Parental restriction reduces the harmful effects of in-bedroom electronic devices

King-wa Fu, PhD [a], Frederick Ka-wing Ho, PGDE [b], Nirmala Rao, PhD [c*],

Fan Jiang, MD, PhD [d], Sophia Ling Li, PhD [b], Tatia Mei-chun Lee, PhD [e,f],

Sophelia Hoi-shan Chan, MBBS [b], Ada Wing-yan Yung, MBBS [b],

Mary Eming Young, MD, DrPH [g], Patrick Ip, MPH [b*]

Affiliations: [a] Journalism and Media Studies Centre, [b] Department of Paediatrics and Adolescent Medicine, [c] Faculty of Education, The University of Hong Kong, Hong Kong; [d] Shanghai Children's Medical Center, Shanghai; [e] Laboratory of Neuropsychology, [f] State Key Laboratory of Brain and Cognitive Sciences, The University of Hong Kong, Hong Kong; [g] China Development Research Foundation, Beijing, China.

Corresponding authors: Patrick Ip and Nirmala Rao

Address correspondence to: Patrick Ip, 1/F, New Clinical Building, Queen Mary Hospital, Hong Kong. Email: patricip@hku.hk, Tel: (852) 28198501. Nirmala Rao, Faculty of Education. The University of Hong Kong, Hong Kong. Email: nrao@hku.hk, Tel: (852) 39177604.

Abbreviations: CEDI: Chinese Early Development Instrument; ED: Electronic device; HKI: Hong Kong Island; YL: Yuen Long; SES: Socioeconomic status

Abstract (237 words)

Objective: To investigate whether school readiness could be affected by placing electronic devices (ED) in children's bedroom and whether the relationship was moderated by parental restriction and family socioeconomic status (SES).

Design: This is a cross-sectional study with bedroom ED placement and parental restriction reported by parents. Multiple linear regressions were used to test the relationship between school readiness and ED placement. Multiple regression with interaction terms were used to test whether the effect was consistent with and without parental restriction.

Setting: Kindergartens randomly selected from two districts of different socioeconomic backgrounds in Hong Kong, China.

Patients: 556 young children attending the third year of kindergarten.

Main outcome measures: Children's school readiness was rated by teachers using the Chinese Early Development Instrument.

Results: 556 preschoolers (mean age 5.46; 51.8% girls) from 20 kindergartens participated in this study. About 30% parents placed at least one ED in their children's bedroom. After controlling for sex and SES, the placement of television in bedroom was associated with lower overall school readiness (β -1.11, 95% CI -1.80 to -0.42) and the placement of game console was associated with lower social competence (β -0.94, 95% CI -1.74 to -0.15). Such harmful effect was more prominent among lower SES families and could be partially alleviated with parental restriction.

Conclusions: ED placement in children's bedroom was associated with lower school readiness, particularly among lower SES families. Parental restriction might help to alleviate the harm.

What is known about this topic

- Young children had increasing exposure to electronic devices
- Placing television in children's bedroom was associated with poor academic performance, sleeping problems, and higher risk of obesity

What this study adds

- Electronic devices placed in child's bedroom was associated with lower school readiness
- The association was moderated by family socioeconomic status and parental restriction
- Parent-child recreation activity mediated the relationship between school readiness and placing electronic device in child's bedroom

Main text (2486 words)

Background

In recent years, young children not only have access to traditional electronic devices (EDs) but also to more advanced ones, such as computers, smartphones, and game consoles.[1] The increasing access to ED in early childhood also raised widespread concerns about their potential harm on child development.[2] Television, being invented for decades, is the most widely studied ED. Numerous studies have shown that prolonged television exposure in early childhood could be harmful on children's cognitive development,[3] socio-behavioral skills,[4] and physical wellbeing.[5] Nevertheless, the effects of other EDs are far less studied and the evidence so far varied. For example, a U.S. infant cohort study[6] identified a negative association between media use and language development but another cohort study[7] focusing on Hispanic toddlers in U.S. concluding none. In fact, a recent systematic review[8] has revealed that 56% of the evidence concerning television viewing reported null effect on cognitive development, 38% reported negative effect, and 6% reported positive effect. This shows that simply studying the time spent on ED may not be sufficient to unveil the complex relationship.

Preliminary studies have shown that the placement of ED could be a strong yet overlooked risk factor for poor health and development. A cross-sectional survey in the U.S. has identified that preschool children who had a television in bedroom were more likely to be overweight after adjusting for television view time and other confounders.[9] A systematic review also concluded that bedroom ED placement could affect children's sleep duration and quality.[10] Nevertheless, none of these studies considered the effect of ED placement on preschoolers' school readiness, a comprehensive construct including cognitive, language, and socioemotional development. Furthermore, these studies also omitted possible moderators

4

(such as socioeconomic status and parental restriction on ED use[10]) and mediators (such as parent-child interaction and sleep duration[11]).

The current study addresses this knowledge gap with the following aims: (1) to study the pattern of bedroom ED placement and parental restriction among Chinese preschool children, (2) to study whether bedroom ED placement may affect school readiness, (3) to understand whether the association between bedroom ED placement and school readiness, if any, was moderated by parental restriction and socioeconomic status, and (4) to explore to which extent the effects of ED placement was mediated by parent-child interaction and sleep duration.

Methods

Study Design

This is a cross-sectional study recruiting 556 preschoolers from 20 kindergartens. These Chinese-speaking kindergartens were selected from two districts of Hong Kong with contrasting SES profiles: Hong Kong Island (HKI) as an affluent district and Yuen Long (YL) as an underprivileged district. In 2012, the median monthly family income of Hong Kong was USD 3,149, while HKI was ranked top (USD 4,240) and YL was ranked bottom (USD 2,680).[12] Twenty-two kindergartens were randomly selected from all preschools in the two districts, and 20 preschools (9 from HKI, 11 from YL) consented to participate.

Participants

With permission from the kindergarten principals, one 5-year-old class was randomly chosen from each participating school. Parents of all children in the class were invited to join the study and provide written consent. This sample also participated in two other published studies on the socioeconomic gradients of school readiness[12] and the relationship between sleep duration and child development.[13] In the present study, parents were asked to complete

a questionnaire on family ownership of EDs, bedroom ED placement, and parental restriction practice. Children's school readiness was rated by trained kindergarten teachers.

Measures

School Readiness and the Chinese Early Development Instrument

School readiness is an indicator of whether a child possesses the cognitive, social, and emotional skills necessary for success in school and has been shown to predict long-term educational outcomes.[14,15] School readiness was measured using the Chinese Early Development Instrument (CEDI), which was based on the Early Development Instrument (EDI), a comprehensive teacher-rated scale.[16] The CEDI was previously validated and shown reliable (Cronbach's αs ≥ 0.90, except for physical wellbeing domain with α = 0.70) for Chinese children.[17]

The teacher most familiar with the child was asked to assess his/her school readiness using the CEDI. All 69 participating teachers received comprehensive training on how to use the instrument, and were given a guide to help them understand, interpret, and code the CEDI items. The training included a one-day orientation workshop, hands-on trials, and continuous support by Ip, Rao, and the research team. Teachers' trial rating was compared with a gold standard before rating the study participants. Further guidance and training were provided if a teacher's trial rating was not consistent with the gold standard.

The CEDI rating scale contains 103 items that assess five developmental domains: physical health and wellbeing, social competence, emotional maturity, language and cognitive development, and communication skills/general knowledge. Each of the five domains was scored on a scale from 0–10, with a higher score indicating better performance in the measured developmental domain. The total CEDI score was calculated as the sum of the five domains giving a score from 0–50.

6

Family Questionnaire

Parents were asked to complete a questionnaire previously developed in a pilot study.[17] It assesses family ownership of EDs, bedroom ED placement, parental restriction of EDs, family demographics, SES, parent-child interaction, and sleep duration.

<u>*Electronic Devices*</u>

Parents were asked about three types of EDs at home: televisions, computers (desktop, laptop, tablet), and gaming devices (home and portable consoles). For each of the three EDs, parents were also asked about: (1) whether the ED were placed in the child's bedroom ('*Are televisions, desktop/laptop computers, and game consoles placed in your child's bedroom?*'), and (2) whether the parents restrict the child's use in that ED ('*Do you limit your child's time spent on (a) televisions, (b) computers, and (c) game consoles?*').

<u>*Family Socioeconomic Status*</u>

Family SES was considered as both a potential confounder and moderator in this study. Several key family SES indicators were assessed: maternal and paternal education, maternal and paternal occupation, family assets, and adjusted family monthly income. These were aggregated into an SES index using principal component analysis with varimax rotation, a validated method to describe SES differences within a population.[18] A higher value in the index indicated the family had a higher SES. The SES index was categorized into three levels with tertiles as cut-offs in moderation analysis for easier understanding.

<u>*Parent-child interaction*</u>

Parent-child interaction was a potential mediator between school readiness and unrestricted bedroom ED placement. The Chinese Parent-Child Interaction Scale was used to access the weekly frequency of eight parent-child interactive activities in the past month: (1) reading, (2)

drawing, (3) singing, (4) storytelling, (5) discussing news and current affairs, and the learning

of (6) Chinese characters, (7) English alphabets, and (8) arithmetic/pre-mathematics. These

items were scored on a 4-point Likert scale, with Recreation (1–5) and Learning (6–8)

Activity subscales. A higher score indicates more frequent parent-child interaction. The scale

has been validated and shown reliable in a Rasch analysis (internal consistency 0.82).[19]

Sleep duration

Sleep duration was also considered as a potential mediator and assessed with a parent-report

item on the average number of hours the child slept per day in the past week, including both

daytime naps and nighttime sleeps. Previous studies have found the parent-report sleep

duration to be valid and reliable.[20]

Statistical Analysis

Associations between school readiness and bedroom ED placement were tested using

multiple linear regressions after controlling for sex and family SES. Parent-child interaction

was not controlled in this analysis because it was a potential mediator and controlling for

mediators may mask the true association. To analyse the moderating effect, interaction

variables were created between bedroom ED placement and the potential moderating

variables (SES and parental restriction). The interaction variables were entered into a

multiple regression along with bedroom ED placement, family SES, and sex. The statistical

significance of the interaction variable indicates a moderator effect.

The mediation effects of SES, parent-child interaction, and sleep duration were firstly tested

by using Spearman's rank correlation coefficients because the ED variables were not

normally distributed. Potential mediators that had significant correlation with ED variables

were used in a path model (Figure 2). A series of model fit indices were used to assess

whether the model was appropriate for the data, including Comparative Fit Index (CFI),

Tucker Lewis Index (TFI), Root Mean Square Error of Approximation (RMSEA), and Standardised Root Mean Square Residual (SRMR). These indices use different approaches in assessing the model fit and therefore should be used simultaneously.[21] A path model was accepted if its CFI and TLI were at least 0.96, RMSEA at most 0.06 and SRMR at most 0.09.[21] The mediation effect was calculated using the Delta Method with the *lavaan* package of the R Statistical Software.[22] The statistical significance of the indirect effect indicates a mediator effect and the proportion of mediation showed the strength of mediation.

Ethics Approval

The study was approved by the ethical committee of the Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster. Informed written consent was obtained from the parents of each participant.

Results

Descriptive Statistics

Parents of 575 K3 children from 20 kindergartens were invited and 567 agreed to participate (98.6% response rate), of which 11 children having special educational needs were excluded.[12] Characteristics of the remaining 556 participants are shown in Table 1. The mean (SD) age was 5.46 (0.70) years and 288 (51.8%) were female. Families on average owned 1.45 (0.73) televisions, 1.96 (0.93) computers, 0.51 (0.72) game consoles, and 1.31 (0.91) smartphones. Median and interquartile range (IQR) statistics were reported in the Supplementary Table 1. About one-third of the families placed at least one ED in children's bedroom and the most common one was computer (114, 20.5%). More than 80% of the families restricted children's use either in television, computer, or game console, but only 71.6% restricted all three types of the EDs.

School Readiness and Bedroom ED Placement

The associations between school readiness and ED placement are shown in Table 2. Any ED placed in children's bedroom was associated with worse social competence (β -0.29, 95% CI -0.50 to -0.08), emotional maturity (β -0.19, 95% CI -0.35 to -0.03), language and cognitive skills (β -0.24, 95% CI -0.39 to -0.10), communication/general knowledge (β -0.26, 95% CI -0.50 to -0.03), and overall school readiness (β -1.11, 95% CI -1.80 to -0.42). In addition, television and game console placed in children's bedroom was associated with worse physical wellbeing (β -0.37, 95% CI -0.59 to -0.14) and social competence (β -0.94, 95% CI -1.74 to -0.15) respectively.

Moderating roles of SES and Parental Restriction

The correlation between family SES and ED use is shown in Table 3. Families with higher SES had more tablet computers (r 0.28, p<0.001) but fewer portable game consoles (r -0.31, p<0.001). They were less likely to place EDs in children's bedroom (r -0.18, p<0.01) and even less likely to allow ED use without parental restriction (r -0.22, p<0.001).

The effect of bedroom ED placement on a child's school readiness was moderated by family SES (Figure 1A). Placing any ED in children's bedroom significantly reduced children's overall school readiness by 2.26 (95% CI 0.38–4.14) if they were from a lower SES family. The same effect was minimal and statistically insignificant for children in medium and higher SES families. The finding was similar for individual ED analysis.

The interaction of bedroom ED placement and parental restriction is shown in Figure 1B. Placing any ED in children's bedroom without corresponding parental restriction was significantly harmful to children's overall school readiness (β -3.83, 95% CI -5.91 to -1.74). However, if bedroom ED placement was accompanied by the corresponding restriction, its harmful effect did not reach statistical significant level (β -0.54, 95% CI -1.59 to 0.51). The

detailed results on ED-specific and domain-specific analysis can be found in Supplementary Table 2.

Mediation analysis

ED variables' correlation with potential mediators are shown in Table 3. Recreation-based parent-child interaction was negatively associated with ED bedroom placement without restriction (r -0.16, p<0.05). ED variables were not significantly associated with learning-based parent-child interaction and sleep duration, which were not included in the subsequent path analysis.

The potential pathway between school readiness and bedroom ED placement without parental restriction is shown in Figure 2. Numbers shown next to the arrows were the path coefficients. After mutual adjustment, recreation-based parent-child interaction (β 1.01, 95% CI 0.23–1.80) and ED placed in bedroom without restriction (β -1.39, -2.20 to -0.58) were associated with overall school readiness. Accounting for both pathways, ED placed in bedroom were harmful to preschoolers' overall school readiness (β -2.70, 95% CI -3.40 to -2.01). The mediated (indirect) effect of recreation-based parent-child interaction was significant (β -1.31, 95% CI -1.92 to -0.69) and the variable alone explained 48.5% of the association. There was still a significant proportion (51.5%) of the association remained unexplained.

Discussion

It was unclear the impact of ED use on child development, particularly among preschoolers who are more susceptible to environmental influence. The present study enriches our understanding about how bedroom ED placement could affect children's school readiness and highlights the importance of parental restriction. School readiness is a holistic measure of child development at about 5 years of age. Even though the present study could not ascertain the long term effects of early use of EDs, school readiness was found to associate with later

developmental outcomes, such as mathematics and language test scores.[23,24] Our local cohort study in Hong Kong also found that the CEDI predicts children's academic performance, psychosocial well-being and behavioural problems in long run.[25] These highlight the importance of school readiness and the harm of placing EDs in child's bedroom could be substantial.

Previous studies found that placing a television in a child's bedroom was associated with poor academic performance,[26] sleeping problems,[27,28] and higher risk of obesity.[9,28] Echoing with these evidence, we found that the placement of a television in a young child's bedroom resulted in poor developmental outcomes. In addition, attention should be paid to game console's effect on young children's social development. Reduction in 0.94 point over a 10-point scale (~10%) is already alarming but the problem could be even more far-reaching. A large-scale longitudinal study has found that the initial social competence of youths could strongly predict whether they would have video gaming addiction – a severe condition which could greatly reduce their future social skills.[29] Therefore, to avoid initiating this vicious cycle, parents of young children should be very cautious about proper placement of game consoles.

Parental restriction of ED use was found to partially alleviate the negative effect of bedroom ED placement. The moderating effect not only reflect the direct reduction in media exposure but might also indicate the reception of more educational media content. Parents who practiced restrictive mediation generally had better awareness towards media content and were more likely to choose educational and more constructive media content for their children.[30]

The reduction in parent-child interaction was found to be a significant mediator between unrestricted bedroom ED placement and children's school readiness. This observation is

supported by the theory of displacement, which states that excessive and unrestricted media use would displace children's engagement in other interactive and learning activities.[31]

Although technology has been regarded as the "The Great Equalizer"[32,33] to bridge the developmental gap between wealthier and poorer children, our study showed an opposite conclusion. Families from lower SES were more likely to place ED in the child's bedroom and children from lower SES families suffered more from the harmful effect of bedroom ED placement. Our findings are consistent with studies conducted in other regions.[34,35] The exact reasons behind this phenomenon are not well understood, but one possible reason was that parents with higher SES were more capable of choosing educational media content which may benefit child development.[36] On the other hand, parents with lower SES tend to use EDs as a means to keep their children occupied and often are not aware of the media content.[37] Exposure to non-educational media content may increase the risk of subsequent attentional problems.[36] As socioeconomic disparity in early childhood development is a serious global issue,[12] policymakers be cautious whether advanced technology would further widen gap between the rich and the poor.

There are several limitations in this study. First, children in this study were recruited from two districts, which may not be representative of the general population. Nevertheless, the sample provided a socioeconomically diverse dataset, which allowed us to study the influence of SES on ED use. Second, this is a cross-sectional study and the causality between improper ED use and lower school readiness cannot be guaranteed. However, based on literature and clinical experience, it seems unlikely that parents of young children will place ED children's bedroom because of their lower school readiness. Third, the self-reported data from parents could be subject to recall bias and social desirability bias. Parents may under-report the placement of EDs in their child's bedroom if they perceive this as a violation of the social norm. Finally, this study did not collect information on the media content, the context

in which children interacted with EDs, and the quality of childcare, which may affect interpretation of the results. Last but not least, the confidence intervals (CIs) in Table 2 were relatively wide. This indicates that the true effect for ED bedroom placement could be less substantial as shown in the point estimates. Nevertheless, we should also note that the interval estimates appear narrower after accounting for parental restriction (Supplementary Table 2), suggesting the less precise CIs in Table 2 could be due to unaccounted moderators.

Conclusion

Placing ED in children's bedroom was associated with lower school readiness but parental restriction of children's ED use could help to alleviate the harmful effect. Such harmful effect was particularly prominent among children from lower SES families, and was partially mediated by less recreation-based parent-child interactive activities. Future studies on this topic should consider a comprehensive measurement related to children's media exposure, including usage pattern and media content.

Conflict of Interest Disclosure

The authors declare that they have no potential conflicts of interest.

Author Contributions

KWF contributed to the study design, data interpretation, and drafted the manuscript. FKWH analysed and interpreted the data, drafted the manuscript, and is the co-first author. NR contributed to the study conceptualisation, data interpretation, critically reviewed the manuscript, and is the co-corresponding author of this manuscript. FJ interpreted the data, and critically reviewed the manuscript. SLL contributed to the study design, and critically reviewed the manuscript. TMCL and SHSC interpreted the data, and critically reviewed the manuscript. EMY contributed to the study conceptualisation and data interpretation, and critically reviewed the manuscript. PI designed the study, interpreted the data, critically reviewed the manuscript, and is the corresponding author of this manuscript. All authors approved the final manuscript as submitted.

References

1.   Vanderloo LM. Screen-viewing among preschoolers in childcare: a systematic review. *BMC Pediatr.* 2014;14(1):205.
2.   O'Keeffe GS, Clarke-Pearson K, Communications Co, Media. The Impact of Social Media on Children, Adolescents, and Families. *Pediatrics.* 2011;127(4):800-804.
3.   Wright JC, Huston AC, Murphy KC, et al. The relations of early television viewing to school readiness and vocabulary of children from low-income families: the early window project. *Child Dev.* 2001:1347-1366.
4.   Mistry KB, Minkovitz CS, Strobino DM, Borzekowski DL. Children's television exposure and behavioral and social outcomes at 5.5 years: does timing of exposure matter? *Pediatrics.* 2007;120(4):762-769.
5.   Pagani LS, Fitzpatrick C, Barnett TA, Dubow E. Prospective associations between early childhood television exposure and academic, psychosocial, and physical well-being by middle childhood. *Arch Pediatr Adolesc Med.* 2010;164(5):425-431.
6.   Tomopoulos S, Dreyer BP, Berkule S, Fierman AH, Brockmeyer C, Mendelsohn AL. Infant media exposure and toddler development. *Arch Pediatr Adolesc Med.* 2010;164(12):1105-1111.
7.   Duch H, Fisher EM, Ensari I, et al. Association of Screen Time Use and Language Development in Hispanic Toddlers A Cross-Sectional and Longitudinal Study. *Clin Pediatr.* 2013:0009922813492881.
8.   Carson V, Kuzik N, Hunter S, et al. Systematic review of sedentary behavior and cognitive development in early childhood. *Prev Med.* 2015;78:115-122.
9.   Dennison BA, Erb TA, Jenkins PL. Television Viewing and Television in Bedroom Associated With Overweight Risk Among Low-Income Preschool Children. *Pediatrics.* 2002;109(6):1028-1035.
10.   Cain N, Gradisar M. Electronic media use and sleep in school-aged children and adolescents: A review. *Sleep medicine.* 2010;11(8):735-742.
11.   Christakis DA. The effects of infant media usage: what do we know and what should we learn? *Acta Paediatrica.* 2009;98(1):8-16.
12.   Ip P, Rao N, Bacon-Shone J, et al. Socioeconomic Gradients in School Readiness of Chinese Preschool Children: The Mediating Role of Family and Kindergarten. *Early Child Res Q.* 2015;In press.
13.   Tso W, Rao N, Jiang F, et al. Sleep Duration and School Readiness of Chinese Children. *J Pediatr.* 2015;In press.
14.   Forget-Dubois N, Lemelin JP, Boivin M, et al. Predicting early school achievement with the EDI: A longitudinal population-based study. *Early Educ Dev.* 2007:405-426.
15.   Silburn S, Brinkman S, Lawrence D, Sayers M, Goldfeld S, Oberklaid F. Establishing the construct and predictive validity of the Australian Early Development Index (AEDI). *Early Hum Dev.* 2007;83:125.
16.   Janus M, Offord DR. Development and psychometric properties of the Early Development Instrument (EDI): A measure of children's school readiness. *Can J Behav Sci.* 2007;39(1):1.
17.   Ip P, Li SL, Rao N, Ng SS, Lau WW, Chow CB. Validation study of the Chinese Early Development Instrument (CEDI). *BMC Pediatr.* 2013;13:146.
18.   Vyas S, Kumaranayake L. Constructing socio-economic status indices: how to use principal components analysis. *Health Policy Plann.* 2006;21(6):459-468.
19.   Ip P, Tso W, Rao N, et al. Rasch Validation of the Chinese Parent-Child Interaction Scale (CPCIS). *World Journal of Pediatrics.* Under review.

20.	Sadeh A. A brief screening questionnaire for infant sleep problems: validation and findings for an Internet sample. *Pediatrics.* 2004;113(6):e570-577.

21.	Hooper D, Coughlan J, Mullen MR. Structural equation modelling: Guidelines for determining model fit. *Electronic Journal of Business Research Methods.* 2008;6(1):53-60.

22.	Oberski D. lavaan. survey: An R package for complex survey analysis of structural equation models. *Journal of Statistical Software.* 2014;57(1):1-27.

23.	Brinkman S, Gregory T, Harris J, Hart B, Blackmore S, Janus M. Associations between the early development instrument at age 5, and reading and numeracy skills at ages 8, 10 and 12: a prospective linked data study. *Child Indicators Research.* 2013;6(4):695-708.

24.	Forget-Dubois N, Lemelin J-P, Boivin M, et al. Predicting early school achievement with the EDI: A longitudinal population-based study. *Early Educ Dev.* 2007;18(3):405-426.

25.	Ip P, Rao N, Li SL, Chow CB. Chinese Early Development Instrument predicts school achievement and psychosocial well-being after three years: A Chinese cohort study. Working paper.

26.	Borzekowski DG, Robinson TN. The remote, the mouse, and the no. 2 pencil: The household media environment and academic achievement among third grade students. *Arch Pediatr Adolesc Med.* 2005;159(7):607-613.

27.	Garrison MM, Liekweg K, Christakis DA. Media Use and Child Sleep: The Impact of Content, Timing, and Environment. *Pediatrics.* 2011;128(1):29-35.

28.	Chahal H, Fung C, Kuhle S, Veugelers P. Availability and night-time use of electronic entertainment and communication devices are associated with short sleep duration and obesity among Canadian children. *Pediatr Obes.* 2013;8(1):42-51.

29.	Gentile DA, Choo H, Liau A, et al. Pathological video game use among youths: a two-year longitudinal study. *Pediatrics.* 2011:peds. 2010-1353.

30.	Barkin S, Ip E, Richardson I, Klinepeter S, Finch S, Krcmar M. Parental media mediation styles for children aged 2 to 11 years. *Arch Pediatr Adolesc Med.* 2006;160(4):395-401.

31.	O'Connor BD. *Childhood Development and Media Use: A Literature Review of the Effects of Media on Children's Physical and Psychosocial Development*. Washington State: College of Nursing, Washington State University-Spokane, WA; 2012.

32.	Wyer K. The Great Equalizer: Assistive Technology Launches a New Era in Inclusion. *Teaching Tolerance.* 2001;19:25-29.

33.	Hancock A. Technology: The Great Equalizer. *Community college journal.* 2001;72(2):16-21.

34.	Zimmerman FJ, Christakis DA, Meltzoff AN. Television and dvd/video viewing in children younger than 2 years. *Arch Pediatr Adolesc Med.* 2007;161(5):473-479.

35.	Christakis DA, Ebee BE, Rivara FP, Zimmerman FJ. Television, video, and computer game usage in children under 11 years of age. *J Pediatr.* 2004;145(5):652-656.

36.	Zimmerman FJ, Christakis DA. Associations between content types of early media exposure and subsequent attentional problems. *Pediatrics.* 2007;120(5):986-992.

37.	Lareau A. Invisible inequality: Social class and childrearing in black families and white families. *Am Sociol Rev.* 2002;67(5):747-776.

Table 1. Characteristics of the study participants (n=556)

	n (%) / mean (SD)
Sex, n (%)	
Female	288 (51.80)
Male	268 (48.20)
Age, mean (SD), years	5.46 (0.70)
District, n (%)	
Hong Kong Island	254 (45.68)
Yuen Long	302 (54.32)
Number of EDs the family owned, mean (SD)	
Television	1.45 (0.73)
Computer	1.96 (0.93)
Tablet computer	0.55 (0.59)
Smartphone	1.31 (0.91)
Game console	0.51 (0.72)
Portable game console	0.58 (0.78)
Placement of ED in child's bedroom, n (%)	
Any	164 (29.50)
Television	99 (17.81)
Computer	114 (20.50)
Game console	16 (2.88)
Parental restriction of ED use, n (%)	
All EDs	398 (71.58)
Television	447 (80.40)
Desktop/laptop Computer	462 (83.09)
Game console	451 (81.12)
Parent-child interaction score, mean (SD) [range: 0–3]	
Recreation-based	1.86 (0.61)
Learning-based	2.04 (0.66)
Sleep duration, mean (SD), hours	9.41 (1.04)
School readiness, mean (SD)	
CEDI total score [range: 0–50]	43.55 (5.57)
CEDI physical wellbeing [range: 0–10]	8.99 (1.06)
CEDI social competence [range: 0–10]	8.40 (1.68)
CEDI emotional maturity [range: 0–10]	8.35 (1.29)
CEDI language and cognitive skills [range: 0–10]	9.29 (1.22)
CEDI communication and general knowledge [range: 0–10]	8.53 (1.87)

CEDI is a teacher-reported assessment for school readiness.
Median (IQR) of the continuous variables were presented in Supplementary Table 1.

Table 2. Effect of placing electronic devices in children's bedroom on school readiness

	Any ED		Television		Desktop/laptop Computer		Game console	
	β (95% CI)	P	β (95% CI)	P	β (95% CI)	P	β (95% CI)	P
Physical	-0.12 (-0.26 to 0.01)		-0.37 (-0.59 to -0.14)	**	-0.05 (-0.27 to 0.17)		-0.05 (-0.56 to 0.46)	
Social	-0.29 (-0.50 to -0.08)	**	-0.49 (-0.84 to -0.14)	**	-0.28 (-0.62 to 0.06)		-0.94 (-1.74 to -0.15)	*
Emotional	-0.19 (-0.35 to -0.03)	*	-0.29 (-0.55 to -0.02)	*	-0.22 (-0.48 to 0.04)		-0.39 (-0.99 to 0.21)	
Language / Cognitive	-0.24 (-0.39 to -0.10)	**	-0.46 (-0.71 to -0.21)	***	-0.20 (-0.43 to 0.04)		-0.39 (-0.95 to 0.16)	
Communication / General	-0.26 (-0.50 to -0.03)	*	-0.52 (-0.92 to -0.13)	**	-0.18 (-0.56 to 0.21)		-0.78 (-1.68 to 0.11)	
Total	-1.11 (-1.80 to -0.42)	**	-2.13 (-3.27 to -0.98)	***	-0.93 (-2.05 to 0.20)		-2.56 (-5.18 to 0.05)	

*P<0.05, **P<0.01, ***P<0.001.

Adjusted for sex and family SES using multiple regression

School readiness measured using CEDI. Total: total score; Physical: physical wellbeing; Social: social competence; Emotional: emotional maturity; Language / Cognitive: Language and cognitive skills; Communication: Communication and general knowledge; Total: Total School Readiness

19

7   Table 3. Spearman correlations between ED use, family SES, parent-child interaction, and
8   sleep duration

	Family SES	Recreation-based parent-child interaction	Learning-based parent-child interaction	Sleep duration
Family ownership				
Television	-0.04	0.05	0.08	0.07
Computer	-0.02	-0.04	-0.05	-0.04
Tablet computer	0.28 ***	0.16	0.10	0.00
Smartphone	0.10	0.14	0.13	0.11
Game Console	-0.08	0.10	0.02	0.04
Portable Game Console	-0.31 ***	-0.05	0.01	0.02
Placement in the child's bedroom				
Any of below	-0.18 **	0.00	0.00	-0.03
Television	-0.18 **	0.01	0.02	-0.03
Desktop/Laptop Computer	-0.12	-0.01	-0.02	-0.04
Game Console	-0.10	0.01	0.02	-0.01
ED placed in bedroom without corresponding parental restriction				
Any of below	-0.22 ***	-0.16 *	-0.10	-0.05
Television	-0.21 ***	-0.16 *	-0.10	-0.06
Desktop/Laptop Computer	-0.14	-0.09	-0.05	-0.05
Game console	-0.08	-0.18 **	-0.11	-0.02

9   **P<0.01, ***P<0.0001

Figure 1. Panel A: Effect of bedroom ED placement on school readiness moderated by family SES. Panel B: Effect of bedroom ED placement on school readiness moderated by parental restriction

Ref: Reference group for comparison.
*P<0.05, ***P<0.001.
Adjusted for sex and family SES

19   Figure 2. Path model to explore the mechanism between ED use and children's school
20   readiness
21
22   Adjusted for sex and family SES. These two variables are not shown in the figure for clarity.
23   Model fit indices: CLI=0.96; TLI=1.00; RMSEA (95% CI)=0.00 (0.00–0.07); SRMR=0.003
24   *P<0.05, **P<0.01, ***P<0.001.
25