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Screen-based Media Use and Blood Pressure in Preschool-aged Children: A Prospective Study in The Odense Child Cohort

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Abstract

Aims: To examine prospective and cross-sectional associations between screen time and blood pressure (BP) in preschool-aged children.

Methods: The Odense Child Cohort study started in January 2010. Children who were born in the municipality of Odense underwent a clinical examination at 3 and 5 years of age, while parents were asked to answer a questionnaire. A total of 628 children were included in the prospective analysis, while 964 children were included in two cross-sectional analyses at 5 years of age. Multivariable adjusted linear and logistic regression models were computed to examine prospective and cross-sectional associations between screen time and BP with adjustment for putative confounding factors.

Results: No significant prospective associations were found between two-year change in screen time and systolic BP (0.55 BP percentile change per 1-hour screen time increase, 95% confidence interval (CI): -1.51;2.60) and diastolic BP (0.74 BP percentile change per 1-hour screen time increase, 95% CI: -1.09;2.57). No significant cross-sectional associations were observed between screen time (≤1 hour/day, >1–2 hours/day, >2 hours/day) and prevalence of high BP at 5 years of age. Exposure to screen time before bedtime 2–5 days/week and ≥6 days/week was significantly associated with greater prevalence of high BP compared to screen time before bedtime 0–1 day/week; Odds Ratios 1.57 (95% CI 1.02;2.42) and 1.82 (95% CI 1.18;2.89), respectively.

Conclusions: No prospective associations were found between screen time and BP. However, a significant cross-sectional association was found between screen time before bedtime and high BP in preschool-aged children.

Keywords: screen time; preschool; cohort study; hypertension

Word count (excluding the abstract, references, figures and tables): 3190

Abbreviations

BP	Blood Pressure
ISCED	International Standard Classification of Education
BMI	Body Mass Index
CI	Confidence Interval

Background

Today, screen media devices such as tablets, smartphones, computers, and televisions are ubiquitous in children's everyday lives. According to the latest report from Common Sense Media, 2- to 4-year old children spend two hours and 39 minutes per day on screen media activities.[1] Children's time spent on screen media could displace time spent on other activities such as free unstructured play. Furthermore, screen time during evening hours could postpone bedtime, which could shorten sleep duration. It is not unlikely that children's screen media behaviour may contribute to poor health behaviour. Studies have suggested that several factors, including unhealthy food intake,[2] overweight,[3] physical activity level,[4] and sleep duration,[5] are related to screen time habits and these factors are also well-known risk factors of high blood pressure (BP).

High BP is the leading risk factor for mortality from cardiovascular diseases in adults[6] and efforts to prevent development of high BP is of major importance to alleviate this burden. BP level is known to track from childhood into adulthood.[7] Meta-analyses of prospective observational studies have reported that high screen time use is related to greater risk of fatal and non-fatal cardiovascular disease in adults.[8, 9] Few prospective studies have investigated the relationship between screen time and BP in school-aged children and to the best of our knowledge only cross-sectional studies have been carried out among preschool-aged children.[10-14] In addition, screen time before bedtime is suspected to alter BP via a decrease in sleep duration.[15, 16] To further investigate the importance of screen time in early life the primary objective of this study was to examine prospective associations between two-year change in screen time and systolic and diastolic BP. The secondary objective was to examine the cross-sectional association between screen time and prevalence of high BP at 5 years of age. The tertiary objective was to examine the cross-sectional association between screen time before bedtime and prevalence of high BP at 5 years of age. It is hypothesized that screen time and screen time before bedtime is positively associated with BP and increased prevalence of high BP.

Methods

Ethics

The Odense Child Cohort study was approved by The Regional Committees on Health Research Ethics for Southern Denmark (S-20090130). The examinations took place at Hans Christian Andersen Children's Hospital. The hospital is located in the municipality of Odense which has a social distribution comparable to the rest of Denmark (192,000 residents). Written informed consent was obtained from all parents of the participating children.[17] Data can be obtained by contacting Henriette Boye Kyhl (henriette.kyhl@rsyd.dk).

Enrolment

All women with registered pregnancies between January 1st 2010 and December 31st 2012 were eligible (n = 6,707). Further details on the enrolment process can be found in Figure 1 and Kyhl et al.[17] A total of 2,874 pregnant women were enrolled which resulted in 2,665 enrolled children. A total of 1,541 (58%) children contributed with clinical examination data and/or questionnaire data at 3 years of age (baseline). Baseline data was collected between August 2013 and December 2016 and follow-up data, two years later, was collected between August 2015 and January 2019.

Outcomes

Systolic and diastolic BP were assessed at baseline and follow-up with an electronic oscillometric device (Welch/Allyn - Vital Signs Series 6000). This type of device has been found to be a valid and suitable alternative to auscultation and an appropriate screening tool in paediatric populations.[18] The cuffs (Welch/Allyn Flexiport Cuffs) used had a cuff-bladder length covering 80-100% of the circumference of the arm. Children were instructed to be calm and seated in a chair. The cuff was placed on the child's left arm with the *Artery Index Marker* positioned over the brachial artery. A single BP measurement was completed for each child by trained personnel. BP percentiles were calculated to age-, height-, and sex-specific percentiles according to the Clinical Practice Guideline for Screening and Management of High Blood Pressure in Children and Adolescents.[19] High BP was defined as systolic and/or diastolic BP above the 95th percentile.[19]

Exposures

At baseline, parents were asked to quantify their child's daily screen time (0 min., 1–29 min., 30–59 min., 1–2 hours, 3–4 hours, and >5 hours) across four different screen media categories (TV, video game consoles, tablet/PC and smartphone). At follow-up, parents were asked to quantify their child's daily screen time (0 min., 1–29 min., 30–59 min., 1–2 hours, 2–3 hours, and >3 hours) in two different screen media categories (video games/computer/tablet and TV/movies) for a typical weekday and a typical weekend day. These categorical variables were transformed to continuous variables using the middle value of each category (e.g. 1–29 min =15 min). As the highest categories (>5 hours and >3hours) had no upper bounds it was assumed that these categories had the same minute range in terms of screen time as the preceding category. Total screen time/day at baseline was calculated by adding the amounts of the four screen device categories. Total screen time/day at follow-up was calculated by adding the amounts from the two screen device categories and then weighing weekday screen time by 5/7 and weekend screen time by 2/7. The questions regarding screen time are similar to the questions in the Sedentary Behaviour Questionnaire, which has been reported to have good reliability.[20] Parents reported how many days/week their child use screen-based media devices within the last hour before bedtime. Answers were collapsed to form a categorical variable (screen time before bedtime) with three levels (0–1 day/week, 2–5 days/week and ≥6 days/week).

Covariates

Self-reported maternal ethnicity was classified as born in Denmark and not born in Denmark. Maternal educational level according to the International Standard Classification of Education (ISCED) were obtained from the enrolment questionnaire. Birthweight (kg) was obtained from the Danish Medical Birth Register. Parents reported a number between 0–31 days/month that their child usually consume a meal containing fish. A healthy diet often include fish, and screen time and blood pressure have both been related to unhealthy food intake. Thus, in an attempt to adjust for dietary pattern, fish consumption was included as a putative confounding factor. Body height and weight were assessed at both clinical examinations and body mass index (BMI) was calculated and converted into three categories (grade 1–3 thinness, normal weight, overweight/obesity) using international gender and age-specific BMI-cut-offs.[21] Parents reported their child's usual wake-up and bedtime, and a sleep duration variable was calculated by weighing weekday sleep by 5/7 and weekend sleep by 2/7. The sleep variable did not include information on daytime napping or sleep disturbances. Parents reported their child's physical activity level compared to peers (much less, somewhat less, around the same, somewhat more, much more). Dichotomization of this variable was necessary due to few observations in the lowest and highest category.

Statistical Analysis

Two prospective and two cross-sectional analyses were conducted with children as the unit of analysis. Participants were included in the respective analyses if they had complete data on exposure, outcome and covariates relating to the analysis in question. The primary objective, which was to examine the prospective associations between change in total screen time and systolic and diastolic BP percentile at 5 years of age, was examined using multiple linear regression. The models were initially adjusted for birthweight, maternal educational level, maternal ethnicity, fish consumption at baseline and at follow-up, screen time at baseline, systolic or diastolic BP percentile at baseline, and follow-up time. Additional adjustment for BMI, sleep duration and physical activity level at baseline and at follow-up were made in separate models to explore the extent to which these variables might confound or mediate the association. In a sensitivity analysis we ran multiple imputation by chained equations including all covariates and respective outcomes to investigate the possibility of selection bias. We obtained β coefficients and standard errors based on 20 imputed datasets. We suspected that adiposity could be the primary confounder or mediator in the relationship between screen time and blood pressure. To explore this suspicion, we conducted an additional analysis with change in BMI z-score as the outcome. The secondary and tertiary objective, which was to examine the cross-sectional association between screen time (≤1 hour/day, >1–2 hours/day and >2 hours/day) and screen time before bedtime (0–1 day/week, 2–5 days/week and ≥6 days/week) and prevalence of high BP at 5 years of age, was examined using multivariable logistic regression. These models were adjusted according to the same protocol as in the analyses using multiple linear regression. The statistical analyses were performed in Stata15 software using an α-level of 0.05.

Results

Descriptive data on participants (individuals with complete data at baseline) and non-participants (individuals with incomplete data at baseline) are shown in Table 1. The proportion of participants, whose mother completed an education above ISCED level 4 or were born in Denmark, were greater among participants compared to non-participants (Table 1).

Table 2 shows the baseline characteristics of the 848 participants in the prospective analysis across three screen time categories <1 hour/day, ≥1–2 hours/day and >2 hour/day. Participants were similar with respect to all variables across the screen time groups (<1 hour/day, ≥1–2 hours/day and >2 hour/day), except for birthweight and physical activity compared to peers. (Table 2). Please consults supplementary table 1 for baseline characteristics on participants vs. dropouts.

Prospective Analysis

Screen Time and Blood Pressure

A total of 628 participants (74%) had complete data at two-year follow-up (Figure 1) and average follow-up time was 2.00 (SD 0.09) years. Total screen time at baseline was on average 1.11 (SD 0.66) hours/day. No significant associations were found between two-year change in screen time and systolic (0.55 percentile, 95% confidence interval (CI): -1.51;2.60) and diastolic BP (0.74 percentile, 95% CI: -1.09;2.57) at 5 years of age, after adjustment for baseline BP percentile and confounding factors. The model was also run without adjustment for BP at baseline, but this had no significant impact on the result. Beta coefficients from separate multiple regression models with additional adjustments for BMI, habitual sleep duration and physical activity level at baseline and at follow-up varied marginally from the model without these adjustments (Table 3). The association between two-year change in screen time and systolic (1.08 percentile, 95% (CI): -1.29;2.44) and diastolic BP (1.01 percentile, 95% CI: -0.81;2.84) were fairly similar in the analyses where missing values were imputed (n=848). Associations between screen time categories and blood pressure was included in supplementary table 2 to enhance comparability with previous studies.

Screen Time and BMI

To explore if change in screen time had an influence on BMI at 5 years of age, we ran an additional multiple linear regression analysis using a BMI z-score as the outcome variable. We made similar statistical adjustments as in the models above, excluding adjustments for BMI category and BP. No significant associations were found between two-year change in screen time and BMI z-score (-0.005, 95% CI: -0.06; 0.05).

Cross-sectional Analyses at 5 years of age

Screen Time and Prevalence of High Blood Pressure

The first cross-sectional analysis included 964 children with complete data on exposure, outcome and all covariates at 5 years of age. Total screen time was on average 1.49 (SD 0.82) hours/day. High BP was present in 46 of 278, 83 of 448, and 49 of 238 individuals in the respective screen time groups (≤1 hour/day, >1–2 hours/day and >2 hours/day). No significant associations were found between total screen time and prevalence of high BP at 5 years of age, after adjustment for confounding factors; odds ratios were 1.18 (95% CI: 0.79;1.77) for screen time >1–2 hours/day and 1.35 (95% CI: 0.86;2.12) for screen time >2 hours/day compared to ≤1 hour/day of total screen time. Further adjustment for BMI, habitual sleep time and physical activity level did not notably change the results (Table 4).

Screen Time Before Bedtime and Prevalence of High Blood Pressure

The second cross-sectional analysis was based on 963 children with complete data on exposure, outcome and all covariates at 5 years of age. High BP was present in 34 of 255, 84 of 430, and 60 of 278 individuals in the respective screen time before bedtime groups (0–1 days/week, 2–5 days/week and ≥6 days/week). Screen time before bedtime was significantly associated with prevalence of high BP at 5 years of age, after adjusting for confounding factors. The prevalence odds ratios for participants with screen time before bedtime 2–5 days/week and ≥6 days/week were 1.57 (95% CI: 1.02;2.42) and 1.82 (95% CI: 1.14;2.89) respectively, compared to screen time before bedtime 0–1 day/week. Additional adjustment for BMI, habitual sleep duration and physical activity level did not alter the results (table 4). Results were also statistically significant when screen time before bedtime was included as a continuous variable 0–7 days/week (odds ratio: 1.09, 95% CI: 1.02;1.16).

Discussion

Based on recently collected prospective data from a population-based sample of Danish preschool-aged children followed over two years, no significant prospective associations were found between total screen time and BP. The cross-sectional analyses revealed no significant associations between total screen time use and prevalence of high BP, however, amount of days/week with screen time before bedtime was associated with a greater prevalence of high BP.

The prospective results of the current study differ from the results of the prospective studies that have examined the relationship between screen time and BP in children. A large prospective study using data collected between 2007 and 2010 (n = 5,061) by de Moraes et al. found that engagement in screen time activities >2 hours/day compared to <2 hours/day was associated with a 28 percent increased risk of high BP in 2–9 year-olds.[10] However, in contrast to the current study, no attempt to adjust for ethnicity, birth weight, or dietary pattern was made, which are potential confounding factors. Another prospective study (n = 698) by Gopinath et al. investigated 6 year-olds using data collected between 2003-2011 and found that each additional hour of screen time at baseline was positively associated with a 0.69 mmHg and 0.59 mmHg increase in diastolic and mean arterial BP at five-year follow-up, respectively.[11] A major possible explanation for the discordant findings between studies may be the fairly large differences in screen time exposure level in the study populations. In de Moraes et al., 48.9 and

39.9 percent of the included boys and girls had >2 hours of screen time per day, respectively, and in Gopinath et al. the average exposure to screen time was 1.91 hours per day at baseline.[10, 11] In the current study, average exposure to screen time was only 1.11 and 1.49 hours/day at baseline and follow-up, respectively. Since screen time is likely to increase with age, the relatively large age difference may also explain the discrepancy in the results.[22] Another explanation may be the fact that the screen media landscape has changed considerably within recent years; studies suggest use of mobile screen devices has increased from 4 percent in 2011 to 34 percent in 2017 among 0- to 8-year-olds.[1] Also it is possible that the societal norm has shifted on screen use in recent years. The desire to conform to a perceived societal norm may increase the likelihood of underreporting, and the potential for this bias could be more widespread in our study with baseline assessment starting in 2013 vs. 2003 and 2007 in Gopinath et al. and de Moraes et al. respectively.

The cross-sectional analysis at 5 years of age, which showed no association between total screen time and prevalence of high BP, are in agreement with cross-sectional results found by Chinapaw et al. (5- to 6-year-olds) and Crispim et al. (2- to 5-year-olds)[13, 14]. In contrast, Stamatakis et al. found a significant positive association between TV-viewing and both systolic and diastolic BP among 2- to 12-year-olds. However, a limitation in the study by Stamatakis et. al. is that the potential impact of weight status was not investigated.[12]

The present study contributes to the literature with unique knowledge on the relationship between screen time before bedtime and prevalence of high BP in preschool-aged children. We found a significant relationship between screen time before bedtime and BP, suggesting that children who engage in screen time before bedtime have increased odds of high BP. This association was not explained by sleep duration. However, a study by Magee et al. suggest that the relationship between screen time and sleep duration may be bidirectional.[23] In relation to this, our finding could be explained by reverse causation since children may use screen media devices before bedtime due to trouble falling asleep. Unquestionably, this is a complex relationship that warrants further investigation in other samples of young children.

Strengths and Limitations

The current study has some major strengths compared to previous studies. Firstly, the prospective design where information on exposure, outcome, and confounding factors were obtained at both baseline and at follow-up, which takes into account that variables may vary over time. Secondly, the analyses are based on a relatively large sample of preschool-aged children from a well-known source population. Despite these strengths, the results of the current study must to be interpreted with the following limitations in mind. Firstly, it is inevitable that parent-reported screen time will increase random measurement error. Furthermore, it may also have introduced recall bias, social desirability bias and bias due to partly unknown exposure status (as the parent may not know the full scope of the child's screen time habits). The limitations described above are expected to introduce lower ratings of exposure and decrease statistical precision. However, one cannot be sure if they cause non-differential or differential misclassification of exposure; therefore, the direction of bias is unknown. Objective measurement of screen time would have solved these problems; however, such methodologies are still to be developed. Secondly, the single BP measurement protocol used in the current study has previously been found to introduce differences compared to a multiple measurement protocol.[24] A classification that is based on a single measurement will most likely overestimate the prevalence of high blood pressure and introduce false-positive readings. However, we expect the error caused by the BP measurement protocol to be random, which would most likely introduce non-differential misclassification, potentially widening the confidence intervals in our prospective analyses where BP is on a continuous scale and inducing bias towards the null in our cross-sectional analysis due to presence of false-positive high BP readings.[25] Thirdly, although thorough adjustments were made to address potential confounders, residual confounding and unknown confounding cannot be ruled out. Fourthly, drop-outs or missing data may have introduced selection bias in the current study. However, results from the multiple imputation analyses did not differ from those of the complete case analyses in the primary prospective analyses. Finally, reverse causation cannot be ruled out.

Conclusions

In conclusion, no evidence was found of a prospective or cross-sectional relationship between screen time and BP among Danish preschool-aged children. However, exposure screen time before bedtime was significantly associated with increased prevalence of high BP at 5 years of age. These results must be interpreted in light of the limitations of the current study. Experimental studies of efficacy of limiting screen-based media use, which are still lacking, are warranted to further investigate the putative effect of high screen time on BP in young people considering the potential impact it could have in primordial prevention of later cardiovascular diseases in adulthood.

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Declaration of Conflicts of Interest

The authors declare that there is no conflict of interest.

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Table 1 – Characteristics of participants vs. non-participants

Characteristics	Participants	Non-participants	P-value	Total n
Gender (% males)	52.36% (n = 848)	52.61% (n = 1817)	[a] 0.902	2665
Birthweight (kg)	3.51 ± 0.53 (n = 848)	3.47 ± 0.59 (n = 1816)	[b] 0.058	2664
Maternal educational level				
ISCED 1–3	22.41%	29.53%		
ISCED 4	9.32%	11.89%		
ISCED 5–6	42.81%	39.00%		
ISCED 7–8	25.47% (n = 848)	19.58% (n = 1236)	[a] <0.001*	2084
Maternal ethnicity (% Born in Denmark)	93.99% (n = 848)	89.74% (n = 1238)	[a] 0.001*	2086

Table 1 shows descriptive data on participants with complete data vs. non-participants (individuals with incomplete data at baseline). Data are presented as proportions (%) or means ±SD of the group. Significant differences are marked *(p<0.05). Categorical variables were compared using chi^2-test ([a]). Continuous parametric variables were compared using a two-sample t-test ([b]). Number of children (n) varied among non-participants due to incomplete data at examinations preceding baseline.

Table 2 – Baseline characteristics (n = 848)

Participant characteristics	**Total Screen Time <1hour/day** (n = 318)	**Total Screen time ≤1–2 hours/day (n = 467)**	**Total Screen Time >2 hours/day** (n = 63)	**All participants** (n = 848)	**P-value**
Gender (% males)	50.00%	52.89%	60.32%	52.36%	[a]0.307
Birthweight (kg)	3.44 ± 0.55	3.55±0.50	3.58±0.65	3.51±0.53	[b]0.015*
Maternal educational level					
ISCED 1–3	21.07%	22.70%	26.98%	22.41%	
ISCED 4	9.75%	8.78%	11.11%	9.32%	
ISCED 5–6	42.14%	44.11%	36.51%	42.81%	
ISCED 7–8	27.04%	24.41%	25.40%	25.47%	[a] 0.857
Maternal ethnicity (% born in Denmark)	93.08%	94.65%	93.65%	93.99%	[a] 0.659
Fish consumption (days/month)	7.91 ± 7.26	8.19 ± 7.25	8.80 ± 8.21	8.13± 7.32	[b] 0.391
BMI					
Grade 1–3 thinness	11.32%	13.70%	23.81%	13.56%	
Normal weight	82.70%	81.80%	69.84%	81.25%	
Overweight/obese	5.97%	4.50%	6.35%	5.19%	[a] 0.243
Habitual sleep duration (hours)	11.16 ± 0.55	11.11 ± 0.55	10.88 ± 0.61	11.11± 0.56	[b] 0.539
Physical activity level compared to peers (% somewhat more or much more physically active)	28.62%	21.20%	20.63%	23.94%	[a] 0.047*

Table 2: Data are presented as proportion (%) or mean ±SD of the group. Significant differences ($p<0.05$) are marked *. Categorical variables were compared using chi^2-test ([a]). Continuous parametric variables were compared using a One-Way ANOVA ([b]).

Table 3 – Prospective associations between two-year change in screen time and systolic and diastolic blood pressure at 5 years of age

	Model 1 Beta coefficient (95% CI)	Model 2 Beta coefficient (95% CI)	Model 3 Beta coefficient (95% CI)	Model 4 Beta coefficient (95% CI)	Model 5 Beta coefficient (95% CI)
Systolic blood pressure percentile (n = 628)	0.55 (-1.51;2.60)	0.59 (-1.47;2.65)	0.56 (-1.50;2.61)	0.53 (-1.52;2.59)	0.59 (-1.48;2.65)
Diastolic blood pressure percentile (n = 628)	0.74 (-1.09;2.57)	0.70 (-1.13;2.54)	0.76 (-1.07;2.59)	0.65 (-1.17;2.48)	0.64 (-1.20;2.48)

Table 3: Beta coefficients (95% CI) are two-year change in blood pressure percentiles per hour change in screen time. Model 1 included adjustments for blood pressure percentile at baseline, total screen time at baseline, birthweight, maternal educational level, maternal ethnicity, fish consumption at baseline and follow-up, and follow-time. Model 2: Included all variables in model 1 and additional adjustment for BMI at baseline and follow-up. Model 3: Included all variables in model 1 and additional adjustment for habitual sleep duration at baseline and follow-up. Model 4: Included all variables in model 1 and additional adjustment for physical activity level at baseline and follow-up. Model 5: Included all variables in model 1, 2, 3, and 4.

Table 4 – Cross-sectional analysis at 5 years of age

	Model 1 OR (95% CI) for presence of high blood pressure	**Model 2** OR (95% CI) for presence of high blood pressure	**Model 3** OR (95% CI) for presence of high blood pressure	**Model 4** OR (95% CI) for presence of high blood pressure	**Model 5** OR (95% CI) for presence of high blood pressure
Screen time and prevalence of high blood pressure (n = 964)					
Total screen time ≤ 1 hour/day (n = 278)	(Reference)	(Reference)	(Reference)	(Reference)	(Reference)
Total screen time >1–2 hours/day (n = 448)	1.18 (0.79;1.77)	1.17 (0.78;1.75)	1.19 (0.0.79;1.1.78)	1.20 (0.80;1.80)	1.20 (0.80;1.80)
Total screen time > 2 hours/day (n = 238)	1.35 (0.86;2.12)	1.35 (0.86;2.12)	1.36 (0.86;2.14)	1.39 (0.88;2.19)	1.40 (0.88;2.21)
Screen time before bedtime and prevalence of high blood pressure (n = 963)					
Screen time before bedtime 0-1 days/week (n = 255)	(Reference)	(Reference)	(Reference)	(Reference)	(Reference)
Screen time before bedtime 2–5 days/week (n = 430)	1.57 (1.02;2.42)	1.57 (1.02;2.43)	1.57 (1.02;2.43)	1.56 (1.01;2.40)	1.57 (1.02;2.43)
Screen time before bedtime ≥6 days/week (n = 278)	1.82 (1.14;2.89)	1.84 (1.16;2.93)	1.82 (1.15;2.90)	1.79 (1.13;2.85)	1.82 (1.14;2.91)

Table 4: Odds Ratios (95% CI) are presented for screen time >1–2 hours/day and >2 hours/day compared to the reference ≤1 hour/day and for screen time before bedtime 2–5 days/week and ≥6 days/week compared to the reference 0–1 days/week. Model 1: Included adjustments for birthweight, maternal educational level, maternal ethnicity and fish consumption. Model 2: Included all variables in model 1 and additional adjustment for BMI at 5 years of age. Model 3: Included all variables in model 1 and additional adjustment for habitual sleep duration at 5 years of age. Model 4: Included all variables in model 1 and additional adjustment for physical activity level at 5 years of age. Model 5: Included all variables in model 1, 2, 3, and 4.

Figure 1 – Flow chart

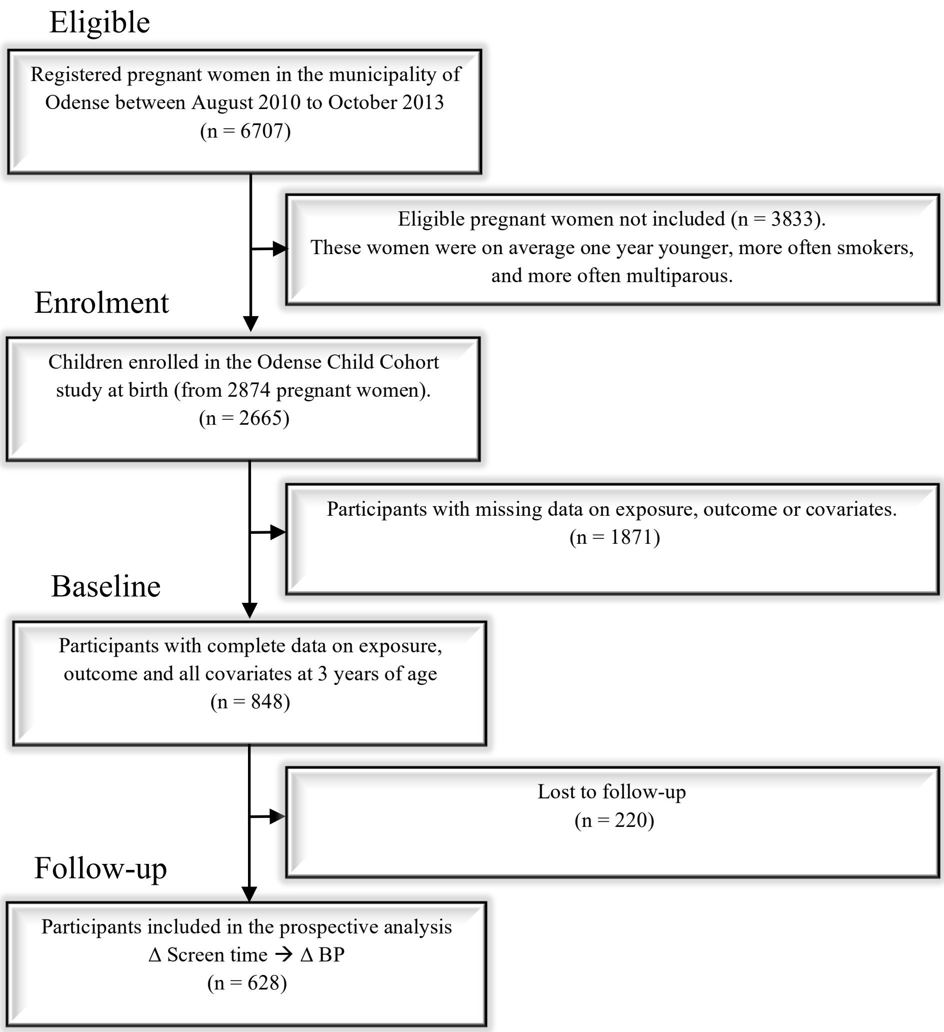

Figure 1: Flow of participants from being eligible to analytic sample in the primary analysis.