not been well documented, and possible cognitive health issues related to regular Internet use have received little attention; therefore, no clear conclusions have been reported regarding caregiver-rated child health.

Our results suggest that regular tablet use might be related to worse health among children. Parents of children age six or younger should be aware of our results, because nearly 20% of the preschool students in the present study used the Internet for seven hours or more per week. Because Internet use at home was also associated with regular tablet use among younger children, it may be important for parents to mediate Internet
## Table 3. Status of mobile phone and tablet use among child regular users by age groups.

|                      | Preschool n (%) | Elementary school n (%) | Junior high school n (%) |
|----------------------|-----------------|-------------------------|--------------------------|
|                      | Mobile phone n | Tablet n | Mobile phone n | Tablet n | Mobile phone n | Tablet n |
| Duration of regular use (years)* | 1.5 ± 0.8 | 1.5 ± 0.7 | 2.5 ± 1.4 | 2.4 ± 1.5 | 3.1 ± 2.1 | 2.1 ± 1.1 |
| Starting age of use (years)* | 2.4 ± 1.4 | 2.9 ± 1.5 | 7.4 ± 2.0 | 7.2 ± 2.4 | 10.6 ± 2.1 | 11.5 ± 1.7 |
| Currently used model | Kids’ phone | 11 (10.4) | 167 (60.5) | — | 39 (23.1) | — |
|                      | Smartphone | 85 (80.2) | 83 (30.1) | — | 100 (59.2) | — |
|                      | Feature phone or other | 10 (9.4) | 26 (9.4) | — | 30 (17.8) | — |
| Purpose of use | Phone call | 25 (23.6) | 7 (7.7) | 226 (81.9) | 28 (15.3) | 141 (83.4) | 10 (11.0) |
|                      | E-mail, including text message | 5 (4.7) | 2 (2.2) | 148 (53.6) | 21 (11.6) | 124 (73.4) | 19 (20.9) |
|                      | Internet, including gaming | 56 (52.8) | 63 (69.2) | 70 (25.4) | 148 (81.8) | 90 (53.3) | 77 (84.6) |
|                      | Download videos or music | 41 (38.7) | 43 (47.3) | 28 (10.1) | 66 (36.5) | 59 (34.9) | 38 (41.8) |
|                      | Camera | 34 (31.2) | 13 (14.3) | 52 (18.8) | 44 (24.3) | 69 (40.8) | 20 (22.0) |
| Ownership | Child’s own | 12 (11.3) | 12 (13.2) | 216 (78.3) | 49 (27.1) | 139 (84.1) | 32 (35.2) |
|                      | Shared with father | 32 (30.2) | 43 (47.3) | 17 (6.2) | 63 (34.8) | 2 (1.2) | 14 (15.4) |
|                      | Shared with mother | 70 (66.0) | 41 (45.1) | 34 (12.3) | 64 (35.4) | 4 (2.4) | 27 (29.7) |
| Duration of Internet use per week | 0 (hours) | 20 (18.9) | 12 (13.2) | 99 (35.9) | 14 (7.7) | 25 (14.8) | 13 (14.3) |
|                      | 1 to 7 | 82 (77.4) | 61 (67.0) | 158 (57.2) | 138 (76.2) | 109 (64.5) | 60 (65.9) |
|                      | 7 or more | 4 (3.8) | 18 (19.8) | 19 (6.9) | 29 (16.0) | 35 (20.7) | 18 (19.8) |

* mean ± SD, SD, standard deviation; SNS, social networking service
**Continuous variables were tested for statistical significance using the t-test and categorical variables were tested for statistical significance using the Chi-square test.

## Table 4. Odds rates for caregivers-rated health and mental disorders stratified by age groups.

|                      | Caregiver rated health | Mental disorders |
|----------------------|------------------------|------------------|
|                      | Low, n (%) | High, n (%) | OR(95%CI) | Low, n (%) | High, n (%) | OR(95%CI) |
| All                  |           |             |         |           |             |         |
| Regular mobile phone use NO | 260 (26.4) | 724 (73.6) | 1 | 954 (97.0) | 30 (3.0) | 1 |
| 1                    | 173 (31.4) | 378 (68.6) | 0.78 (0.62–0.99)* | 534 (96.9) | 17 (3.1) | 1.01 (0.55–1.85) |
| Regular tablet use NO | 311 (26.5) | 861 (73.5) | 1 | 1141 (97.4) | 31 (2.6) | 1 |
| 1                    | 118 (32.5) | 245 (67.5) | 0.76 (0.59–0.98)* | 347 (95.8) | 16 (4.4) | 1.70 (0.92–3.14) |
| Regular Wi-Fi use NO | 167 (23.7) | 538 (76.3) | 1 | 687 (97.4) | 18 (2.6) | 1 |
| 1                    | 266 (32.0) | 564 (68.0) | 0.66 (0.52–0.83)* | 801 (96.5) | 29 (3.5) | 1.38 (0.76–2.51) |
| Preschool            |           |             |         |           |             |         |
| Regular mobile phone use NO | 143 (24.0) | 454 (76.0) | 1 | 587 (98.3) | 10 (1.7) | 1 |
| 1                    | 30 (28.3) | 76 (71.7) | 0.80 (0.50–1.27) | 104 (98.1) | 2 (1.9) | 1.13 (0.24–5.23) |
| Regular tablet use NO | 143 (23.4) | 469 (76.6) | 1 | 602 (98.4) | 10 (1.6) | 1 |
| 1                    | 30 (33.0) | 61 (67.0) | 0.62 (0.39–1.00)* | 89 (97.8) | 2 (2.2) | 1.35 (0.29–6.28) |
| Regular Wi-Fi use NO | 93 (21.6) | 338 (78.4) | 1 | 424 (98.4) | 7 (1.6) | 1 |
| 1                    | 80 (29.4) | 192 (70.6) | 0.66 (0.47–0.93)* | 267 (98.2) | 5 (1.8) | 1.13 (0.36–3.61) |
| Elementary school    |           |             |         |           |             |         |
| Regular mobile phone use NO | 89 (27.3) | 232 (72.3) | 1 | 309 (96.3) | 12 (3.7) | 1 |
| 1                    | 75 (27.2) | 201 (72.8) | 1.03 (0.72–1.47) | 270 (97.8) | 6 (2.2) | 0.57 (0.21–1.54) |
| Regular tablet use NO | 113 (27.2) | 303 (72.8) | 1 | 405 (97.4) | 11 (2.6) | 1 |
| 1                    | 51 (28.2) | 130 (71.8) | 0.95 (0.64–1.40) | 174 (96.1) | 7 (3.9) | 1.48 (0.56–3.88) |
| Regular Wi-Fi use NO | 58 (25.2) | 172 (74.8) | 1 | 223 (97.0) | 7 (3.0) | 1 |
| 1                    | 106 (28.9) | 261 (71.1) | 0.83 (0.57–1.21) | 356 (97.0) | 11 (3.0) | 0.98 (0.38–2.58) |
| Junior high school   |           |             |         |           |             |         |
| Regular mobile phone use NO | 28 (42.4) | 38 (57.6) | 1 | 58 (87.9) | 8 (12.1) | 1 |
| 1                    | 68 (40.2) | 101 (59.8) | 1.09 (0.61–1.95) | 160 (94.7) | 9 (5.3) | 0.41 (0.15–1.11) |
| Regular tablet use NO | 59 (41.0) | 85 (59.0) | 1 | 134 (93.1) | 10 (6.9) | 1 |
| 1                    | 37 (40.7) | 54 (59.3) | 1.01 (0.59–1.73) | 84 (92.3) | 7 (7.7) | 1.12 (0.41–3.05) |
| Regular Wi-Fi use NO | 16 (36.4) | 28 (63.6) | 1 | 40 (90.9) | 4 (9.1) | 1 |
| 1                    | 80 (41.9) | 111 (58.1) | 0.79 (0.40–1.56) | 178 (93.2) | 13 (6.8) | 0.73 (0.23–2.36) |
use by their young children [21]. One limitation of this study is that the caregivers responding to the questionnaire may not have been fully aware of the actual level of their older child’s mobile phone or tablet use. A disproportionate response rate from caregivers of older children may potentially produce a biased estimate of the relationship between mobile device use rates and health [22].

5. Conclusions

This Internet survey estimated that the proportion of Japanese children regularly using mobile phones was 15.1% among preschool students, 46.2% among elementary school students, and 71.9% among junior high school students, while 12.9%, 30.3%, and 38.7% regularly used tablets, respectively. Since the factor with the greatest influence on whether children can easily use mobile devices was availability of Wi-Fi at home, parents should be aware of how their children use the Internet. As young children are likely to be exposed to internet for the purpose of babysitting, this study suggested that parents should be aware of mental influence for tablets and Wi-Fi use. Appropriate family rules might be considered when younger children first begin to use the Internet, especially in the case when preschool students have their own tablets. A longitudinal research study could further advance knowledge in this area.

Data availability statement

The data that support the findings of this study are available upon reasonable request from the authors.

Conflicts of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Authors’ contributions

N K designed the study, analyzed and interpreted the data, and wrote the initial draft of the manuscript. All other authors contributed to data interpretation, and critically reviewed the manuscript. All authors approved the final version of the manuscript.

ORCID iDs

Noriko Kojimahara @ https://orcid.org/0000-0003-4099-6167
Yasuto Sato @ https://orcid.org/0000-0003-4767-331X

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