

1 Television-watching in the early years of life and the association with parents' concerns  
2 about decreased visual acuity in their elementary school-aged child: results of a  
3 nationwide population-based longitudinal survey of Japan

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5 Running head: Television-watching and vision concern

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24

25 **Abstract**

26 **Purpose** To study the association between television-watching in the earlier years of life  
27 and subsequent parents' concerns about decreased visual acuity in their elementary  
28 school-aged child.

29 **Study design** Population-based longitudinal cohort.

30 **Methods** Television-watching and its daily duration, as the main exposure, and parents'  
31 concerns for their child's decreased visual acuity during the school years, as the main  
32 outcome, were picked up from yearly questionnaires performed for the Longitudinal  
33 Survey of Newborns in the 21st Century involving all babies born in Japan during 2  
34 periods: between January 10 and 17, 2001 and between July 10 and 17, 2001 (N =  
35 47,015).

36 **Results** Television/video-watching as the main play of children at the age of 1.5 years  
37 and 2.5 years was significantly associated with parents' concerns for their child's  
38 decreased visual acuity raised once or more in 6 surveys conducted between the ages of  
39 7 and 12 years (odds ratio, 1.1 and 1.09; 95% CI, 1.05-1.15 and 1.04-1.14,  
40 respectively). The association remained significant after adjustment for confounding  
41 variables, including child's sex, preterm birth, multiple birth, mother's age at delivery,  
42 mother's and father's education, and residential area. Longer daily duration of  
43 television-watching at 2.5 years was significantly associated with concerns for the  
44 child's decreased visual acuity between the ages of 7 and 12 years, but not at the ages of  
45 3.5, 4.5, and 5.5 years. The association remained significant in a sensitivity analysis of  
46 28,820 children who participated in all 6 surveys.

47 **Conclusions** Longer daily exposure to television in children in the earlier years of life  
48 was associated with subsequent parents' concerns for decreased visual acuity in their  
49 elementary school-aged child.

50

51 **Keywords** children, longitudinal study, school ages, television-watching, visual acuity

52

## 53 **Introduction**

54 Visual acuity testing in children in Japan begins at the age of 3.5 years as part of the  
55 health checkup [1, 2], in accordance with the Maternal and Child Health Act, and is also  
56 done at the age of 5 years in kindergartens and just before the child enters elementary  
57 school at the age of 6 years. Thereafter, visual acuity is tested as part of the child's  
58 health checkups in school every year from the ages of 6 to 18 years, in accordance with  
59 the School Health and Safety Act [3, 4]. Parents receive a notice from schools to have  
60 their child's visual acuity tested by an eye doctor and to have a relevant document filled  
61 in and then returned to the school. This social system for children's health care in Japan  
62 highlights why parents tend to have concerns for the visual acuity of their children  
63 during their school years.

64 In the general field of pediatric healthcare, television-watching has long been  
65 thought to affect various aspects of child development, not only visual development but  
66 also mental and behavioral development [5]. In addition, television as well as gadgets in  
67 the earlier years of life have behavioral and social impacts on children [6]. In the field  
68 of ophthalmology, case reports showed that frequent use of smartphones by children  
69 may be a precipitating factor for the development of acute-onset esotropia [7, 8].  
70 However, until now, no study has addressed whether television-watching in the earlier  
71 years of life affects the visual acuity of children in the later years of life.

72 A longitudinal study is necessary to determine the impact of television on the  
73 subsequent vision of children. The government of Japan has been conducting a  
74 nationwide population-based longitudinal survey of babies born in 2001 as part of the  
75 nation's vital statistics. Data on television-watching as a habit and daily duration of  
76 television-watching in the earlier years of life were collected in yearly questionnaires

77 conducted for in the Longitudinal Survey of Newborns in the 21st Century (2001  
78 cohort), which followed children born in a certain period of the year 2001 [9]. In this  
79 study, these data were used to determine the association between television-watching in  
80 the earlier years of life and subsequent vision problems in the school years.

81

## 82 **Methods**

### 83 *Data source and participants*

84       The Longitudinal Survey of Newborns in the 21st Century (2001 cohort) has been  
85 conducted as part of the nation's vital and health statistics, based on the Statistics Act,  
86 by the Ministry of Health, Labor and Welfare of the Government of Japan every year  
87 since 2001 [9]. Participants in the 2001 cohort were all babies born in Japan between  
88 January 10 and 17, 2001 or between July 10 and 17, 2001. The first questionnaire for  
89 53,575 infants at the age of 6 months was sent to the families in 2001 and 2002, and the  
90 number of responses was 47,015 (87.8%). The 15<sup>th</sup> questionnaire, as the latest, was sent  
91 in 2016 to families of 31,408 children at the age of 15 years, and the number of  
92 responses was 28,810 (91.7%). In the yearly survey, the response rate ranged from  
93 87.8% to 93.5% (Table 1). The data for descriptive statistics in the yearly surveys have  
94 been published on the ministry's website. The non-linkable anonymized data sets for  
95 analytic epidemiologic studies were provided to Okayama University from the  
96 government of Japan with administrative permission after the ethical approval of the  
97 study. This retrospective study of the data collected in this nationwide survey  
98 conformed to the tenets of the Declaration of Helsinki and was approved by the Ethics  
99 Committee of Okayama University Graduate School of Medicine, Dentistry, and  
100 Pharmaceutical Sciences and Okayama University Hospital (identifier, 1506-073).

101 The survey questions changed from year to year, according to the age of the  
102 participants and the administrative requirements. The second and third surveys in  
103 children at the ages of 1.5 and 2.5 years had a question, “What kind of play?” and had  
104 an answer to choose, “Watch television or video,” in the list of other forms of play such  
105 as drawing, singing, and outdoor walking. The third to sixth surveys, conducted at the  
106 ages of 2.5, 3.5, 4.5, and 5.5 years, had a question, “How long to watch television?” to  
107 which the respondent could answer a daily duration of 0 to 1 hour, 1 to 2 hours, 2 to 3  
108 hours, or 3 hours or more. Six surveys from the 7<sup>th</sup> to the 12<sup>th</sup> surveys, conducted at the  
109 ages of 7 years to 12 years, had a question as to concerns for the child raised by parents,  
110 “The visual acuity of the child has gotten worse.” The period of observation in this  
111 longitudinal cohort was 12 years after birth in each child (Table 1).

#### 112 *Exposure and outcome indicators*

113 In this study, the number of “Yes” answers to the question about having concerns  
114 about the child’s decreased visual acuity raised by parents once or more in 6 surveys  
115 conducted from the ages of 7 to 12 years were used as the main outcome. “Yes” answers  
116 to the questions about television-/video-watching as the main form of play at the ages of  
117 1.5 and 2.5 years and about daily duration of television-watching at the ages of 2.5, 3.5,  
118 4.5, and 5.5 years were used as explanatory variables or the main exposure (Table 2).  
119 **D**aily duration of television-watching was categorized at 4 levels: from 0 to less than 1  
120 hour, 1 hour to less than 2 hours, 2 hours to less than 3 hours, and 3 hours or more.

121 To reconfirm the relation with the exposure and outcome in the overall data sets,  
122 which were rather incomplete, a sensitivity analysis was conducted. In the sensitivity  
123 analysis, the data were restricted to the 28,820 children who participated in all 6 surveys  
124 conducted from the ages of 7 to 12 years. The main outcome was defined as a “Yes”

125 answer as to parents' concerns for child's decreased visual acuity "twice or more" in the  
126 6 surveys. The main exposure was the same as that described in the main analysis.

### 127 *Statistical analysis*

128 In the statistical analysis using STATA software (version 16; StataCorp), the odds  
129 ratio and 95% CI (confidence interval) were calculated in the presence of the main  
130 exposure, television-/video-watching, in comparison with the absence of the main  
131 exposure. In the case of daily duration of television-watching, the odds ratio and 95%  
132 CI were calculated for the daily duration of 1 to 2 hours, 2 to 3 hours, and 3 hours or  
133 more, in comparison with daily duration of 0 to 1 hour. The child's sex, preterm birth,  
134 multiple birth, maternal age at child's birth, maternal cigarette smoking, mother's and  
135 father's education levels, and residential area were defined as confounding variables on  
136 the basis of our previous studies using the same data set.<sup>10-15</sup>

137

### 138 **Results**

139 Television-/video-watching as the main form of play of children at the age of 1.5 years  
140 as the exposure was significantly associated with the outcome of "Yes" answer as to  
141 having concerns for child's decreased visual acuity raised by parents once or more in  
142 the survey at the ages of 7 to 12 years (odds ratio [OR], 1.1; 95% CI, 1.05-1.15). The  
143 association remained significant (OR, 1.1; 95% CI, 1.05-1.15) after adjustment for  
144 confounding variables including child's sex, preterm birth, multiple birth, mother's age,  
145 mother's and father's education, and residential area (Tables 3 and 4).

146 Television-/video-watching as the main form of play of children at the age of 2.5  
147 years as the exposure was significantly associated with the outcome of "Yes" answer as  
148 to having concerns for child's decreased visual acuity raised by parents once or more in

149 the survey at the ages of 7 to 12 years (OR, 1.09; 95% CI, 1.04-1.14). The association  
150 remained significant (OR, 1.09; 95% CI, 1.04-1.15) after adjustment for confounding  
151 variables including child's sex, preterm birth, multiple birth, mother's age at delivery,  
152 mother's and father's education, and residential area (Table 3, 4).

153 At the age of 2.5 years, daily duration of television-watching, 2 to 3 hours and 3  
154 hours or more, compared with television-watching for 0 to 1 hour was significantly  
155 associated with parents' concerns for the child's decreased visual acuity at elementary  
156 school age, whilst no significant association was found between the parents' concerns  
157 and daily duration of television-watching for 1 to 2 hours (Table 5). The association  
158 remained significant after adjustment for confounding variables. Daily duration of  
159 television-/video-watching at the ages of 3.5, 4.5, and 5.5 years was not associated with  
160 parents' concerns for child's decreased visual acuity at elementary school age (Table 5).

161 In the sensitivity analysis of the 28,820 children who participated in all 6 surveys  
162 between the ages of 7 and 12 years, the number of children who raised parents' concerns  
163 for their decreased visual acuity was 915 (3.1%) at the age of 7 years, 1714 (5.9%) at 8  
164 years, 4181 (14.5%) at 9 years, 5360 (18.6%) at 10 years, 6145 (21.3%) at 11 years, and  
165 6456 (22.4%) at 12 years. Television-/video-watching as the main form of play of  
166 children at the ages of 1.5 years and 2.5 years was significantly associated with parents'  
167 concerns for child's decreased visual acuity raised twice or more in the survey at the  
168 ages of 7 to 12 years (Table 6). Only at the age of 2.5 years, daily duration of television-  
169 watching, 1 to 2 hours, 2 to 3 hours, and 3 hours or more, compared with television-  
170 watching for 0 to 1 hour, was significantly associated with parents' concerns for child's  
171 decreased visual acuity raised twice or more in the survey at the ages of 7 to 12 years  
172 (Table 7).



173

174 **Discussion**

175 The goal of this study, as a clinical question, was to determine whether television-  
176 watching in the earlier years of life leads to subsequent development of vision problems  
177 in children at elementary school age. At visual acuity testing in schools every year in  
178 Japan, the visual acuity in decimals with glasses or contact lenses is measured in each  
179 eye and marked into 4 grades: 1.0 or better as A, 0.9 to 0.7 as B, 0.6 to 0.3 as C, and 0.2  
180 or worse as D. In the case of grade B, C, or D, parents are notified with a document  
181 stating the visual acuity grade of each eye of the child and asked to have the child visit  
182 an eye clinic to undergo an examination. Under these circumstances, parents and family  
183 members naturally have concerns for child's decreased visual acuity every year at the  
184 notice issued from the school. Decreased visual acuity during school age is mainly  
185 attributed to the progression of myopia [16-21].

186 In this study, we demonstrated that television-watching at the ages of 1.5 and 2.5  
187 years in children was a risk factor for subsequent parents' concerns for child's decreased  
188 visual acuity at elementary school ages. Especially at the age of 2.5 years, longer daily  
189 duration of television-watching tended to be associated with a greater odds ratio for the  
190 association in the sensitivity analysis of the 28,820 children who participated in all 6  
191 surveys between the ages of 7 and 12 years. Television-watching at the age of 2.5 years  
192 and the parents' concerns raised twice or more for child's decreased visual acuity at  
193 elementary school age might have a dose-response relationship. The decreased visual  
194 acuity is probably be due to the progression of myopia at these ages, as mentioned  
195 above [16-21]. It should be noted that longer daily duration of television-watching at the  
196 younger age of 2.5 years was an underlying factor for subsequent visual acuity

197 problems at elementary school age, whereas longer daily duration of television-  
198 watching at the older ages of 3.5, 4.5, and 5.5 years did not have such consequences.  
199 These facts suggest that exposure to television only in the earlier years of life, but not in  
200 the later years of life, might affect subsequent progression of myopia at elementary  
201 school age.

202 Television-watching has been shown to have social and behavioral effects on  
203 children [5, 10]. The results of this study add further that exposure to television in the  
204 earlier years of life, younger than 3 years, carries a risk for subsequent development of  
205 visual acuity problems at elementary school age. Children in the earlier years of life,  
206 who were here shown to be prone to having the subsequent influence induced by  
207 television-watching, are indeed in the process of visual development associated with  
208 visual plasticity, the so-called critical period [22], which is most active up to the age of  
209 3 years. In this sense, it is understandable that in this study, television-watching in  
210 children at the age of 3 years or older did not lead to subsequent visual acuity problems  
211 at school age.

212 In parallel with this study, near work and outdoor activity were tested to  
213 determine whether they were associated with visual acuity and refractive error in a  
214 cross-sectional study of Chinese school children at the ages of 10 and 11 years [23].  
215 Interestingly at these ages, computer use and smartphone use were positively associated  
216 with higher degrees of myopia, whilst television-watching was not associated with the  
217 degree of myopia. Those results might be along the same lines as the present results that  
218 television-watching only in the earlier years of life influence later decreased visual  
219 acuity, presumably by myopia, at school age.

220 The general epidemiologic limitations in this nationwide cohort with yearly  
221 questionnaires are the yearly dropout of participants and the filling-in accuracy in  
222 answering each question. As for the yearly dropout, the return rate of questionnaires at  
223 each year was about 90%, and yearly questionnaires were sent mainly to parents who  
224 had sent back the questionnaire in the preceding year. Therefore, the number (32,065) of  
225 the 12<sup>th</sup> questionnaire returned at the age of 12 years was 68% of the number (47,015)  
226 of the first questionnaire returned at the age of 0.5 years (Table 1). As for the accuracy  
227 of the data, the availability of data for television-watching as a main form of play at the  
228 ages of 1.5 and 2.5 years was above 90%. In contrast, the data for daily duration of  
229 television-watching at the age of 2.5 years were available for about 90% of the  
230 respondents, whilst those data at the ages of 3.5, 4.5, and 5.5 years were available at the  
231 level between 80% and 90%. Furthermore, the data availability for parents' concerns  
232 about their child's decreased visual acuity was as low as 65%. To cope with the yearly  
233 participant dropout and the data availability in the nationwide cohort, we conducted a  
234 sensitivity analysis in the limited cohort of 28,820 children who participated in all 6  
235 surveys at the ages of 7 to 12 years. The main outcome was defined as "Yes" answer as  
236 to parents' concerns for child's decreased visual acuity "twice or more" in 6 surveys at  
237 the ages of 7 to 12 years. Even in this sensitivity analysis, television-watching in the  
238 earlier years of life was associated with parents' concerns for child's decreased visual  
239 acuity at school age.

240 The confounding variables in this study were chosen from the viewpoint of our  
241 previous studies using the same nationwide longitudinal cohort [10-15] and were not  
242 based on their statistical significance. Adhering to statistical significance would carry  
243 the risk of missing crucial confounding variables [24]. Differential misclassification as

244 information bias would be negligible in this study since the timing of the main exposure  
245 and that of the main outcome were different and did not overlap with each other in the  
246 time course of the yearly questionnaires. Television-watching and its daily duration,  
247 chosen as the exposure, were in earlier years of life, whilst parents' concerns for child's  
248 decreased visual acuity, chosen as the main outcome, were at the ages from 7 to 12  
249 years in elementary school enrollment.

250 A major limitation specific to this study is that the main outcome was concerns  
251 for the child's decreased visual acuity raised by parents or family members, but not the  
252 real documentation of the visual acuity decrease in the children. Because the survey has  
253 started in 2001, there was no question regarding smartphone or tablet personal computer  
254 (PC) use in the 2001 cohort. There is another cohort of babies born in 2010 that has  
255 been followed longitudinally in parallel with the cohort of babies born in 2001. The  
256 survey in the 2010 cohort included questions about smartphone and tablet PC use.  
257 Future studies, using the 2010 cohort, may elucidate the effect of other gadgets in  
258 children at younger ages.

259 As for the epidemiologic methods used in this study, we believe that the overall  
260 data sets, although incomplete, are desirable to have an overview of the relation with  
261 exposure and outcome. To assess the reliability of the results using the overall data sets,  
262 the same exposure and outcome were tested in the selected group of children who  
263 participated in all 6 surveys at the ages of 7 to 12 years as the sensitivity analysis.  
264 Survival analysis was not chosen as an epidemiologic method in this study because the  
265 time span, for instance between 1.5 years and 7 years, could not be assessed accurately  
266 in the present questionnaire-based survey. Furthermore, the timing of outcome at a  
267 specific age was not the point of our clinical question in this study. Our clinical question

268 was simply to know whether children with the exposure in the earlier years of life  
269 would have the outcome in the 6-year period in elementary school.

270 In conclusion, to the best of our knowledge, this nationwide population-based  
271 longitudinal study is the first to demonstrate that television-watching only in the earlier  
272 years of life, but not in the later years, leads to the later consequence of visual acuity  
273 problems at elementary school age. Care must be taken in terms of television-watching  
274 especially in children in the process of visual development, younger than 3 years.

275

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278

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