

1 **Title:** The diurnal pattern and social context of screen behaviours in adolescents: a cross-sectional  
2 analysis of the Millennium Cohort Study.

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## 13 Abstract

14 **Background:** Screen behaviours are highly prevalent in young people and excessive screen use may  
15 pose a risk to physical and mental health. Understanding the timing and social settings in which young  
16 people accumulate screen time may help to inform the design of interventions to limit screen use.  
17 This study aimed to describe diurnal patterns in adolescents' screen-based behaviours and examine  
18 the association of social context with these behaviours on weekdays and weekend days.

19 **Methods:** Time use diary data are from the sixth wave (2015/2016) of the Millennium Cohort Study,  
20 conducted when participants were aged 14 years. Outcome variables were electronic games/Apps,  
21 TV-viewing, phone calls and emails/texts, visiting social networking sites and internet browsing. Social  
22 context was categorised as alone only, parents only, friends only, siblings only, parents and siblings  
23 only. Multilevel multivariable logistic regression was used to examine the association between social  
24 contexts and screen activities.

25 **Results:** Time spent in TV-viewing was greatest in the evening with a peak of 20 minutes in every hour  
26 between 20:00 and 22:00 in both sexes on weekdays/weekend days. Time spent using electronic  
27 games/Apps for boys and social network sites for girls was greatest in the afternoon/evening on  
28 weekdays and early afternoon/late evening on weekend days. Screen activities were mainly  
29 undertaken alone, except for TV-viewing. Compared to being alone, being with family members was  
30 associated with (Odds Ratio (95% Confidence Interval)) more time in TV-viewing in both boys and girls  
31 throughout the week (Weekdays: Boys, 2.84 (2.59, 3.11); Girls, 2.25 (2.09, 2.43); Weekend days: Boys,  
32 4.40 (4.16, 4.67); Girls, 5.02 (4.77, 5.27)). Being with friends was associated with more time using  
33 electronic games on weekend days in both sexes (Boys, 3.31 (3.12, 3.51); Girls, 3.13 (2.67, 3.67)).

34 **Conclusions:** Reductions in screen behaviours may be targeted throughout the day but should be  
35 sensitive to differing context. Family members, friends, and adolescent themselves may be important  
36 target groups in behaviour change interventions. Future research to address the complex interplay

37 between social context, content and quality of screen behaviours will aid the design of behaviour  
38 change interventions.

39 **Keywords:** screen behaviours, adolescents, diurnal pattern, social context, time-use diary, cross-  
40 sectional.

## 41 Background

42 Screen behaviours are highly prevalent in young people and excessive screen use may contribute to  
43 an increased risk of cardio-metabolic syndrome, mental health disorders, and poor academic  
44 attainment.(1–4) The most prevalent screen activities include TV-viewing, tablet and smart-phone  
45 use,(5) with data showing that more than half of young people exceed current screen-time  
46 recommendations of 2 hours a day.(6) Considering that these behaviours track into adulthood,(7) it is  
47 important for interventions to target them early in life.

48 Changing health behaviours requires an understanding of the factors that influence behaviour and the  
49 context in which they occur. The socio-ecological framework serves as a useful model for outlining the  
50 factors that might impact engagement in screen behaviours. This is because socio-demographic,  
51 environmental, and social factors play a key role in determining the accumulation of individuals'  
52 screen time.(8–10) It is likely that humans behave differently in different contexts due to their innate  
53 ability to transform and connect in different ways at different times with a changing environment.(11)

54 Several recent studies have examined the social context in which young people's screen behaviour  
55 occurs, highlighting possible locations for the delivery of behavior change interventions.(12,13) For  
56 example, previous research has shown that adolescents who spent more time alone after school  
57 reported higher screen-time than those who were with family or friends.(13) Much of this previous  
58 work, however, has focused on composite measures of screen time, aggregating data on different  
59 types of behaviour, such as TV-viewing and computer use. The Royal College of Paediatrics and Child  
60 Health advise against the use of composite screen-time markers in light of emerging evidence that the  
61 different behaviours may be differentially associated with health and wellbeing.(14) To mitigate health  
62 risks, the development of interventions therefore should be informed by understanding of the context  
63 in which specific screen-based activities take place.

64 In addition to understanding the social and environmental context of screen-based activity,  
65 understanding its distribution across the day may also be informative for intervention design,

66 highlighting periods of the day when specific behaviours are likely to occur. Previous research has  
67 shown that accelerometer measured time spent sedentary was greater after-school than before or  
68 during school,(15) with around half of this time spent using screens.(12) Evidence also suggests that  
69 the afternoon and evening period during weekends represents the largest accumulation of sedentary  
70 time.(15) However, our understanding is limited by the paucity of evidence regarding the timing of  
71 different types of screen activities throughout the day. There is evidence that sedentary behaviour  
72 patterns differ between boys and girls and that the determinants of these behaviours may also differ  
73 by sex,(8) but we have limited information about how contextual factors may vary by sex. A recent  
74 study reported no difference by sex in where adolescents spent their after-school and weekday  
75 evening periods, or who they spent time with, but screen time was derived as a composite measure  
76 rather than by specific activity in that work, potentially masking true variation.(13)

77 There is a need to better understand the timing and contexts in which screen behaviours take place if  
78 interventions to address them are to be targeted precisely. This evidence will help to identify which  
79 agents of change to target (i.e. parents, peers), where interventions should be implemented (e.g.  
80 home, school) and/or the time of day (e.g. preschool, evening) that intervention strategies should be  
81 activated.(16) The aim of this study, therefore, is to describe diurnal patterns in adolescents' screen-  
82 based behaviours and examine the association of social context with these behaviours at weekdays  
83 and weekend days.

## 84 **Methods**

### 85 **Sample and data collection**

86 Data are from the Millennium Cohort Study (MCS), a national longitudinal birth cohort study run by  
87 the Centre for Longitudinal Studies at the University College London. The MCS examines the social,  
88 economic, and health related circumstances of young people born in 2000-2002, recruited from all  
89 four countries of the UK (England, Scotland, Wales and Northern Ireland).(17,18) The MCS was  
90 nationally representative at inception and 18,552 families (18 818 children) were recruited at baseline.

91 Data collection has taken place when participants were 9 months, and 3, 5, 7, 11, 14, and 17 years of  
92 age. This cross-sectional analysis uses data from the sixth wave of assessment (MCS6; data collection:  
93 January 2015-April 2016), when participants were aged 14 years. In MCS6, 15,415 families were  
94 contacted for participation; 11,884 participants from 11,726 families provided partial or complete  
95 data. Parents and cohort members provided written and verbal consent prior to completing the  
96 survey.(19) The MCS6 was approved by the National Research Ethics Service, Research Ethics  
97 Committee London – Central (REC ref: 13/LO/1786). Data were anonymised and obtained from the  
98 UK Data Service (<http://doi.org/10.5255/UKDA-SN-8156-7>).

### 99 Time-use diary

100 Participants were invited to complete a time-use diary, available in 3 formats: online via the web, App  
101 via tablet or phone, and paper. Sixty-four percent of participants selected the App diary format, 29%  
102 used the online version and 7% the paper diary. Participants completed the diary for two randomly  
103 chosen days (one weekday and one weekend day) with behaviour recorded in 10-minute slots from  
104 4am to 4am the next day. For each slot, participants indicated their main activity, selecting from a pre-  
105 specified list of 44 activities, nested within 12 categories (the full list of activity codes is presented in  
106 Additional file 1). In addition to reporting their main activity, cohort members also reported who they  
107 were with at that time, selecting from one or more of the following five options: alone, parents,  
108 siblings, friends, other adults.

109 Six screen-based activities were chosen for this analysis: electronic games and Apps, TV-viewing,  
110 phone calls, emails/texts, visiting social networking sites and internet browsing. Data were aggregated  
111 to mean minutes per hour spent in each activity, separately for weekdays and weekend days.

112 Reports of adolescents' social context (i.e., 'who they were with') were coded into six categories: alone  
113 only, parents only, friends only, siblings only, parents and siblings only and other grouping (i.e., a  
114 combination of parents and friends and/or parents, friends and other adults).

## 115 Covariates

116 Participants sex, family income, ethnicity, body mass index (BMI) and home location (rural or urban  
117 classification) were included as potential covariates in the analysis.(20) Indicators for home location  
118 were derived by geographically linked data across the four countries that specified whether  
119 participants were located in rural/urban areas based on population density.(21) Family income was  
120 measured using the Organisation for Economic Co-operation and Development (OECD) equivalised  
121 income quintiles, based on parent-reported household income. Ethnicity was parent-reported and  
122 categorised as White, Mixed, Indian, Pakistani and Bangladeshi, Black or Black British, and Other Ethnic  
123 group (including Chinese). Weight and height were measured by trained research assistants. Body  
124 mass index (BMI) was calculated as weight divided by height squared ( $\text{kg}/\text{m}^2$ ) and International  
125 Obesity Task Force (IOTF) thresholds were used to categorise participants as underweight/normal  
126 weight, overweight and obese.(22)

127

## 128 Data analysis

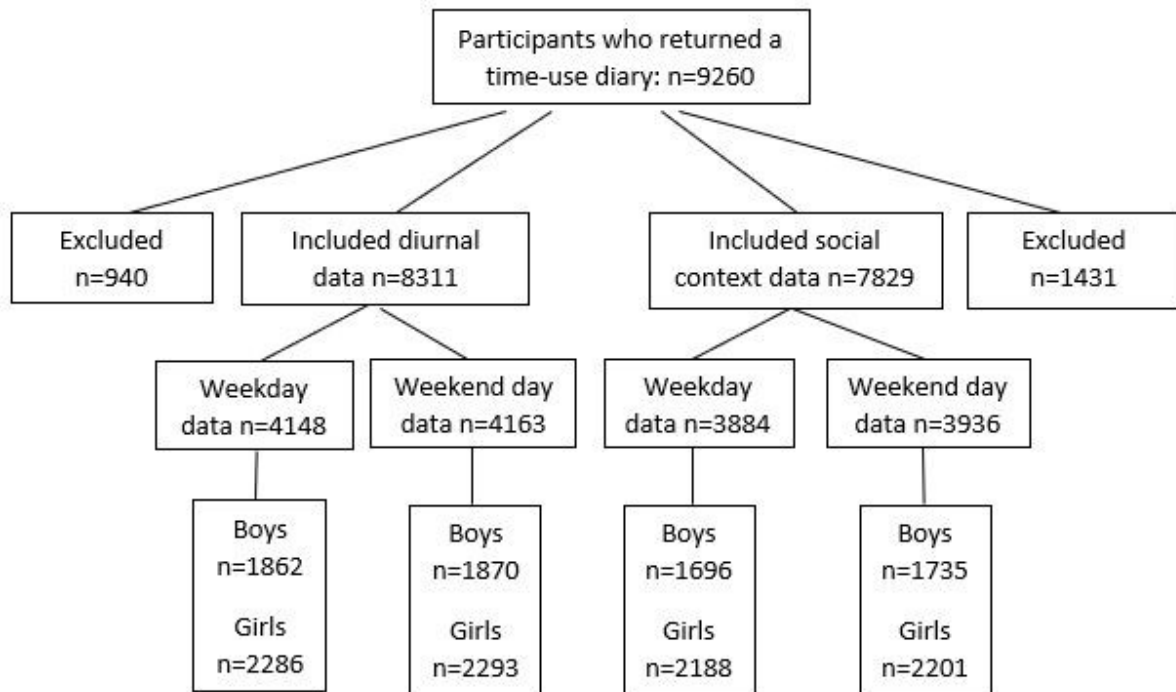
129 Analyses were conducted using STATA 16.0 (Stata Corporation, Texas, USA), with survey commands  
130 used to account for the stratified clustered design of MCS. Due to differences in the social and  
131 environmental contexts in which participants were immersed, analyses were conducted separately  
132 for week and weekend days. To describe diurnal patterns in each of the selected behaviours, data  
133 were aggregated to summarise duration (minutes) in each behaviour for each hour of the 24h period  
134 of assessment. Social context information is presented as the proportion of time reported in each of  
135 the 6 contexts, separately for each behaviour of interest. Screen behaviour duration data were highly  
136 skewed; therefore, behavioural outcomes were dichotomised (no screen activity vs. screen activity)  
137 in the analysis of associations with social context. In addition, due to infrequent reports in phone calls,  
138 text/emails, using social network sites and internet browsing we created two composite outcomes for  
139 use in this analysis: (1) phones, texts, and emails, (2) using social network sites and internet browsing.

140 Reports of TV-viewing and electronic games/apps were analysed individually. Multilevel multivariable  
141 logistic regression was used to assess associations between social contexts (i.e., who the adolescents  
142 were with) and screen activities. All models were adjusted for weight status, ethnicity, family income  
143 and home location. In preliminary analyses, we examined whether associations between social  
144 context and screen behaviours were moderated by sex, sibling status, ethnicity, socioeconomic  
145 position and family structure. Interaction terms were non-significant in all instances except for sex.  
146 Accordingly, all analyses were conducted separately for boys and girls. To account for the limited  
147 occurrence of screen-activities before and during school hours, weekday analysis of social context  
148 were restricted to the after-school period (15.00-23.00). Analyses of weekend data focussed on the  
149 full 24h period.



## 150 Results

151 Data were available for 9,251 diaries, of which 1,431 were excluded due to missing data on social  
152 context and 940 were excluded due to missing data on diurnal pattern. Figure 1 shows diary and data  
153 inclusion. The analytical samples for diurnal and social context analyses were  $n=8,311$  and  $n=7,829$   
154 respectively. Drop-out analysis indicated that participants included in the analyses were more likely  
155 to be of white ethnicity ( $P < 0.001$ ), have normal weight ( $P < 0.05$ ) and come from families with higher  
156 income ( $P < 0.05$ ) compared to those who were excluded.



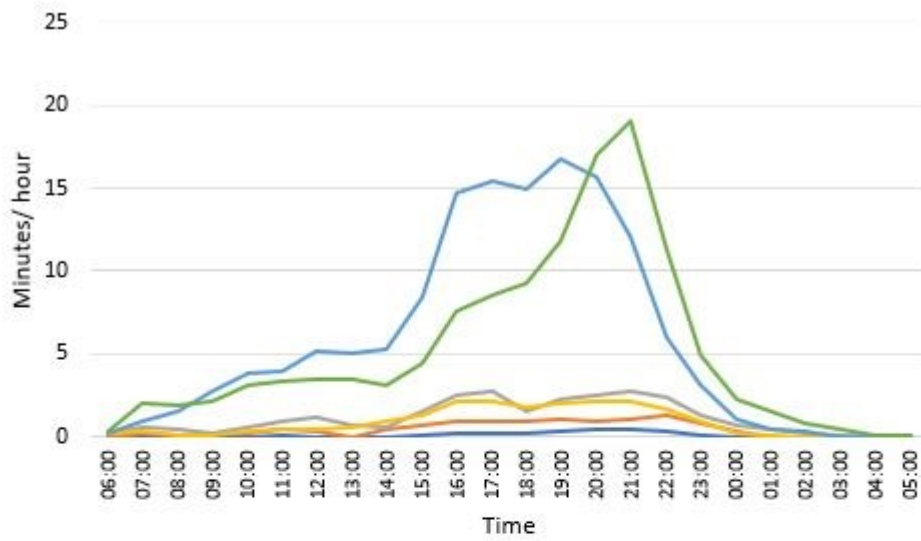
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158 **Figure 1.** Participants who provided diurnal and social context data.

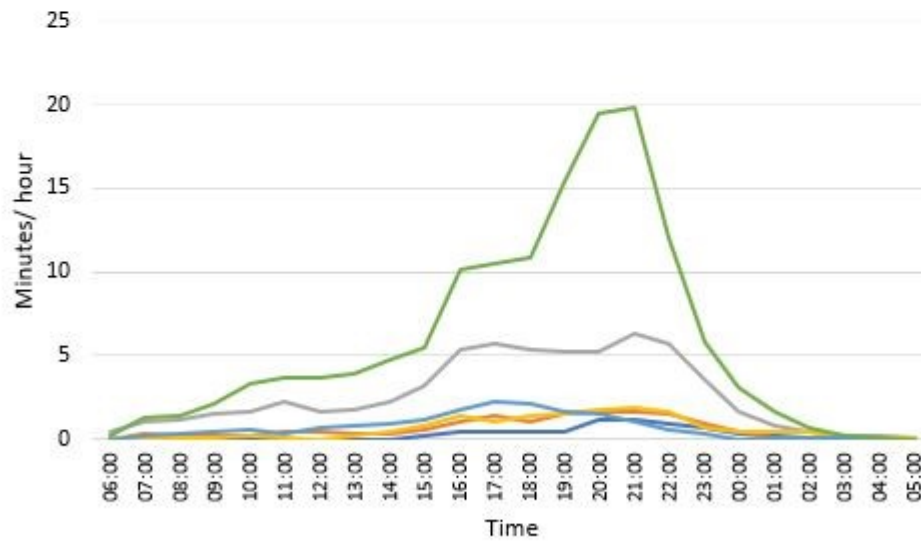
## 159 Diurnal patterns in screen activities

160 Figure 2 shows time spent in screen activities on a weekday, separately for boys and girls. Between  
161 midnight and 06:00, all screen behaviours accounted for less than 5 minutes in every hour. The most  
162 prevalent screen behaviour was TV viewing in both sexes, followed by electronic games/apps in boys  
163 and using social networking sites in girls. The time spent viewing TV was greatest in the evening, rising  
164 gradually from approximately 15:00 onwards to a peak of just under 20 minutes per hour between  
165 21:00 and 22:00 for both sexes. In boys, the time spent using electronic games/Apps was greatest in  
166 the late afternoon and evening hours, rising from approximately 14:00 onwards to a peak of 15-17  
167 minutes per hour between 16:00 and 19:00. The time spent using social network sites ranged of 5-7  
168 minutes for girls. Time spent on the phone, sending emails / texts and browsing the internet peaked  
169 between the hours of 16:00 and 22:00, but remained low at approximately 2 minutes per hour for  
170 both sexes.

171 Figure 3 shows time spent in screen activities on a weekend day, separately for boys and girls. Between  
172 midnight and 06:00 all screen behaviours accounted for less than 1 minute in every hour. The most  
173 prevalent screen behaviour was TV viewing in both sexes, followed by electronic games/apps in boys  
174 and using social networking sites in girls. The time spent viewing TV was greatest in the evening, but  
175 rose gradually from approximately 08:00 onwards, peaking at approximately 23 minutes between  
176 20:00 and 21:00 for both sexes. In boys, use of electronic games/Apps was common throughout most  
177 of the waking day, averaging 10-15 minutes per hour between 11:00 and 21:00. In girls, use of social  
178 network sites was spread throughout the day accounting for 4-5 minutes per hour from 09:00-23:00.  
179 In both sexes, time spent on the phone, sending email/texts and browsing the internet remained low  
180 at approximately 2 minutes per hour throughout the day.

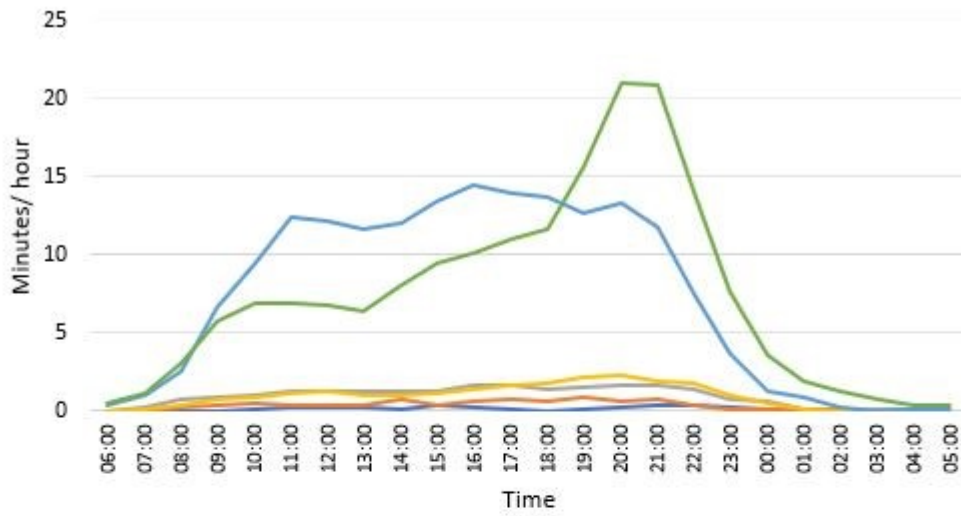


A)

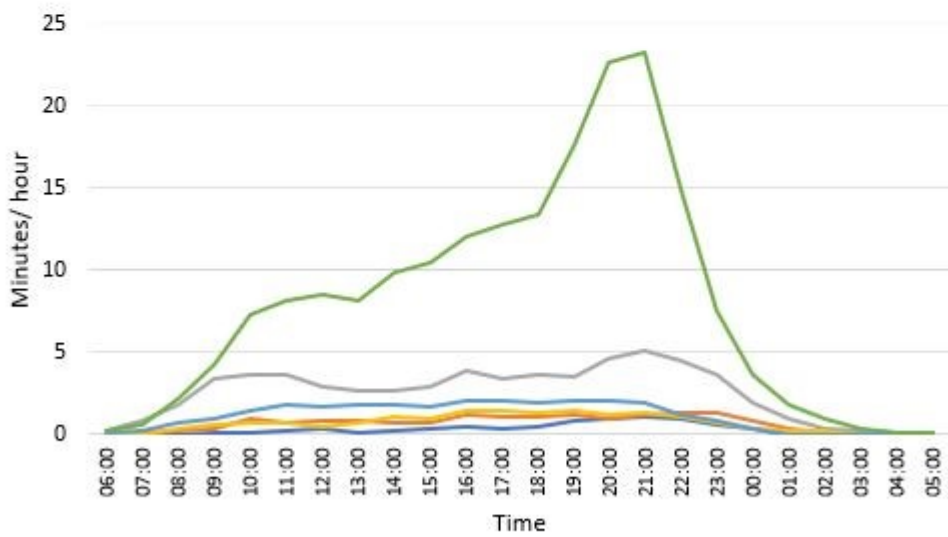


B)

181  
182 **Figure 2.** Minutes per hour spent in screen behaviours on weekdays: A) boys, B) girls.



A)



B)

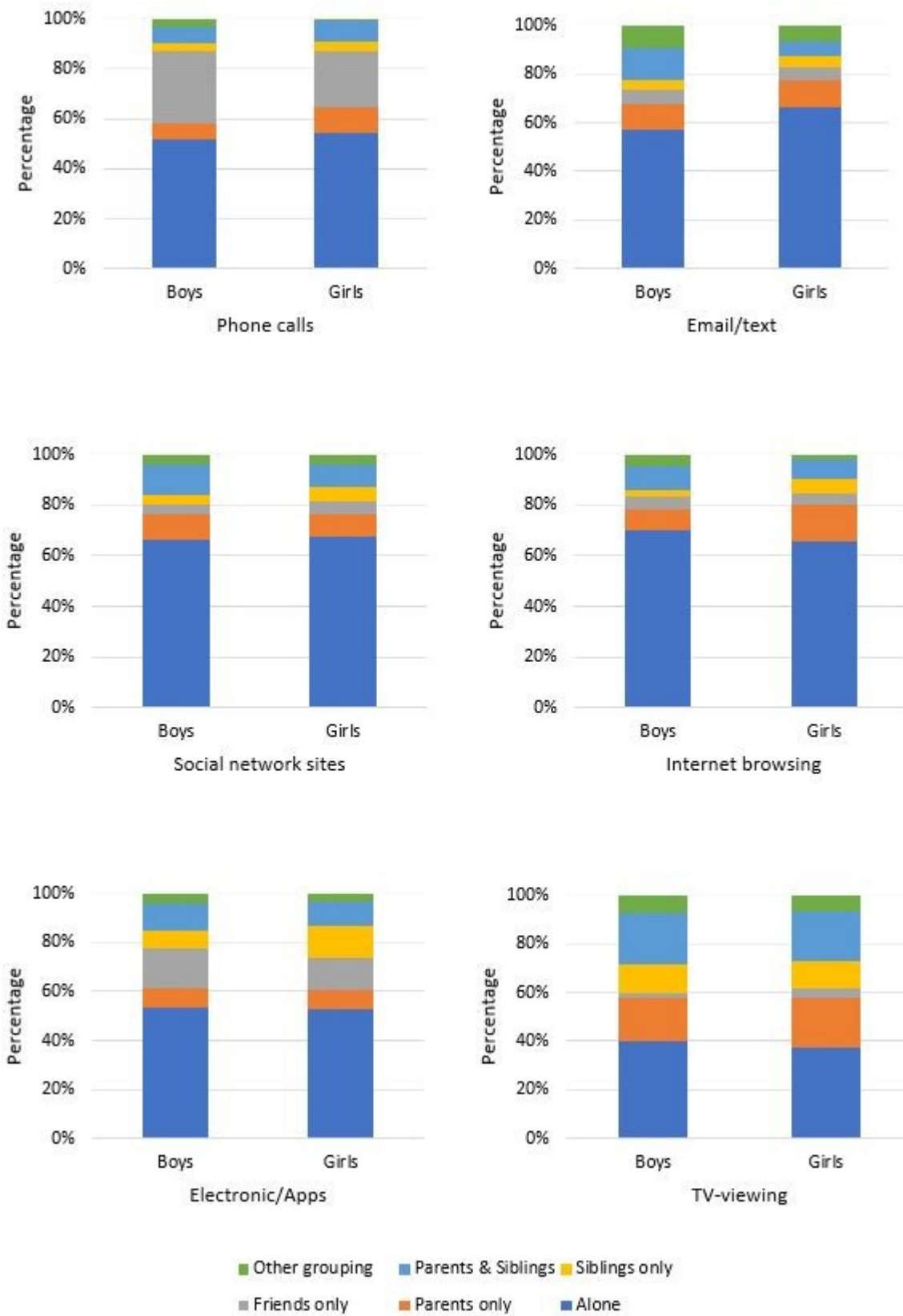
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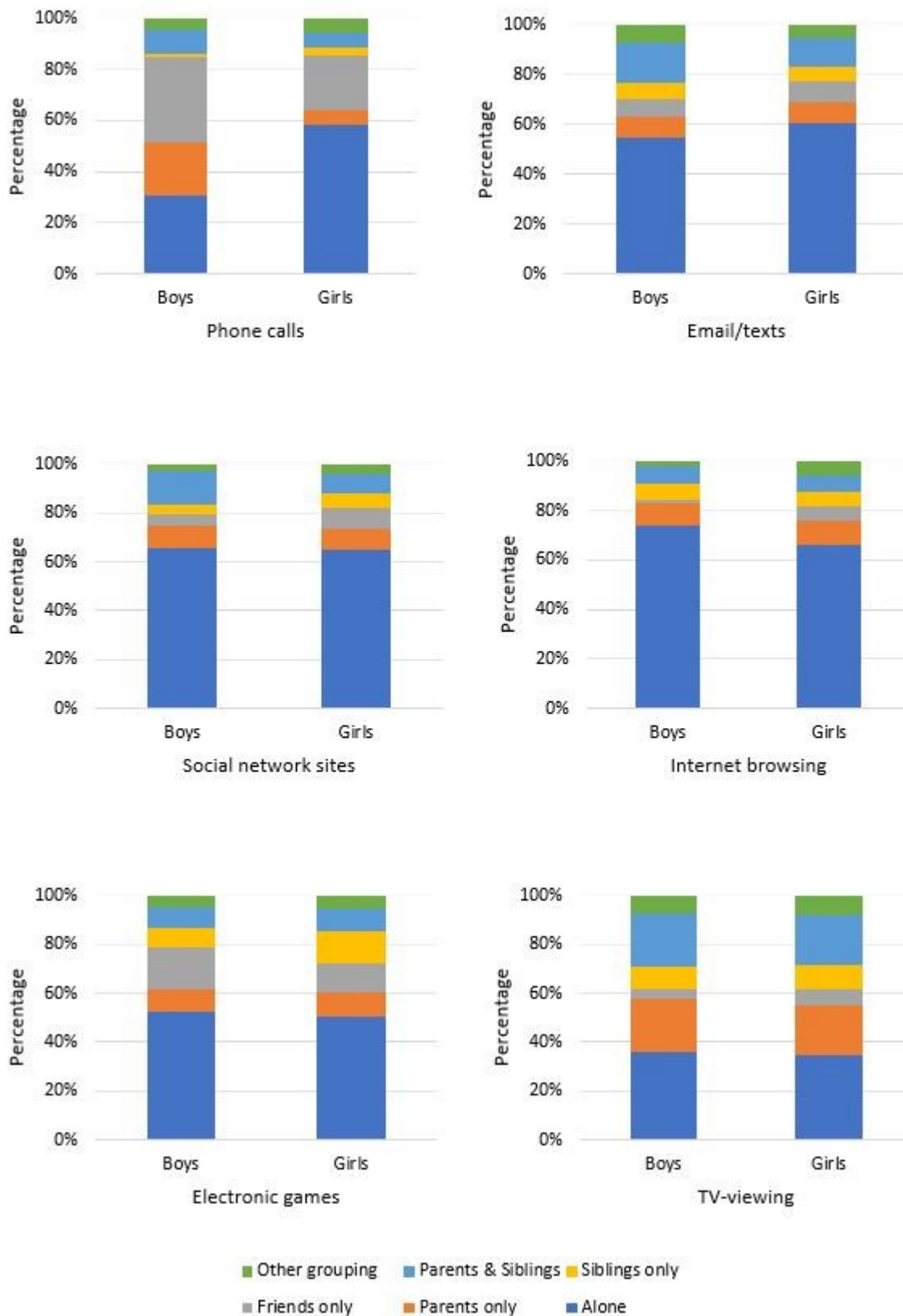
**Figure 3.** Minutes per hour spent in screen behaviours on weekend days: A) boys, B) girls.

## 186 Social contexts in screen behaviours

187 Figures 4 and 5 show social context of screen behaviours stratified by sex on a weekday and weekend  
188 day respectively. All the behaviours considered were undertaken alone for more than 50% of the time,  
189 except for TV viewing and phone calls at the weekend (boys only). Secondary to being alone, the most  
190 frequently reported contexts were 'friends' and 'parents', but these accounted for less than 20% of  
191 time spent in each behaviour. Approximately 40% of the time spent in TV-viewing, was undertaken  
192 alone, 20% of the time with parents only and 20% with parents and siblings. The only categories of  
193 behaviour frequently undertaken with friends were playing electronic games or making phone calls;  
194 this was the case on both week and weekend days.



197 **Figure 4.** Social context of screen behaviours on a weekday, stratified by sex.



198

199 **Figure 5.** Social context of screen behaviours on a weekend day, stratified by sex.



200 Associations between social contexts and screen behaviours on weekdays and weekend  
201 days

202 Associations between social contexts and screen-based activities on weekdays and weekend days  
203 stratified by sex are presented in Tables 1 and 2. Compared to the reference category of being alone,  
204 all social contexts were associated with lower odds of undertaking any of the behaviours studied on  
205 weekdays, with differences being highly statistically significant. In girls only, being with siblings was  
206 associated with higher odds of playing electronic games compared to being alone. Being with parents  
207 or siblings only and parents & siblings combined was associated with higher odds of time spent in TV  
208 viewing on a weekday in boys and girls.

209 On weekend days, compared to the reference category of being alone, all social contexts were  
210 associated with lower odds of undertaking any of the behaviours studied in boys and girls, with most  
211 of the differences being highly statistically significant. In boys only, being with friends only was  
212 associated with higher odds of time spent in phone calls/emails compared to being alone. Being with  
213 friends only or siblings only was associated with higher odds of time spent in electronic games in both  
214 boys and girls, whilst being with parents or siblings only, parents & siblings and other grouping was  
215 associated with higher odds of time spent in TV viewing in boys and girls.

216 Sensitivity analyses were conducted excluding data collected during August, corresponding to the  
217 main school summer holiday in the UK. The overall pattern of findings did not differ meaningfully to  
218 our main analysis either for weekdays or weekend days.

219 Table 1. Cross-sectional association between social contexts and screen behaviours on a weekday in  
 220 boys (n=1805) and girls (n= 2180).

221

<b>Phone calls and Email/texts</b>				
	Boys		Girls	
	OR (95% CI)	P value	OR (95% CI)	P value
Alone	Reference group		Reference group	
Parents only	0.43 (0.21, 0.84)	0.01	0.28 (0.16, 0.47)	<0.001
Friends only	0.34 (0.15, 0.78)	0.01	0.30 (0.17, 0.51)	<0.001
Siblings only	0.52 (0.36, 0.74)	<0.001	0.59 (0.22, 1.06)	0.08
Parents & siblings	0.25 (0.14, 0.34)	<0.001	0.30 (0.25, 0.37)	<0.001
Other grouping	0.23 (0.08, 0.65)	0.005	0.08 (0.03, 0.21)	<0.001

<b>Social network and Internet browsing</b>				
	Boys		Girls	
	OR (95% CI)	P value	OR (95% CI)	P value
Alone	Reference group		Reference group	
Parents only	0.22 (0.13, 0.37)	<0.001	0.22 (0.16, 0.32)	<0.001
Friends only	0.04 (0.02, 0.09)	<0.001	0.05 (0.03, 0.09)	<0.001
Siblings only	0.28 (0.13, 0.58)	0.001	0.40 (0.26, 0.61)	<0.001
Parents & siblings	0.22 (0.14, 0.35)	<0.001	0.19 (0.14, 0.27)	<0.001
Other grouping	0.08 (0.06, 0.10)	<0.001	0.09 (0.05, 0.16)	<0.001

<b>Electronic games</b>				
	Boys		Girls	
	OR (95% CI)	P value	OR (95% CI)	P value
Alone	Reference group		Reference group	
Parents only	0.21 (0.15, 0.32)	<0.001	0.30 (0.13, 0.70)	0.006
Friends only	0.67 (0.46, 0.96)	0.03	0.56 (0.43, 0.74)	<0.001
Siblings only	0.80 (0.70, 0.91)	<0.001	2.03 (1.58, 2.60)	<0.001
Parents & siblings	0.23 (0.16, 0.33)	<0.001	0.46 (0.36, 0.59)	<0.001
Other grouping	0.15 (0.13, 0.18)	<0.001	0.14 (0.09, 0.21)	<0.001

<b>TV-viewing</b>				
	Boys		Girls	
	OR (95% CI)	P value	OR (95% CI)	P value
Alone	Reference group		Reference group	
Parents only	2.28 (1.66, 3.13)	<0.001	2.57 (2.11, 3.14)	<0.001
Friends only	0.06 (0.03, 0.12)	<0.001	0.12 (0.09, 0.17)	<0.001
Siblings only	3.62 (2.47, 5.32)	<0.001	3.00 (2.34, 3.86)	<0.001
Parents & siblings	2.85 (2.15, 3.80)	<0.001	2.48 (2.06, 2.98)	<0.001
Other grouping	0.78 (0.69, 0.89)	<0.001	0.64 (0.50, 0.83)	0.001

222 OR, Odd Ratio; 95% CI, 95% Confidence Interval.

223 Table 2. Cross-sectional association between social contexts and screen behaviours on a weekend  
 224 day in boys (n=1805) and girls (n= 2180).

225

<b>Phone calls and Email/texts</b>				
	Boys		Girls	
	OR (95% CI)	P value	OR (95% CI)	P value
Alone	Reference group		Reference group	
Parents only	0.80 (0.65, 0.97)	0.02	0.53 (0.36, 0.77)	<0.001
Friends only	1.85 (1.59, 2.15)	<0.001	0.93 (0.60, 1.42)	0.74
Siblings only	1.02 (0.48, 2.16)	0.94	0.60 (0.37, 0.98)	0.04
Parents & siblings	0.88 (0.46, 1.67)	0.70	0.52 (0.33, 0.81)	0.004
Other grouping	0.72 (0.55, 0.95)	0.02	0.37 (0.22, 0.64)	<0.001

<b>Social network and Internet browsing</b>				
	Boys		Girls	
	OR (95% CI)	P value	OR (95% CI)	P value
Alone	Reference group		Reference group	
Parents only	0.64 (0.57, 0.72)	<0.001	0.47 (0.43, 0.63)	<0.001
Friends only	0.17 (0.10, 0.35)	<0.001	0.42 (0.31, 0.57)	<0.001
Siblings only	0.94 (0.56, 1.59)	0.84	0.64 (0.43, 0.94)	0.02
Parents & siblings	0.48 (0.42, 0.54)	<0.001	0.26 (0.19, 0.36)	<0.001
Other grouping	0.23 (0.13, 0.40)	<0.001	0.22 (0.14, 0.33)	<0.001

<b>Electronic games</b>				
	Boys		Girls	
	OR (95% CI)	P value	OR (95% CI)	P value
Alone	Reference group		Reference group	
Parents only	0.59 (0.45, 0.79)	<0.001	1.17 (0.99, 1.37)	0.05
Friends only	3.23 (2.36, 4.44)	<0.001	3.12 (1.59, 6.09)	0.001
Siblings only	2.13 (1.43, 3.19)	<0.001	4.67 (2.78, 7.86)	<0.001
Parents & siblings	0.41 (0.30, 0.55)	<0.001	0.95 (0.61, 1.49)	0.84
Other grouping	0.46 (0.30, 0.72)	0.001	0.70 (0.57, 0.86)	<0.001

<b>TV-viewing</b>				
	Boys		Girls	
	OR (95% CI)	P value	OR (95% CI)	P value
Alone	Reference group		Reference group	
Parents only	4.79 (3.82, 6.01)	<0.001	4.61 (3.82, 5.57)	<0.001
Friends only	0.51 (0.33, 0.77)	0.002	0.96 (0.73, 1.27)	0.80
Siblings only	5.43 (3.98, 7.41)	<0.001	4.59 (3.53, 5.97)	<0.001
Parents & siblings	4.40 (3.49, 5.57)	<0.001	5.01 (4.11, 6.10)	<0.001
Other grouping	1.79 (1.66, 1.93)	<0.001	1.51 (1.18, 1.94)	0.001

226 OR, Odd Ratio; 95% CI, 95% Confidence Interval.

227

## 228 Discussion

229 This study describes diurnal patterns in adolescents screen behaviours and examines the role of social  
230 context in these behaviours separately for week and weekend days. We found screen behaviours  
231 peaked in the late afternoon and evening, with TV viewing being most prevalent in both sexes,  
232 followed the use of electronic games/apps in boys and social networking sites in girls. Screen activities  
233 were mainly reported as being undertaken alone, except for TV-viewing. Being with family members  
234 was associated with more time TV-viewing in both sexes on weekdays and weekend days. These strong  
235 diurnal and social contextual patterns indicate that behaviour change interventions may be most  
236 efficacious if they are targeted at particular times of the day and particular agents, depending on the  
237 behaviour of interest.

238 Television viewing was found to be the main screen activity, rising from the afternoon onwards and  
239 peaking in the evening hours for both sexes on weekdays and weekend days. Our findings are in line  
240 with a systematic review showing that TV-viewing was the most prevalent behaviour in the hours  
241 immediately after school (from 15:00 to dinner time).(12) This is also consistent with evidence in the  
242 field of physical activity which shows that participation in active pursuits declines in the late afternoon  
243 and evening.(23,24) Our findings therefore suggest that adolescents may be substituting active  
244 behaviours, for example sports and other non-screen activities with TV viewing in the evenings, and  
245 this occurs more frequently as they reach young adulthood. Further, qualitative evidence shows that  
246 TV-viewing is a popular family-based activity, mostly used to watch movies in the evenings.(25)  
247 Considering that evening screen time may adversely impact sleep,(26,27) our findings suggest that the  
248 development of interventions aimed at reducing TV-viewing should be targeted at the evening,  
249 although, as discussed below, the impact on family function would require careful consideration.

250 During the late afternoon and evening on weekdays and the entire waking day at the weekend, the  
251 observed increase in time spent TV viewing was accompanied by higher levels of electronic game play  
252 in boys and social media use in girls. The differences we observed in electronic gaming and social

253 networking use by sex are consistent with previous studies.(28,29) Data suggest that electronic game  
254 play and social media use occurs throughout the day, though at a relatively low level. This is consistent  
255 with survey data showing that 45% of US adolescents are online and open an app on their telephone  
256 at least 50 times a day.(30) Further, a systematic review showed that young people spend around 6%  
257 of the after-school time in screen behaviours other than TV viewing.(12) Whilst these behaviours  
258 might substitute for more physically active pursuits, they are pervasive and become the means for  
259 modern youth to connect and communicate with friends online,(25) and develop new skills.  
260 Interventions to reduce screen time should therefore acknowledge the importance and the role of  
261 these screen behaviours in adolescents' social life, with a goal of the elimination of screen behaviours  
262 not therefore being feasible or desirable. Rather there is a need to balance screen time with other  
263 activities and support adolescents in establishing a healthy approach to screen use. Understanding co-  
264 occurrence or patterns in behavioural transitions would be a valuable adjunct to the data presented  
265 in this paper. Sex-specific findings suggest a potential need for tailored interventions for boys and girls  
266 by addressing constraints that are unique to, or most pronounced for boys and girls.

267 Being with family members was associated with more time spent in TV viewing in both sexes on  
268 weekdays and weekend days. The scarcity of evidence on the associations of social context with  
269 specific screen behaviours makes the direct comparison of our findings with prior research difficult.  
270 Nevertheless, other studies have noted that TV-viewing is often a family-based activity, supported by  
271 parents as an opportunity for quality family time and communication amongst family  
272 members.(25,31) However, qualitative evidence suggests that TV viewing is often a secondary or  
273 background activity alongside mobile phone or tablet use, which may undermine potential benefits  
274 associated with family interaction.(32) Considered alongside evidence that having a television in the  
275 bedroom, which facilitates viewing alone, is associated with an increased likelihood of being exposed  
276 to violent or age-inappropriate content,(33) family-based TV viewing may be preferable to that  
277 undertaken in other contexts. In a prospective observational study, parental monitoring of children's  
278 media use, encompassing limit-setting and discussion of use/content, was positively associated with

279 a number of social and behavioural outcomes.(34) These findings illustrate the need to work alongside  
280 families in the development of interventions to modify children’s screen use, ensuring efforts to limit  
281 screen time do not result in unintended adverse consequences on family dynamics or health.

282 The predominant social context for social network use or internet browsing was alone, whilst making  
283 phone calls/sending texts and playing electronic games was more likely to be done in the company of  
284 friends and/or siblings, though this varied by sex and day of the week. Numerous studies have  
285 reported that social networking and playing video games provide valued opportunities for young  
286 people to socialise with friends,(35) but it is interesting to observe that this sometimes takes place  
287 alone and sometimes in the company of others. Any attempt to modify screen use in this population  
288 will need to account for the social function these activities hold in young peoples’ lives. It is also likely  
289 that intervention programmes will need to be tailored to the sex- and time-specific (week / weekend)  
290 contexts in which these behaviours occur. Qualitative research has shown that young people  
291 recognise a range of benefits and problems associated with screen behaviours.(32) Intervention  
292 developers should work alongside young people to identify key areas of concern and the most valued  
293 outcomes from behaviour change programmes targeting screen behaviours. Our findings indicate  
294 that such programmes will need to accommodate the varied social contexts that accompany these  
295 behaviours, perhaps drawing upon siblings and friends to support behaviour change.

296 The study has several strengths and weaknesses. A key strength is the large geographically and  
297 demographically diverse sample. In addition, time-use diary data allowed us to study specific screen  
298 behaviours and the temporal and social context in which they were undertaken; something which has  
299 been little studied in this field to date. Lastly, the reporting of data in screen behaviours separately for  
300 weekday and weekend days allowed us to distinguish patterns to better inform the development of  
301 interventions. Results should be interpreted with the following limitations in mind. Firstly, data are  
302 derived from a British population and, as such, conclusions may not be generalizable to other nations,  
303 especially lower income countries with lower adoption of screen behaviours. Secondly, our analytical

304 sample differed in a number of social and demographic characteristics to the wider cohort. Finally,  
305 this analysis was not able to account for concurrent screen use, such as using a mobile phone whilst  
306 also watching television.

## 307 **Conclusion**

308 To our knowledge, this is the first study to use time-use diary data to describe diurnal patterns in  
309 adolescents screen behaviours and examine the association of social context with these behaviours.  
310 The development of interventions aimed at reducing TV-viewing should be targeted at the evening.  
311 Family members and friends may be particularly important targets in behaviour change interventions,  
312 but further research is needed to understand the potential impact of interventions to reduce screen  
313 time on family functioning and how best to support young people in achieving a healthy balance of  
314 screen and non-screen behaviours throughout the day and week.

## 315 **List of abbreviations**

316 MCS - Millennium Cohort Study

317 BMI - Body Mass Index

318 OECD - Organisation for Economic Co-operation and Development

319 IOTF - International Obesity Task Force

320

321 **Declarations**

322 **Ethics approval and consent to participate**

323 The MCS6 was approved by the National Research Ethics Service, Research Ethics Committee London  
324 – Central (REC ref: 13/LO/1786). This study was conducted according to the principles expressed in  
325 the Declaration of Helsinki.

326 **Consent for publication**

327 Not applicable.

328 **Availability of data and materials**

329 The datasets generated and/or analysed during the current study are available in the UK Data Service  
330 repository, [<http://doi.org/10.5255/UKDA-SN-8156-7>]

331 **Competing interests**

332 The authors declare that they have no competing interests.

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341 **Authors' contributions**

342 EK, AJ, AA contributed to the research proposal and design. EK analysed, interpreted the data, and  
343 wrote the manuscript. AJ and AA critically revised and edited the manuscript for important intellectual  
344 content. All authors read and approved the final manuscript.

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