Differential associations between Quantity, content, and context of screen time, and Children's health-related quality of life: A two-wave study

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A B S T R A C T

Existing literature suggests that lengthy durations of screen time (ST) are associated with lower levels of health-related quality of life (HRQoL) and other negative outcomes in children. Nonetheless, the current available evidence largely relies on cross-sectional studies. In addition, data on the content and context (parent–child co-use and solitary use) of ST are scarce. We set out to conduct a one-year, two-wave longitudinal study to investigate the association between exposure to different types of ST and HRQoL among primary school children in Hong Kong, from 2021 to 2022. A population representative random sample ($N = 1428$) participated in the study. Results from pooled ordinary least squares regressions showed children's ST duration was significantly associated with worse HRQoL ($\beta = -1.101$, $p < 0.0001$). However, interactions of ST content and context, including parent–child co-use $\times$ TV viewing ($\beta = 1.305$, $p < 0.0001$), parent–child co-use $\times$ video gaming ($\beta = 0.280$, $p < 0.0001$), solitary use $\times$ video gaming ($\beta = 0.198$, $p < 0.0001$), and solitary use $\times$ social media use ($\beta = 0.454$, $p < 0.0001$) were significantly associated with better HRQoL. Our findings suggest that increased overall durations of ST are associated with worse HRQoL in children, but this association is impacted by the types of ST content and context.

1. Introduction

In light of the advancement of digital technology and the increasing rate of media accessibility, coupled with the global COVID-19 pandemic, screen time (ST), which refers to interaction with any device that provides content on a screen, including television (TV), computers, video game consoles, and mobile devices, has become ubiquitous in the lives of children and adolescents (Nagata, Magid, & Gabriel, 2020; Twenge, Martin, & Spitzberg, 2019). Over-exposure to ST among children continues to concern parents and health professionals; there has been a decade-long debate on the effects of ST on children's development and well-being (Madigan, Browne, Racine, Mori, & Tough, 2019). Despite some reported benefits of moderate screen media use in facilitating children's outcomes, such as learning, school readiness, and social interactions (Hill et al., 2016; O'Keeffe & Clarke-Pearson, 2011), prolonged ST is associated with different impairments in children. Several meta-analyses show that greater durations of ST are significantly associated with more internalizing and externalizing problems, and other negative psychological outcomes in children (Eirich et al., 2022; Ophir,

Rosenberg, & Tikochinski, 2021). Apart from these important outcomes in children, health-related quality of life (HRQoL) is a more comprehensive and multidimensional construct which encompasses broad areas of functioning in physical, psychological, social, and school dimensions (Varni et al., 2001). Hence, measuring HRQoL is an alternative to conventional or direct measures of illness, symptoms, or developmental outcomes (Simon et al., 2008) and moves toward a holistic approach to understanding the health state of a person. HRQoL has emerged to be an important indicator of child health and has been studied in the ST literature (Wong et al., 2021). For example, a meta-analytic review indicates an association between higher levels of ST and lower HRQoL, especially the physical domain (Boberska et al., 2018).

Growing research argues that merely measuring the amount of time spent with a screen is insufficient to examine the benefits and harms of ST among children, calling for a more comprehensive investigation of the different aspects of screen use (Daugherty, Dossani, Johnson, & Wright, 2014; Eirich et al., 2022; Linder, McDaniel, Stockdale, & Coyne, 2021). Emerging studies provide evidence supporting the idea that the impacts of ST are content-specific (e.g., Domingues-Montanari, 2017;

Sanders, Parker, delPozo-Cruz, Noetel, & Lonsdale, 2019). For instance, passive ST, such as TV viewing, is negatively associated with executive functioning and social skills, while active, interactive ST through the use of computers and tablets is positively associated with language skills (Hu et al., 2020). Drawing on the socio-ecological perspective, which emphasizes the influence of the social environment on individuals and person-and-environment interactions (Bronfenbrenner, 1977; Bronfenbrenner & Morris, 2006), the social context of ST is crucial, among other factors, in the study of screen-based media use in children. For children, ST is not necessarily a solitary activity; it may also occur within a parent–child context, which may lead to different ST experiences and outcomes in children.

An earlier study supports this contextual perspective, providing evidence of the buffering effect of positive parenting against the negative influences of increased exposure to TV on executive functioning (Linebarger, Barr, Lapierre, & Piotrowski, 2014). In a meta-analytic review (Collier et al., 2016), there is an overall positive association between parent–child co-use and reduced screen media use, aggression, and other risk behaviors, indicating potential benefits of parent–child co-use in regard to ST. The protective role of parents is also recognized in the ST guidelines offered by national health organizations, including the American Academy of Pediatrics (AAP Council on Communications and Media, 2016) and the Canadian Pediatric Society (2017), which advise parents to co-view ST with their children to mitigate the disadvantages of solitary viewing. Hence, when assessing children's ST, it is important to differentiate between solitary and parent-child co-viewing (i.e., the context of ST) and examine whether they influence children differently.

Drawing upon the extant literature on the elevated mental health risk associated with solitary participation in risk behaviors such as gambling and drinking among adolescents (Bristow, Bilevicius, Stewart, Goldstein, & Keough, 2018; Ju, Kim, Oh, & Park, 2019), it is reasonable to hypothesize that spending increased ST alone will have more deleterious effects on children. Furthermore, although it is generally accepted that there are advantages of parent–child co-use in regard to ST (Gentile, Reimer, Nathanson, Walsh, & Eisenmann, 2014), it remains unclear whether such effects are consistent across different types of ST content. An investigation into the nuances of ST by considering the interaction between types of ST content and context (solitary viewing vs. parent–child co-viewing) and their different associations with children's functioning will add to the current literature and help inform and refine the ST guidelines for parents, practitioners, and educators.

Building on past literature, which suggests that screen use is a multifaceted construct, the objectives of the present study are to: 1) evaluate the association between the amount of ST and children's HRQoL; and 2) examine how ST content (TV, gaming, social media, and studying) and context (solitary vs. parent–child co-use) influence the outcome under study. We hypothesize that higher levels of ST would be associated with worse HRQoL and that increased solitary ST, but not parent–child co-use, would be associated with worse HRQoL. We also explore whether the associations between ST and HRQoL are different across the domains of HRQoL. The findings of this study offer professionals insights into evidence-informed guidance with respect to appropriate technology use by children.

2. Methods

2.1. Study design and sampling

This is a two-wave population-based survey study over the course of one year. The study involved 1428 parents with children attending grades one to six (aged six to 11 years) in primary schools in Hong Kong. Though Hong Kong has a smartphone penetration rate of over 99% for residents of age 25 to 64 (Hong Kong Census and Statistics Department, 2023), we randomly sampled the target participants by both landline and mobile phone numbers using random dialing method to ensure parents of all socioeconomic classes were included in the pool.

2.2. Study Procedures

The study was conducted from June 2021 to August 2022. We used a two-stage sampling strategy, with random sampling via random digit dialing for the first stage. A total of 20,907 territory-wide telephone numbers were randomly sampled. In the second stage, we selected eligible parents based on our participant selection criteria (i.e., a parent or guardian of a child attending primary school (grades one to six) in Hong Kong. Of the 20,907 respondents, 18,552 were invalid cases (i.e., no target respondents, office numbers, inactive numbers), resulting in 2355 eligible participants. When contact was successfully established with a target parent, after briefing them on the study content and purpose and seeking their verbal and written informed consent, including study participation and mobile phone contacts, they were asked to complete the questionnaire online through a link sent to them via the recorded phone number. The questionnaire took about 20 min. Eligible participants with more than one child attending primary school were asked to select a child using the last birthday method and to refer to that child when answering the survey items. For situations where participants would like to clarify some questions e.g., items related to the use of electronic products with their children (occurred to <1% of the participants). Our experienced interviewers provided some examples as stated in the questionnaire, then, the participants continued with the self-administered questionnaire. A total of 1428 target parents completed the survey successfully, with a response rate of 60.6% for the baseline questionnaire during the period from June to August 2021. We made use of WhatsApp to maximize retention for the follow-up questionnaire. WhatsApp is the most commonly used messenger mobile application in Hong Kong with 80% overall population coverage (Thomala, 2023) and is very widely used among parents for communication with teachers and other parents. In our study, most of the parents were WhatsApp users and we informed them at the baseline assessment that there would be a one-year follow-up assessment. At the follow-up assessment, we contacted the participants to remind them of the study, obtained their verbal consent, and sent them the survey link if they agreed to participate. The survey link was sent via text messages, mainly via WhatsApp messenger, and some via SMS and emails (<5%). A total of 1033 target participants completed the follow-up survey online during the period from June to August 2022, with a follow-up response rate of 72.3%.

2.3. Measurements

2.3.1. Outcomes

Children's Health-Related Quality of Life (HRQoL). Parents reported various aspects of their children's functioning using the Chinese version of the Pediatrics Quality of Life Inventory Parent-Proxy Report (PedsQL; Lau et al., 2010). The 23-item PedsQL consists of four subscales measuring children's physical, emotional, social, and school functioning. A higher score indicates better HRQoL. In the current administration, we acquired good to excellent Cronbach's alphas for the physical functioning (0.90), emotional functioning (0.86), social functioning (0.91), and school functioning (0.79) subscales in our sample.

2.3.2. Exposure

Children's Screen Time (Quantity, Content, and Context). Parents were asked to report the daily time their children spent on four major types of screen content (TV, gaming, social media, and studying), regardless of whether the content was online or offline. They reported their children's ST for each type of media content on a typical weekend day and weekday separately. They also indicated the overall amount of ST represented by parent–child co-viewing and child solitary viewing, separately. In the study, co-viewing was defined as screen use accompanied by a parent and with parental guidance and supervision (e.g., screening appropriate content for the child, discussing content with the child, encouraging the child to express their own views on the content). A weighted average of daily ST and daily ST for each type of ST content

and context was computed ((ST weekday × 5 + ST weekend × 2)/7).

2.3.3. Covariates

We controlled for demographics, socioeconomic status, household and residence information, and health status in our inferential analysis models. These covariates were selected because of they are the potential causes of ST and HRQoL, i.e. confounder (Qin, Wang, Ware, Sha, & Xu, 2021; Wong et al., 2021; Xiang et al., 2022). Parents' demographic characteristics were measured as categorical variables: sex (male = 1), age (18–24, 25–34, 35–44, 45–54, >55). Socioeconomic status was measured according to both parents' educational attainment (primary school or below, middle school, high school, and college degree above), current employment status (full-time employed, part-time employed, housekeeping, unemployed, and retired), whether or not the family was receiving social security assistance (yes = 1), and eight monthly household income categories, ranging from < HKD5,000 (~USD640) to

≥ HKD50,000 (~USD60,000). Household information included parent's marital status (never married, cohabiting, married, widower/widow, and divorced/separated), residence type, and household size. Parents were also asked to report whether they had a chronic illness (yes = 1) and their own screen time. Children's demographics included sex (boy = 1) and age. We also measured the children's average daily sleep duration (as reported by the parent), daily leisure activity time, and daily physical activity time, a weighted value of each measure was computed and included in our models. Parents were asked to report the total physical (and leisure) activity times of their target child, accounting for all his or her extracurricular activities, in a typical weekday and weekend on the Children's Leisure Activities Study Survey Questionnaire-Chinese version (CLASS-C) (Liang, Lau, Huang, Maddison, & Baranowski, 2014). The questionnaire captures the frequency and duration of children's engagement in physical and leisure activity during the past week with a checklist of 31 activities. Then we calculated

Table 1a

Summary of demographic statistics of sampled households at baseline.

	Child's screen time[a]					
	<1 h	1–2 h	2–3 h	3–4 h	>4 h	Total
	(N = 40)	(N = 110)	(N = 217)	(N = 277)	(N = 784)	(N = 1428)
Parent's sex						
Male	9 (22.5%)	24 (21.8%)	57 (26.3%)	38 (13.7%)	181 (23.1%)	309 (21.6%)
Female	31 (77.5%)	86 (78.2%)	160 (73.7%)	239 (86.3%)	603 (76.9%)	1119 (78.4%)
Parent's age						
18–24	0 (0%)	0 (0%)	0 (0%)	1 (0.4%)	4 (0.5%)	5 (0.4%)
25–34	12 (30.0%)	17 (15.5%)	41 (18.9%)	51 (18.4%)	157 (20.0%)	278 (19.5%)
35–44	23 (57.5%)	79 (71.8%)	144 (66.4%)	197 (71.1%)	504 (64.3%)	947 (66.3%)
45–54	5 (12.5%)	14 (12.7%)	32 (14.7%)	27 (9.7%)	111 (14.2%)	189 (13.2%)
>55	0 (0%)	0 (0%)	0 (0%)	1 (0.4%)	8 (1.0%)	9 (0.6%)
Education attainment						
Primary school	0 (0%)	0 (0%)	2 (0.9%)	1 (0.4%)	4 (0.5%)	7 (0.5%)
Middle school	6 (15.0%)	11 (10.0%)	22 (10.1%)	28 (10.1%)	89 (11.4%)	156 (10.9%)
High school	20 (50.0%)	46 (41.8%)	92 (42.4%)	132 (47.7%)	408 (52.0%)	698 (48.9%)
College or above	14 (35.0%)	53 (48.2%)	101 (46.5%)	116 (41.9%)	283 (36.1%)	567 (39.7%)
Employment status						
Full-time employment	21 (52.5%)	70 (63.6%)	138 (63.6%)	184 (66.4%)	467 (59.6%)	880 (61.6%)
Part-time employment	4 (10.0%)	12 (10.9%)	24 (11.1%)	21 (7.6%)	82 (10.5%)	143 (10.0%)
Housekeeping	15 (37.5%)	28 (25.5%)	53 (24.4%)	70 (25.3%)	226 (28.8%)	392 (27.5%)
Unemployed	0 (0%)	0 (0%)	2 (0.9%)	2 (0.7%)	8 (1.0%)	12 (0.8%)
Retired	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (0.1%)	1 (0.1%)
Chronic illness status						
Yes	1 (2.5%)	3 (2.7%)	5 (2.3%)	14 (5.1%)	28 (3.6%)	51 (3.6%)
No	39 (97.5%)	107 (97.3%)	212 (97.7%)	263 (94.9%)	756 (96.4%)	1377 (96.4%)
Marital status						
Never married	1 (2.5%)	1 (0.9%)	0 (0%)	1 (0.4%)	17 (2.2%)	20 (1.4%)
Cohabiting	0 (0%)	4 (3.6%)	1 (0.5%)	5 (1.8%)	9 (1.1%)	19 (1.3%)
Married	36 (90.0%)	99 (90.0%)	208 (95.9%)	252 (91.0%)	704 (89.8%)	1299 (91.0%)
Widower/widow	1 (2.5%)	0 (0%)	0 (0%)	2 (0.7%)	5 (0.6%)	8 (0.6%)
Divorced/separated	2 (5.0%)	6 (5.5%)	8 (3.7%)	17 (6.1%)	49 (6.3%)	82 (5.7%)
Household size						
2	2 (5.0%)	3 (2.7%)	3 (1.4%)	4 (1.4%)	20 (2.6%)	32 (2.2%)
3	18 (45.0%)	51 (46.4%)	82 (37.8%)	89 (32.1%)	330 (42.1%)	570 (39.9%)
4	14 (35.0%)	36 (32.7%)	90 (41.5%)	120 (43.3%)	283 (36.1%)	543 (38.0%)
5	4 (10.0%)	16 (14.5%)	32 (14.7%)	56 (20.2%)	104 (13.3%)	212 (14.8%)
≥ 6	2 (5.0%)	4 (3.6%)	10 (4.6%)	8 (2.9%)	47 (6.0%)	71 (5.0%)
Monthly household income (HKD)						
< $5000	0 (0%)	0 (0%)	2 (0.9%)	3 (1.1%)	6 (0.8%)	11 (0.8%)
$5000–$9999	0 (0%)	0 (0%)	3 (1.4%)	3 (1.1%)	17 (2.2%)	23 (1.6%)
$10,000–$14,999	4 (10.0%)	3 (2.7%)	4 (1.8%)	12 (4.3%)	50 (6.4%)	73 (5.1%)
$15,000–$19,999	3 (7.5%)	2 (1.8%)	18 (8.3%)	24 (8.7%)	71 (9.1%)	118 (8.3%)
$20,000–$29,999	6 (15.0%)	11 (10.0%)	36 (16.6%)	32 (11.6%)	165 (21.0%)	250 (17.5%)
$30,000–$39,999	5 (12.5%)	21 (19.1%)	37 (17.1%)	36 (13.0%)	141 (18.0%)	240 (16.8%)
$40,000–$49,999	3 (7.5%)	17 (15.5%)	21 (9.7%)	34 (12.3%)	113 (14.4%)	188 (13.2%)
≥ $50,000	10 (25.0%)	24 (21.8%)	47 (21.7%)	42 (15.2%)	131 (16.7%)	254 (17.8%)
Unknown	9 (22.5%)	32 (29.1%)	49 (22.6%)	91 (32.9%)	90 (11.5%)	271 (19.0%)
Child's sex						
Male	17 (42.5%)	49 (44.5%)	117 (53.9%)	129 (46.6%)	426 (54.3%)	738 (51.7%)
Female	23 (57.5%)	61 (55.5%)	100 (46.1%)	148 (53.4%)	358 (45.7%)	690 (48.3%)
Child's age						
Mean (SD)	7.25 (1.72)	8.12 (1.86)	8.26 (1.77)	8.48 (1.88)	8.70 (1.93)	8.51 (1.90)

[a] Screen time is categorized into five groups for descriptive comparisons only.

the weighted values based on the formula (physical/leisure activity time weekday $\times$ 5 + physical/leisure activity time weekend $\times$ 2)/7. The same formula was used to compute sleep duration measure. Body mass index (BMI) was based on this formula: individual weight in kg/height in m^2, in which the child's weight and height were recorded in both study waves. Though potentially relevant, number of siblings was not included in the analyses, to avoid multicollinearity with household size.

3. Statistical analysis

To minimize selection bias, we used multiple imputation with 10 iterations to handle missing values of the measured outcome at follow-up based on demographic and covariate data. To examine the association between total ST and HRQoL, pooled ordinary least squares (POLS) regressions were conducted using the two-wave panel data in the current study, after model diagnostics. Moderated POLS regression was conducted for each interaction of ST context (solitary or parental; in hours) and ST content type (TV, gaming, social media, or studying; in hours), to examine the moderation effect. These models were adjusted for both parents' sex and age, education attainment, employment status, chronic illness status, marital status, residence type, household size, monthly household income, social security assistance, parent's screen time, child's sex and age, sleep duration, leisure activity time, physical activity time, and BMI. Robust standard error was used in all POLS models to account for potential data dependence across time points. All results were considered statistically significant at alpha <0.05. All data manipulations and analyses were performed using R version 4.3.1.

4. Results

4.1. Descriptive statistics

A total of 1428 households' parents participated in the study, 78.4% of whom were mothers. Table 1a presents the descriptive statistics of the participants' demographic data stratified by five groups of reported ST per day for the child. More than two-thirds of the surveyed households had three to four members, with 91% reporting being currently married. Most of the participating parents were between 35 and 44 years of age (66.3%). A clear trend of ST exposure is present in which most of the participated household children (N = 784, 54.9% of total sample) spent more than 4 h of ST daily, and the number decreases as ST hour

diminishes. No other apparent trend of ST is observed across all measured parent's and household demographics except for those whose monthly household income exceeds HKD50,000 (~USD6,384). In this group of households (N = 254, 17.8% of total sample), a descending trend of child's ST can be observed in which a relatively large proportion of children spent less than 1 h of ST per day, and the proportion generally declines as the number of hours rises. See Table 1a for details.

Table 1b tabulates the means and standard deviations (SD) of daily ST, ST content, and ST context, stratified by child's sex and school grade. Due to the violations of normality assumption, Mann-Whitney U tests were performed for ST exposure variables between the sexes, while Kruskal-Wallis rank sum test was used to test the difference among school grades. On average, children's daily ST was 5.38 h (SD = 3.24). Their ST was mostly attributed to gaming (1.51 h, SD = 1.36), followed by studying (1.41 h, SD = 1.20), watching TV (1.25 h, SD = 0.80), and browsing social media (1.21 h, SD = 1.08), though the differences were small and the order differed between boys and girls. Boys' total daily ST was statistically significant to a greater extent than was girls' (mean difference, MD = 0.45; p = 0.0154). Boys also spent significantly more ST time gaming (MD = 0.36, p < 0.0001) and alone (MD = 0.40, p = 0.0247). Kruskal-Wallis rank sum tests showed that school grade was significantly positively associated with total daily ST (χ^2 = 28.11) and ST spent gaming (χ^2 = 41.15), browsing social media (χ^2 = 32.97), and studying (χ^2 = 29.75), all ps < 0.0001. School grade was also positively associated with solitary ST, both in absolute measure (χ^2 = 40.62, p < 0.0001) and relative to parental co-use (χ^2 = 40.81, p < 0.0001).

4.2. inferential statistics

Within-subject t-tests showed that the one-year follow-up score of PedsQL (M = 53.791, SD = 13.437) was not statistically significantly different from that measured at baseline (M = 56.216, SD = 13.319; p = 0.1121). Our adjusted POLS models indicated that average daily ST was negatively associated with both overall PedsQL (β = −1.101; 95% CI -1.154, −1.047) and all of its subscales' scores (ps < 0.0001). A detailed summary of results is presented in Table 2.

A total of two ST context types (solitary and parental) $\times$ four ST content types (TV, game, social media, and study) = eight moderated POLS models were performed to examine the interaction effects on children's HRQoL. A summary of the results is illustrated in Table 3 (for results of unadjusted models, see eTable 3 in supplementary materials).

Table 1b

Summary of screen time statistics at baseline stratified by child's sex and school grade.

	Total (N = 1428)	Sex		p-value[a]	Grade						p-value[b]
		Male (N = 738)	Female (N = 690)		1 (N = 379)	2 (N = 217)	3 (N = 208)	4 (N = 219)	5 (N = 183)	6 (N = 222)	
Daily ST	5.38 (3.24)	5.60 (3.33)	5.15 (3.12)	0.0154	4.84 (3.19)	5.14 (3.10)	5.17 (2.92)	5.72 (3.37)	5.88 (3.16)	6.01 (3.48)	<0.0001
ST content											
TV	1.25 (0.798)	1.24 (0.782)	1.25 (0.815)	0.5513	1.25 (0.826)	1.31 (0.776)	1.34 (0.835)	1.22 (0.852)	1.25 (0.807)	1.11 (0.646)	0.0758
Game	1.51 (1.36)	1.68 (1.43)	1.32 (1.25)	<0.0001	1.28 (1.28)	1.38 (1.23)	1.34 (1.25)	1.68 (1.46)	1.67 (1.33)	1.87 (1.51)	<0.0001
Social media	1.21 (1.08)	1.23 (1.12)	1.20 (1.03)	0.6486	1.07 (1.08)	1.11 (1.09)	1.22 (0.962)	1.21 (1.08)	1.41 (1.08)	1.40 (1.11)	<0.0001
Study	1.41 (1.20)	1.45 (1.19)	1.37 (1.21)	0.0693	1.24 (1.09)	1.34 (1.22)	1.27 (1.17)	1.61 (1.28)	1.54 (1.21)	1.63 (1.25)	<0.0001
ST context											
Solitary	4.40 (2.78)	4.59 (2.88)	4.19 (2.65)	0.0247	3.86 (2.75)	4.16 (2.61)	4.22 (2.50)	4.72 (2.95)	4.91 (2.68)	4.98 (2.95)	<0.0001
Solitary %	80.4 (14.7)	80.4 (14.1)	80.4 (15.3)	0.6889	0.768 (0.143)	0.805 (0.151)	0.810 (0.152)	0.808 (0.159)	0.842 (0.134)	0.826 (0.128)	<0.0001
Parental	0.986 (0.849)	1.02 (0.841)	0.955 (0.857)	0.0934	0.988 (0.745)	0.981 (0.848)	0.952 (0.862)	0.994 (0.863)	0.971 (0.924)	1.03 (0.930)	0.8627
Parental %	6 (14.7)	19.6 (14.1)	19.6 (15.3)	0.6889	0.232 (0.143)	0.195 (0.151)	0.190 (0.152)	0.192 (0.159)	0.158 (0.134)	0.174 (0.128)	<0.0001

Descriptive statistics are presented in means and standard deviations (in brackets).

All units were measured or computed in hours per day.

[a] Mann-Whitney U tests were performed to test the potential difference of all screen time variables between boys and girls due to the violations of normality assumption.

[b] Kruskal-Wallis rank-sum tests were performed to test the potential difference of all screen time variables among school grades.

Table 2
Summary of results from five pooled ordinary least squares regression models of children's screen time against the health-related quality of life of children in Hong Kong.

	Beta[a]	SE	2.5% CI	97.5% CI	p-value	N
Overall PedsQL	−1.1005	0.0275	−1.1544	−1.0466	<0.0001	1144
Physical functioning	−1.2832	0.0289	−1.3400	−1.2265	<0.0001	1144
Emotional functioning	−0.9001	0.0333	−0.9654	−0.8349	<0.0001	1143
Social functioning	−1.3552	0.0312	−1.4165	−1.2940	<0.0001	1142
School functioning	−1.0469	0.0325	−1.1106	−0.9831	<0.0001	1144

[a]Covariates include both parents' sex and age, education attainment, employment status, chronic illness status, marital status, residence type, household size, monthly household income, social security assistance, child's sex and age, sleep duration, leisure activity time, physical activity time, and BMI.

Table 3
Summary of results from moderated pooled ordinary least squares regression models of interaction terms (solitary and parental × ST content types) against the health-related quality of life of children in Hong Kong.

Term[a]		Beta[b]	SE	2.5% CI	97.5% CI	p-value	N
ST context	ST content						
Solitary ×	TV	0.0424	0.0320	−0.0203	0.1051	0.1849	1143
	Game	0.1975	0.0183	0.1616	0.2334	<0.0001	1143
	Social media	0.4540	0.0225	0.4098	0.4982	<0.0001	1143
	Study	0.0029	0.0244	−0.0450	0.0508	0.9045	1143
Parental ×	TV	1.3047	0.0685	1.1705	1.4390	<0.0001	1143
	Game	0.2799	0.0333	0.2146	0.3451	<0.0001	1143
	Social media	−0.7108	0.0419	−0.7929	−0.6288	<0.0001	1143
	Study	−0.5269	0.0440	−0.6132	−0.4406	<0.0001	1143

[a] Individual interactive predictor terms are omitted for concise illustration.
[b] Covariates include both parents' sex and age, education attainment, employment status, chronic illness status, marital status, residence type, household size, monthly household income, social security assistance, parent's screen time, child's sex and age, sleep duration, leisure activity time, physical activity time, and BMI.

The solitary context moderated the associations of gaming ($\beta = 0.198$; 95% CI 0.162, 0.233; $p < 0.0001$) and browsing social media ($\beta = 0.454$; 95% CI 0.023, 0.410; $p < 0.0001$) with PedsQL score, whereas the associations for TV viewing and studying were statistically non-significant (both $ps > 0.05$). On the other hand, the parent-child co-use context moderated all associations between ST activities and HRQoL, though directions varied. Specifically, TV viewing ($\beta = 1.305$; 95% CI 1.171, 1.439; $p < 0.0001$) and gaming ($\beta = 0.280$; 95% CI 0.215, 0.345; $p < 0.0001$) were positively associated with PedsQL score. Browsing social media ($\beta = -0.711$; 95% CI -0.793, −0.629; $p < 0.0001$) and studying ($\beta = -0.527$; 95% CI -0.613, −0.613; $p < 0.0001$), however, were negatively associated with PedsQL score.

5. Discussion

The present study provides important additions to the existing body of research on the risks and benefits of ST by evaluating the nuances of ST in a representative sample of parents of 1428 children in Hong Kong, using a two-wave longitudinal study design. Children in our study spent an average of 5.38 h on screen-based media per day. Although our study was carried out during the early years of the COVID-19 pandemic, the average ST we obtained is comparable to that reported in another study conducted in Hong Kong before the pandemic (Wong et al., 2021). Considering the general rule of 2 h of ST per day recommended by the World Health Organization guidelines for children (Bull et al., 2020), a meta-analysis of international studies shows that only 58.7% and 40.6% of global children aged six to 14 years adhered to the 2-h limit before and after the pandemic outbreak, respectively (Qi et al., 2023). Our study reports an even substantially lower compliance level, with only 10.5% of the children meeting the guidelines. This level is the lowest compared with other technologically advanced Asian countries, such as Singapore (41%), South Korea (28.2%–60.3%), and Japan (21.5%) (Lee, Khan, Uddin, Lim, & George, 2020; Tanaka, Tremblay, Okuda, Inoue, & Tanaka, 2020; Tay et al., 2023), though these figures were reported before the pandemic. Although the benefits of parent–child co-use have been advocated by health professionals, children in our study spent

approximately 80% of their ST alone, implying an overall low level of parental involvement in children's ST. This may be partly related to the demographic characteristics of the current sample, with the majority of parents being employed; they may not have sufficient time to supervise or participate with their children in regard to screen media activities. Alternatively, past studies offer other potential explanations for parental involvement, including beliefs about screen-based media, parental self-efficacy, and family socioeconomic status (Hamilton, Spinks, White, Kavanagh, & Walsh, 2016; Mansor, Ahmad, Raj, Mohd Zulkefli, & Mohd Shariff, 2021). In accordance with previous evidence for gender differences in children's screen-based media use (Hu et al., 2020; Twenge & Farley, 2021), our study observed higher levels of daily ST, time spent gaming, and engaging in ST alone among boys than girls. Further, consistent with the developmental perspective that children gain and need more autonomy as they age, there was a positive relationship between school grade and the amount of daily ST and the proportion of solitary ST relative to parent–child co-viewing.

The study's findings on the influence of the duration of ST on children show that increased time spent on screen-based media was associated with lower levels of overall HRQoL, which is consistent with previous research (Boberska et al., 2018; Tooth, Moss, & Mishra, 2021; Wong et al., 2021). We also explored whether this association differed across the domains of HRQoL. The results show that the associations between ST and social and physical functioning were stronger than for the school and emotional domains. The greater influence in regard to physical functioning may be explained by the tendency to adopt a sedentary lifestyle characterized by extended time spent sitting among children who engage in prolonged screen-based activities (Carson et al., 2016). Regarding the association with social functioning, increased ST may have displaced children's time for healthier activities (Neuman, 1995), including face-to-face social interactions with peers and family, which subsequently impact their social well-being.

A recently published article provides an extensive review on the existing body of knowledge on the associations between screen use and a wide range of health and educational outcomes in children (Sanders et al., 2023). The review indicates that the harmful effects of ST were

inflated when studies only examined general screen use without making distinctions between the context and content (Sanders et al., 2023). Our study further extends the literature through the evaluation of how the social context (solitary vs. parent–child co-viewing) and content of ST (TV, gaming, social media, and studying) affect children's HRQoL, which reveals the complexity of the issue of ST. In the context of solitary use, the unadjusted findings indicated among the four ST activities examined, TV viewing and studying were associated with HRQoL. But after the adjustment of confounding covariates, which we believe represents a more accurate causal estimate of reality, spending more time participating in video gaming and social media became significantly associated with better HRQoL, while the associations between increased time spent viewing TV and studying and HRQoL were non-significant. These findings may be relevant to the discussion in the field of developmental psychology concerning the way in which solitude, a state of being alone, may have both positive and negative implications for children's well-being, depending on the nature of the solitude (Coplan, Bowker, & Nelson, 2021). It is obvious that technology and new media have changed the nature of solitude, as people can interact and connect with other people even when physically alone, such as during video gameplay and social media activities (Hollis et al., 2020); hence, solitary ST activities do not necessarily lead to social withdrawal and impairments in functioning for children. Further, engagement in these solitary leisure activities is more likely to be intrinsically motivated and associated with positive emotions and a sense of autonomy (Hipson, Coplan, Dufour, Wood, & Bowker, 2021), as compared with solitary participation in risk behaviors, such as solitary alcohol drinking and gambling (Bristow et al., 2018; Ju et al., 2019), which tend to be associated with negative emotions and detrimental effects. Additional research is needed to verify these hypotheses and the risks and benefits of ST in the context of solitary use for children.

More time spent playing video games had a positive association with HRQoL, and such association was influenced by the context of ST. Specifically, the association was stronger in the parent-child context than in the solitary context. It may be that some genres of games are designed for multiple players to collaborate or to compete, which naturally creates parent–child conversation and interaction during the game. Additionally, when parents play video games with their children, they usually do it for fun (Ulicsak & Cranmer, 2010). Parental participation in gaming may therefore bring about positive parent–child experiences and family fun time, which in turn lead to better outcomes in children. In addition, joint video gaming may allow parents to become involved in their children's lives in a positive way (Coyne, Padilla-Walker, Fraser, Fellows, & Day, 2014), which is beneficial for children's overall functioning and development. Likewise, increased time spent on TV in the co-viewing context was positively associated with children's HRQoL. A possible explanation for this is that parents tend to select high-quality and age-appropriate programs when they watch TV with their children (Downing et al., 2019), and that the non-interactive nature of TV content may allow more space for parent–child conversation and discussion, which are beneficial to children. Regarding parental involvement in other types of ST content, increased social media and studying was inversely associated with HRQoL. The nature of these two types of ST content and the parent–child dynamics involved may explain the findings. Children's activities on social media are likely to be more private and involve their own social network; parental involvement in these activities may therefore be perceived by children as intrusive, especially for older children who are making the transition into adolescence, when they have increased needs for privacy and autonomy in their screen-based media use (Erickson et al., 2016). Spending increased time on studying-related ST accompanied in the parent-child co-use context, particularly when such activities are parent-initiated, one-way, and instructional, may induce studying-related stress resulting in negative effects on children.

5.1. Strengths and limitations

The strengths of this study include the use of population representative sample and the evaluation of the novel variable of the social context of ST (solitary viewing and parent–child co-viewing). Despite these strengths, the study's findings should be interpreted with the consideration of the following limitations. To minimize participants' burden, the measures of solitary viewing and parent-child co-viewing in the current study only captured overall ST hours across various types of ST content. Our interpretations of the results assume similar levels of the corresponding context hold across all examined ST content types. Also, given that the data were collected during the COVID-19 pandemic, the association between children's ST and their HRQoL may potentially be affected by pandemic-related confounding factors that were induced by the strict social distancing policies of schools, though our findings were mostly consistent with studies conducted before COVID-19. Furthermore, we adopted POLS regressions in the current study based on the two-wave nature of the data, and the assumption of independent variables' lack of correlation with unmeasured errors (i.e., strict exogeneity) must hold. Results of this study should be interpreted with caution. It should also be noted that, the differential qualitative changes in the associations of solitary ST but not in parental ST between our crude and adjusted models may indicate potential bias induced by parents' proxy-report on children's ST.

5.2. Implications

Regarding practice and policy, the findings on the negative influences of prolonged screen-based media use on children's HRQoL suggest that preventive strategies are needed to minimize children's overexposure to screen media and its impacts on children's health and development. Preventive strategies targeting parents and the whole family may be more effective, as the family environment is an important context in which to promote the development of safe and healthy screen-based media use in children (Terras & Ramsay, 2016). Practitioners are positioned to support parents in this regard, as parenting in the digital age can be challenging. While ST guidelines are important references for parents in regard to fostering healthy screen media use in children, our findings suggest that some of the recommendations may need to be reviewed and updated. Specifically, the advice on parent–child co-viewing may need to be re-evaluated, as our findings indicate that the protective role of parental involvement may be dependent on the types of screen-based media content in question. Although our study's findings suggest that gaming and social media activities, especially in the solitary context, are associated with better HRQoL, it is premature to draw this conclusion due to insufficient evidence in the literature. Extended exposure to ST may still pose risks to children's health.

The current study also provides implications for several future research directions. As many studies suggest, increased ST is unlikely to be directly harmful to children (Paulich, Ross, Lessem, & Hewitt, 2021). Further investigations into the potential underlying mechanisms regarding the association between ST and HRQoL will provide further insights into the topic. We also call for more studies to examine the social context of ST, such as longer-term longitudinal research to clarify the impacts of solitary ST on children's outcomes, and studies that capture and address the potential discrepancy between parents' and children's perceived co-viewing experiences. The current study narrowly defines co-viewing as screen use accompanied by a parent and with parental guidance and supervision but, in real life, parents likely adopt a combination of co-viewing strategies and their decisions may be subject to the types of screen media activities children engage in, the child's age, and the child's needs. Studies examining different forms of parental co-viewing strategies more closely are warranted. Additionally, future studies should address the limitations of using proxy-reported or self-reported ST measures and develop innovative and validated objective tools to assess different types of ST, especially methods that can

capture children's simultaneous use of multiple devices for different purposes and in different social contexts. A complete understanding of all of these aspects of ST and dynamics involved in children's screen-based media use will facilitate the development of more specific and practical ST recommendations.

6. Conclusion

The current study provides novel insights into how the content and context of ST influence HRQoL. Based on two-wave, one-year data from a representative sample of parents of primary school children in Hong Kong, we found that increased ST was associated with worse HRQoL in children, but the association was influenced by the types of ST content and context. Spending increased time gaming and engaging in social media activities in the solitary context was associated with better HRQoL in children. In the context of parent-child co-viewing, children spending increased time engaging in TV viewing and gaming had better HRQoL, but spending more time studying and using social media via the screen was related to worse HRQoL. These findings suggest that current recommendations regarding parent–child co-use and solitary use may need to be reviewed. We also call for additional research to verify these findings.

Ethical approval

The study was conducted according to the principles of the Declaration of Helsinki. Ethical approval for the study was obtained from the Institutional Review Board of the Hong Kong Polytechnic University (ref. no. HSEARS20191204001) prior to the commencement of the study.

CRediT authorship contribution statement

Camilla Kin Ming Lo: Writing – review & editing, Writing – original draft, Methodology, Investigation, Funding acquisition, Conceptualization, Formal analysis. **Ko Ling Chan:** Writing – review & editing, Methodology, Conceptualization. **Edward Wai Wa Chan:** Writing – original draft, Formal analysis, Writing – review & editing. **Frederick K. Ho:** Writing – review & editing, Methodology. **Patrick Ip:** Writing – review & editing.

Declaration of competing interest

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

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.chb.2024.108284.

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