

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

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ABSTRACT

Objective To investigate whether school readiness could be affected by placing electronic devices (EDs) 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% of parents placed at least one ED in their children's bedroom. After controlling for sex and SES, the placement of television in the bedroom was associated with lower overall school readiness ($\beta -1.11$, 95% CI -1.80 to -0.42) and the placement of game console was associated with lower social competence ($\beta -0.94$, 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.

Conclusion 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.

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 EDs 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 to children's cognitive development,³ sociobehavioural skills⁴ and physical well-being.⁵ Nevertheless, the effects of other EDs are far less studied and the evidence so

What is already known on 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 children'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 an electronic device in the child's bedroom.

far varied. For example, a US infant cohort study⁶ identified a negative association between media use and language development, but another cohort study⁷ focusing on Hispanic toddlers in the USA concluded none. In fact, a recent systematic review⁸ 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 USA 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 socio-emotional development. Furthermore, these studies also omitted possible moderators (such as socioeconomic status (SES) and parental restriction on ED use)¹⁰ and mediators (such as parent-child interaction and sleep duration).¹¹



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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 SES and (4) to explore the extent to which 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 US\$3149, while HKI was ranked top (US\$4240) and YL was ranked bottom (US\$2680).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 readiness¹² 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 $\alpha \geq 0.90$, except for physical well-being domain with $\alpha = 0.70$) 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 1-day orientation workshop, hands-on trials and continuous support by PI, NR 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 well-being, 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 to 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 to 50.

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.

Electronic devices

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 EDs 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?').

Family SES

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 that the family had a higher SES. The SES index was categorised into three levels with tertiles as cut-offs in moderation analysis for easier understanding.

Parent-child interaction

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-reported item on the average number of hours the child slept per day in the past week, including both daytime naps and night-time sleeps. Previous studies have found the parent-reported 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

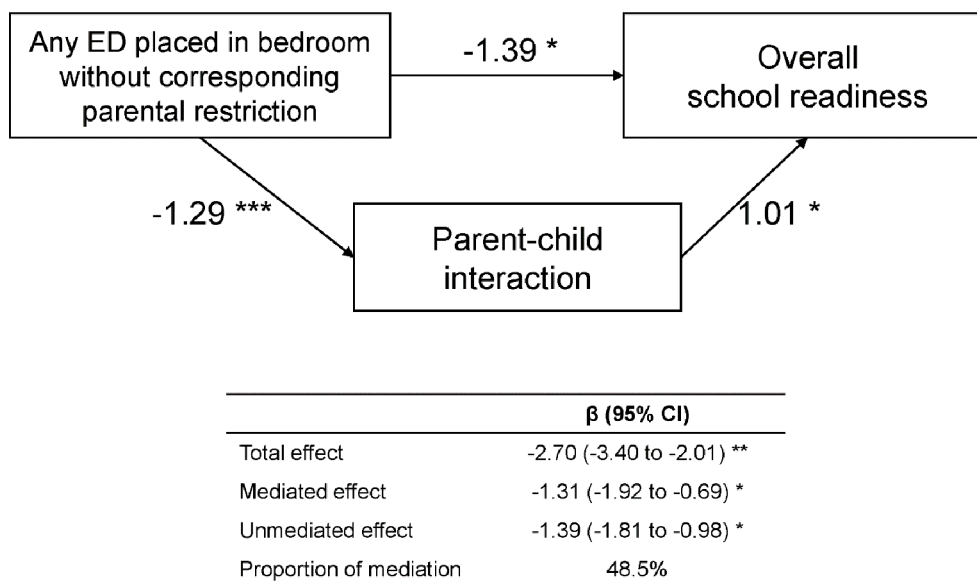


Figure 1 Path model to explore the mechanism between electronic device (ED) use and children's school readiness, adjusted for sex and family socioeconomic status. These two variables are not shown in the figure for clarity. Model fit indices: Comparative Fit Index=0.96; Tucker-Lewis Index=1.00; root mean square error of approximation (95% CI)=0.00 (0.00 to 0.07); standardised root mean square residual=0.003. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

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 first 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 1). 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 (TLI), 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 IQR statistics were reported in the online supplementary table 1. About one-third of the families placed at least one ED in the children's bedroom and the most common one was computer

(114, 20.5%). More than 80% of the families restricted children's use of either 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 the children's bedroom was associated with worse social competence ($\beta -0.29$, 95% CI -0.50 to -0.08), emotional maturity ($\beta -0.19$, 95% CI -0.35 to -0.03), language and cognitive skills ($\beta -0.24$, 95% CI -0.39 to -0.10), communication/general knowledge ($\beta -0.26$, 95% CI -0.50 to -0.03) and overall school readiness ($\beta -1.11$, 95% CI -1.80 to -0.42). In addition, television and game console placed in the children's bedroom was associated with worse physical well-being ($\beta -0.37$, 95% CI -0.59 to -0.14) and social competence ($\beta -0.94$, 95% CI -1.74 to -0.15), respectively.

Moderating roles of SES and parental restriction

The correlation between family SES and EDs 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 the 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 2A). Placing any ED in the children's bedroom significantly reduced children's overall school readiness by 2.26 (95% CI 0.38 to 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 2B. Placing any ED in the children's bedroom without corresponding parental restriction was significantly harmful to children's overall school readiness ($\beta -3.83$, 95% CI -5.91 to -1.74). However, if bedroom ED placement was accompanied by the corresponding restriction, its harmful effect did not

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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 well-being (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 online supplementary table 1.

CEDI, Chinese Early Development Instrument; ED, electronic device.

reach a statistically significant level ($\beta -0.54$, 95%CI -1.59 to 0.51). The detailed results on ED-specific and domain-specific analyses can be found in online supplementary table 2.

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 socioeconomic status using multiple regression.

School readiness measured using Chinese Early Development Instrument. Total: total score; Physical: physical well-being; Social: social competence; Emotional: emotional maturity; Language/cognitive: language and cognitive skills; communication: communication and general knowledge; total: total school readiness.

ED, electronic device.

Table 3 Spearman correlations between ED use, family SES, parent-child interaction and 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 the 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

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.0001$.

ED, electronic device; SES, socioeconomic status.

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 1. Numbers shown next to the arrows were the path coefficients. After mutual adjustment, recreation-based parent-child interaction ($\beta 1.01$, 95% CI 0.23 to 1.80) and ED placed in the bedroom without restriction ($\beta -1.39$, 95% CI -2.20 to -0.58) were associated with overall school readiness. Accounting for both pathways, ED placed in the bedroom were harmful to preschoolers' overall school readiness ($\beta -2.70$, 95% CI -3.40 to -2.01). The mediated (indirect) effect of recreation-based parent-child interaction was significant ($\beta -1.31$, 95% CI -1.92 to -0.69) and the variable alone explained

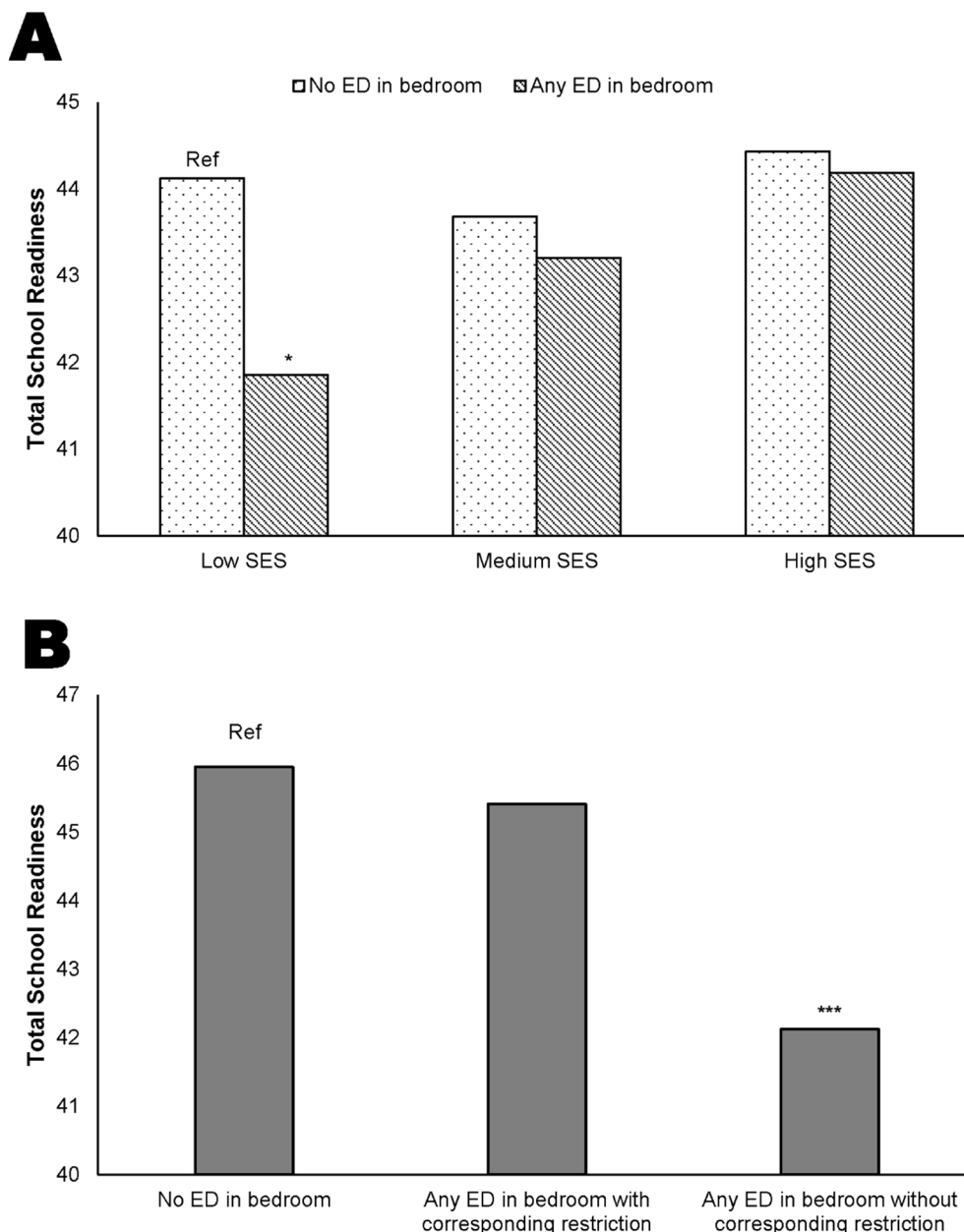


Figure 2 (A) Effect of bedroom electronic device (ED) placement on school readiness moderated by family socioeconomic status (SES). (B) Effect of bedroom ED placement on school readiness moderated by parental restriction. Adjusted for sex and family SES. * $p < 0.05$, *** $p < 0.001$. Ref, reference group for comparison.

48.5% of the association. There was still a significant proportion (51.5%) of the association that remained unexplained.

DISCUSSION

The impact of ED on child development, particularly among preschoolers who are more susceptible to environmental influence, was unclear. 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 be associated 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 the long run. These highlight the importance of school readiness, and the harm of placing EDs in the children's bedroom could be substantial.

Previous studies found that placing a television in a child's bedroom was associated with poor academic performance,²⁵ sleeping problems^{26 27} and higher risk of obesity.^{9 27} 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.²⁸ 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 reflects the direct reduction in media exposure and also indicates the reception of more educational media content. Parents who practised restrictive mediation generally had better awareness towards media content and were more likely to choose educational and more constructive media content for their children.²⁹

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.³⁰

Although technology has been regarded as the ‘The Great Equalizer’^{31–32} 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.^{33–34} 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.³⁵ 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.³⁶ Exposure to non-educational media content may increase the risk of subsequent attentional problems.³⁵ As socioeconomic disparity in early childhood development is a serious global issue,¹² policy-makers should be alerted 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 data set, 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 the literature and clinical experience, it seems unlikely that parents of young children will place ED in the 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 child-care, which may affect interpretation of the results. Last but not least, the 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 (see online supplementary table 2), suggesting that the less precise CIs in [table 2](#) could be due to unaccounted moderators.

CONCLUSION

Placing ED in the 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.

Correction notice This paper has been amended since it was published Online First. Owing to a scripting error, some of the publisher names in the references were replaced with ‘BMJ Publishing Group’. This only affected the full text version, not the PDF. We have since corrected these errors and the correct publishers have been inserted into the references.

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Contributors K-wF 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 and 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. TM-CL and SH-SC interpreted the data and critically reviewed the manuscript. MEY 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.

Competing interests None declared.

Ethics approval Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster.

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