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The effect of mobile phone use at night on the sleep of pre-adolescent (8–11 year), early adolescent (12–14 year) and late adolescent (15–18 year) children: A study of 252,195 Australian children

Valentina Salcedo Correa, BPsych (Hons), Stephanie Centofanti, PhD, Jillian Dorrian, PhD, Andrew Wicking, PhD, Peter Wicking, BSc, Kurt Lushington, PhD*

UniSA Justice and Society, University of South Australia, Adelaide, SA, Australia

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ABSTRACT

Objectives: To examine whether the association previously reported between mobile phone use at night and poor sleep in adolescents also generalizes to pre-adolescent children.

Design: Cross sectional.

Setting: Database provided by Resilient Youth Australia Pty Ltd.

Participants: Survey completed by 84,915 pre-adolescent (8–11 years), 99,680 early adolescent (12–14 years) and 67,600 late adolescent Australian children (15–18 years).

Measurement: Children were asked how frequently they obtained 8 hours of sleep on most nights and if they used their mobile phone at night to send and receive messages between 10 PM and 6 AM. Binary logistic regression analyses were used to examine the association between mobile phone use at night and sleeping 8h or more on most nights with gender, socioeconomic status and year of study (2014–2018) as covariates.

Results: For all age cohorts including pre-adolescent children, mobile phone use at night was associated with lower odds of obtaining 8 hours of sleep on most nights.

Conclusion: The present findings confirm that the association between mobile phone use at night and poor sleep previously reported in adolescent children also generalises to pre-adolescent children. Given the increased uptake of smartphone devices in ever younger children the findings point to the need to provide parents, schools and communities with resources to promote child sleep hygiene and media use at bedtime.

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Introduction

Due to lowering cost and their multi-function capabilities, the last decade has seen an increasing number of children owning mobile phones (aka cell phones and smartphones). Currently, more than a half of US and Australian children and up to 90% of UK children owns a mobile phone by age eleven.^{1–3} Given their portability and capacity to be used unsupervised, a growing concern is the intrusion of mobile phones into the bedroom and the consequences for child sleep. Mobile use prior to or at bedtime may potentially delay sleep onset while mobile phone use after bedtime may potentially fragment and displace sleep.⁴ A further contributing factor may be the effect of screen-light on circadian phase and a delay in sleep timing.⁵

Current reviews and meta-analyses conclude that mobile phone use at night is associated with disturbed sleep.^{6–8} Notably, reviews prior to 2010 report no association between mobile use at night and sleep in

children (eg,⁹), but these reviews are based on findings that precede the evolution of and substantive uptake of web-enabled mobile phone devices among children.^{10,11} Although supportive of an association between mobile phone use at night and disturbed sleep, most studies to date have either examined adolescents or combined adolescent and pre-adolescent cohorts. Adolescent compared to pre-adolescent children are more likely to have greater autonomy regarding the usage of devices and, as well, are more likely to engage with social media and peer communications.^{12,13} Thus, it is not clear how well the mobile phone use and sleep findings generalise to pre-adolescent children (ie, children <12 years). To date, only a few studies have examined the association between mobile phone use at night and sleep in pre-adolescent children. Most report a higher frequency of disturbed and/or shorter sleep^{14–17} but not all.^{13,18} This literature remains to be expanded.

In sum, given the uptake at an ever-younger age of mobile phone devices and the limited studies that have examined the association with sleep in pre-adolescent children, further examination is warranted. To examine this relationship, we obtained a dataset from Resilient Youth Australia (<https://resilientyouth.org/home>)

*Corresponding author: Kurt Lushington, PhD, University of South Australia, GPO Box 2471, Adelaide, SA, Australia.

E-mail address: kurt.lushington@unisa.edu.au (K. Lushington).

containing a single item each assessing the frequency of messaging/reading texts on a mobile phone between 10 PM and 6 AM and sleep (obtaining 8 hours on most nights) in 263,108 children divided into pre-adolescent (8–11 years), early adolescent (12–14 years) and late adolescent (15–18 years) children. We hypothesize for all age cohorts that frequent mobile phone use at night will be associated with a lower likelihood of obtaining 8 hours sleep on most nights.

Methods

Participants, apparatus, and procedure

The dataset provided by Resilient Youth Australia contained responses to an omnibus questionnaire assessing well-being and developmental assets from 263,108 children aged 7–19 year from school year levels 3–12 (male = 127,195, female = 134,811, gender diverse = 1102). Participation was voluntary and there were no exclusion criteria. Ethics approval for the use of archival data was granted by the University of South Australia Human Ethics Committee (#204389). Informed consent was obtained from parents and children by participating schools.

The questionnaire was administered in successive waves from 2012 to 2018 to 664 Australian state government and private/religious primary and secondary schools from both rural and urban areas and all Australian states and territories (South Australia = 6.9%, Victoria = 72.8%, Western Australia = 0.9%, Queensland = 14.5%, Tasmania = 3.6%, Northern Territory = 0.3%, New South Wales = 0.9% and Australian Capital Territory = 0.04%).

The dataset included a single item examining sleep, “Do you get at least eight hours of sleep on most nights?” (1 = Not at all or rarely to 4 = Almost always or extremely often) and a single item examining mobile phone use at night, “During the last week, how many times have you used your mobile to send or receive calls or texts, between the hours of 10 PM and 6 AM?” (1 = nil to 5 = > 10 times per week).

The dataset also included demographic items assessing gender, ethnicity, and socioeconomic status (SES). The Socioeconomic Index for Areas (SEIFA) (1 = disadvantage to 10 = least disadvantaged) as derived from postcode was used to assess SES which was then collapsed into Low (SEIFA 1–3), Middle (SEIFA 4–7) and High (SEIFA 8–10) SES (Australian Bureau of Statistics, 2018).

The survey was administered electronically to students during school hours via an online web application. De-identified data were provided to authors.

Data analysis

Data were analysed using IBM SPSS Statistics software v.26 (IBM Corp., Armonk, NY). A binary logistic regression was used to test the

association between mobile phone use at night and sleep which was dichotomised into 0 = not at all/rarely/somewhat/sometimes obtained 8 hours sleep (ie, ≤ 8 hours) and 1 = often/almost always/extremely often obtained 8-hours sleep (ie, > 8 hours). Because the interval between scores was not scalar, mobile phone use at night was also dichotomised into 0 = nil and 1 = ≥ 1 times in the previous week. Regression analyses were separately undertaken in pre-adolescent (8–11 years), early adolescent (12–14 years) and late adolescent (15–18 years) children. In children, gender and SES have been previously reported to impact both sleep duration and mobile phone use^{13,19–22} while screen time is reported to have increased over the years that the present study was conducted.²³ Accordingly, the following covariates were entered into the regression analyses: (1) gender (0 = Female and 1 = Male); (2) SES (0 = Low, 1 = Mid and 3 = High); and (3) Year of Data Collection (2014–2018). Effect sizes were estimated using the criteria suggested by Chen et al.²⁴

Results

Excluded from analyses because of small number were (1) children ≤ 7 and > 18 years, (2) the 2012 and 2013 sample sets and (3) children that identified as gender diverse. Cases with missing sleep, mobile phone use and postcodes responses were also excluded leaving a final sample of 252,195 children aged 8–18 years.

Demographic data is reported in Table 1 while the demographic profile of the children who reported receiving or sending text messages and calls at night at least once per night is given in Supplementary Table S1. The cohort included the following ethnicities: Australian = 79.5%, Asian = 8.7%, European = 3.6%, Aboriginal or Torres Strait Islander = 1.9%, African = 1.0%, Pacific Islander = 0.9% and Other = 4.4%. The survey was completed by 15,624 children in 2014 (6.2%), 50,037 (19.8%) in 2015, 53,322 (20.1%) in 2016, 68,442 (27.1%) in 2017 and 64,770 (25.7%) in 2018. Nearly one third of pre-adolescent children (28%), half of early adolescent children (57%) and most of late adolescent children (80%) reported receiving or sending text messages and calls at night (10 PM–6 AM) at least once per week. About a third of pre-adolescent children (29%), two-fifths of early adolescent children (38%) and three-fifths of late adolescent children (58%) rarely or only sometimes obtained 8h of sleep on most nights.

The distribution by age group and by year of study of responses according to gender for the frequency of mobile phone use and, likewise the frequency of obtaining 8 hours sleep on most nights is summarised in Fig. 1 (nb, due to smaller numbers the mobile phone use by years 2014 and 2015 were combined). In general, the frequency of mobile phone use increased with age while the percentage of children obtaining > 8 h sleep most nights decreased with age. Both the frequency of mobile phone use and the percentage of children obtaining > 8 h sleep most nights remained relatively

Table 1
Demographics.

Demographic variables (%)	Pre-adolescent (8–11 y: n = 84,915)	Early adolescent (12–14 y: n = 99,680)	Late adolescent (15–18 y: n = 67,600)
Percent of total sample	33.7%	39.5%	26.8%
Age (mean (SD)y)	9.9 (0.98)	13.0 (0.81)	16.0 (0.92)
Female	49.5%	51.5%	54.4%
<i>Socioeconomic status</i>			
Low	16.7%	19.9%	16.8%
Middle	31.4%	33.0%	30.3%
High	51.9%	47.1%	53.0%
<i>Number of children in each age cohort by year of study</i>			
2014	13.1%	63.2%	23.7%
2015	30.8%	43.5%	25.6%
2016	34.7%	37.5%	27.8%
2017	35.2%	35.9%	28.9%
2018	38.4%	36.2%	25.4%

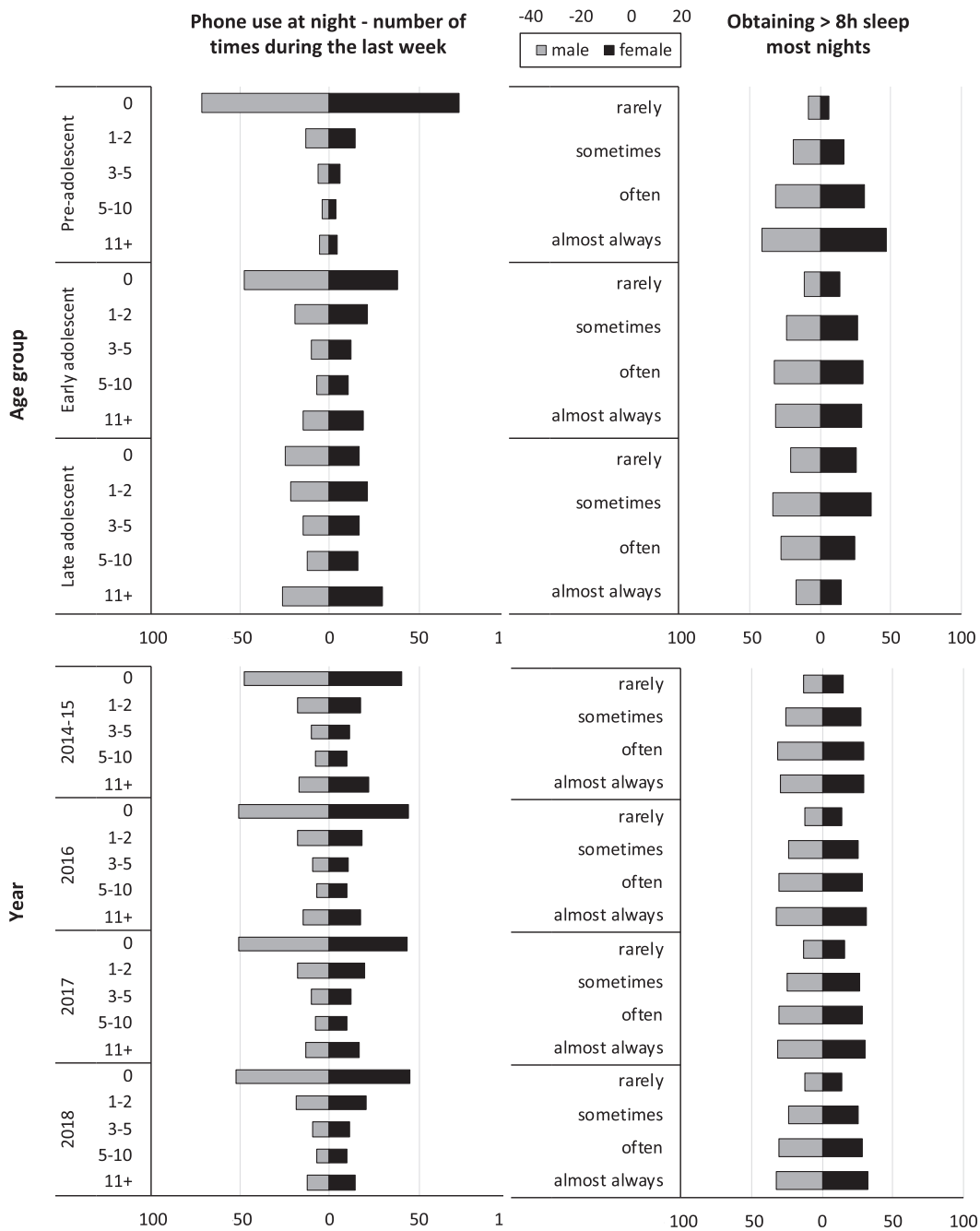


Fig. 1. Tornado charts showing proportion of participants reporting mobile phone use between 10 PM and 6 AM in the preceding week by frequency of use (none, 1-2 times, 3-5 times, 5-10 times, 11+ times), and the proportion who reported obtaining >8 h sleep most nights by frequency (not at all/rarely, somewhat/sometimes, very/often, extremely/ almost always). Data are shown by age group (upper) and year of study (lower). Gray bars show males, and black bars show females.

consistent over the years of the study. There was a trend in all age cohorts for females compared to males to report obtaining ≤ 8 hours of sleep on most nights and for early and late adolescent females compared to male peers to report using their mobile once or more times in the prior week. The gender differences in sleep and mobile phone use were relatively comparable for each year of the study.

Collapsed across the year of study, the proportion by age group of participants according to gender who reported mobile phone use between 10 PM and 6 AM at least once in the preceding week, and the proportion who reported rarely or sometimes obtaining 8 hours of sleep per night is summarized in Fig. 2. Increasing age was associated with a higher frequency of mobile phone use and a lower

likelihood of obtaining 8 hours or more of sleep on most nights. Females were more likely to report using their mobile phone at least once in the preceding week and less likely to report obtaining 8 hours or more of sleep on most nights.

The results of the binary regression with unadjusted and adjusted ORs are reported in Table 2. For all age cohorts, using a mobile phone use at night was a significant predictor of sleeping <8 hours most nights. The 44%-55% reduction observed across the age cohorts in the adjusted OR of sleeping >8 hours, represents a medium effect size. The addition of covariates (gender, SES, and Year of Data Collection) to the models made little difference to the magnitude of the odds ratios observed in the models without covariates.

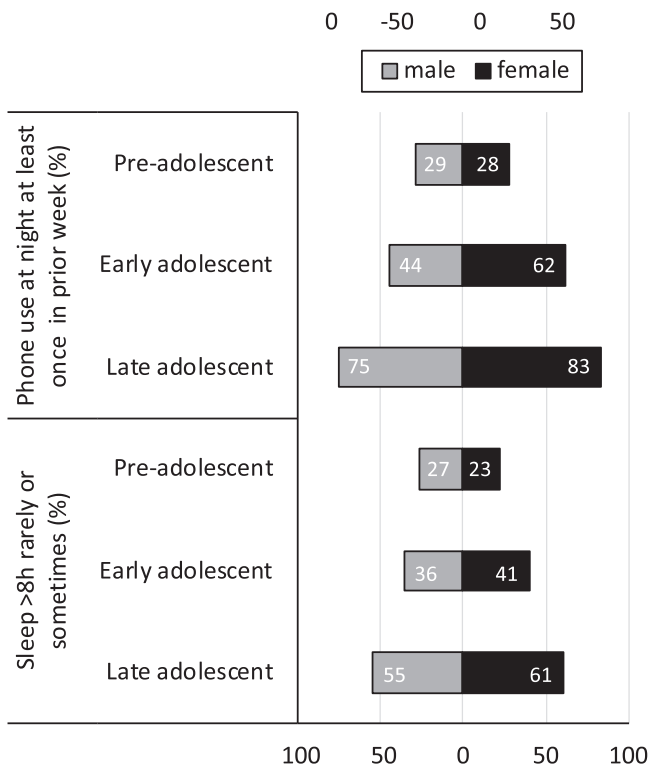


Fig. 2. Tornado chart showing proportion of pre-, early, and late adolescent children who reported mobile phone use between 10 PM and 6 AM at least once in the preceding week, and the proportion who reported obtaining >8 h sleep most nights not at all/rarely, or somewhat/sometimes. Gray bars show males, and black bars show females (numbers in each bar indicate percentages).

In consideration of the change in mobile phone technology and the uptake of web-enabled devices over the study period,^{10,11} binary logistic regressions were undertaken separately for each year of the study (due to the relatively smaller number of children, years 2014 and 2015 were combined). As previously, gender and SES were entered as covariates in the analyses (see Supplementary Table S2). For all age cohorts and for all years of the study, using a mobile phone use at night was a strong predictor of sleeping ≤ 8 hours most night. The addition of covariates did not improve model fits and the unadjusted and adjusted ORs were comparable in magnitude. There was however observed across all age cohorts a reduction in the adjusted odds of sleeping >8 hours with each increasing year of study.

Table 2

Binary logistic regression results: Predictors of reporting >8 h sleep per night. Table shows unadjusted (OR) and adjusted (aOR) odds ratios and 95% confidence interval (CI) lower and upper limits.

Models	Number	OR	95% CI		aOR	95% CI	
			Lower	Upper		Lower	Upper
Pre-adolescent ^a	84,915	0.56	0.54	0.57	0.56	0.54	0.58
Early adolescent ^b	99,680	0.45	0.44	0.46	0.46	0.44	0.47
Late adolescent ^c	67,600	0.53	0.51	0.55	0.54	0.52	0.56

Notes. Dependent variable: >8 h sleep, 0 = not at all/rarely/somewhat/sometimes and 1 = often/almost always/extremely often. Independent variable: mobile phone use 10 PM–6 AM (0 = nil and 1 = ≥ 1 per week). Covariates: gender (0 = female and 1 = male), year of study (2014–2018), SES (low, middle, and high). Unadjusted Model: ^a $\chi^2 = 1203.3^{**}$, Nagelkerke R^2 (NR²) = 0.021. ^b $\chi^2 = 3495.3^{**}$, NR² = 0.47. ^c $\chi^2 = 1078.4^{**}$, NR² = 0.021. Adjusted Model: ^a $\chi^2 = 2016.7^{**}$, NR² = 0.035. ^b $\chi^2 = 4032.1^{**}$, NR² = 0.054. ^c $\chi^2 = 1305.2^{**}$, NR² = 0.026. * $p < .05$, ** $p < .01$.

Discussion

The present study aimed to investigate the impact of mobile phone use at night on sleep duration in pre-adolescent children. Results suggest that the odds of pre-adolescent children obtaining the recommended 8 hours of sleep, on most nights, significantly decreased with night-time mobile phone use. This is consistent with the majority of findings in adolescents and preliminary findings in pre-adolescent children.^{6–8,14–17} In addition, it is consistent with large population studies that have examined the association between screen time exposures in general during the daytime and sleep.^{4,25} The present findings also indicated that a substantial portion of children used their mobile phone devices at night, with one in three pre-adolescent children, one in two early adolescent children, and the majority of late adolescent children reporting receiving or sending text messages and calls between the hours of 10 PM and 6 AM at least once per week.

The present study adds to those which have examined mobile phone use at bedtime and sleep in pre-adolescent children. Meltzer et al.¹⁴ surveyed 171 US children aged 8–12 years and asked children if ‘I used my phone, computer, or other electronic device just before falling asleep.’ They found that 38% of children almost always or always used screen enabled devices at bedtime which, in turn, was associated with more disturbed sleep. Rhodes¹⁵ surveyed 3797 Australian children aged 0–18 years and found that 38% of children aged 6–13 years regularly used a smartphone or tablet devices at bedtime. Although Rhode and colleagues did not separately examine the findings in pre-adolescent children, they found that 26% of the combined child and adolescent sample had sleep problems related to screen use. In a survey of 3398 Canadian children in grade 5, Chahal et al.¹⁶ found that children who used a cellular phone (or other handheld communication device) after they would normally be expected to go to sleep slept 6 minutes less per night. In their 2015 study, Falbe et al.¹⁷ asked 2048 US children: ‘Some kids use devices to play games or send text messages or chats to their friends like cell phones, smartphones, and the iPod Touch. How often do you sleep with one of these devices near where you sleep, such as in your bed or next to your bed?’ Sixty-five percent of 7th graders and 46% of 4th graders reported sleeping with a device. In addition, compared to those who did not sleep with a device, sleeping with a device was associated with 21 minutes less sleep per weekday in the past week.

All the studies reporting an association between mobile phone use and sleep including the present have relied on self-report (nb, 2 parental-report^{15,16} and 2 child-report^{14,17}). In contrast to the self-report findings, So et al.¹⁸ used actigraphy to assess sleep. In their study involving 55 US children aged 7–11 years, So and colleagues failed to find an association between self-reported electronic media use prior to bedtime and actigraphic sleep estimates (and similarly for computer, television and video screen time). An explanation for the lack of a significant association is unclear but may be explained by the different methodologies used to assess sleep. Bruni et al.¹³ surveyed 434 Italian children aged 11–13 years and measured the frequency of mobile phone activities (ie, texting, surfing, etc.) and mobile phone ‘addiction’ (ie, I feel connected with others when I use my mobile phone, I lose track of how much I am using my mobile phone, etc). They found that up to a quarter of children reported using a mobile phone between 2100 hours and before turning off their devices at bedtime (25% mobile phone texting, 22% texting on social networks, 20% WhatsApp messaging, 14% talking on the phone and 21% surfing the web). However, and while significant in adolescent children, Bruni et al. report no association in pre-adolescent children between either the number of phone activities or mobile phone ‘addiction’ with the number of sleep-wake problems ($p = .33$ and $.06$, respectively). The negative findings reported by Bruni et al.¹³ are difficult to reconcile. Notably, however they report that Internet use (surfing using computer, social networks using computer, computer television/

movies) was predictive of sleep-wake problems in pre-adolescent children ($p = .001$). It is also noted that the study by Bruni et al. was conducted in 2015 and prior to the widespread adoption of web-enabled smartphone.^{10,11} It is possible that advances in technology and especially Internet access may underlie the greater mobile phone use at night and hence disruption to sleep reported in more recent studies (eg, ¹⁴). The findings by So et al.¹⁸ and Bruni et al.¹³ point to the need for more objective sleep measures such as actigraphy and more detailed information on the timing and type of mobile phone activities to be included in future studies.

In the present study we asked children “How many times have you used your mobile to send or receive calls or texts, between the hours of 10 PM and 6 AM?”. Although we were unable to cross-tabulate mobile phone use with sleep onset times, we can assume that for most pre-adolescent children in the present study that the 10 PM cut-off was at least near and most likely after bedtime. In support of the latter claim, we note that the mean sleep onset time in pre-adolescent Australian children aged 6–12 years is typically between 8:30 and 9:30 PM.^{26,27} This raises the possibility that we were assessing mobile phone use mostly after sleep onset in pre-adolescent children. Conceivably, mobile phone use during the night compared to pre sleep onset might be more disruptive to sleep and hence the stronger association observed between mobile phone use and sleep. It would be informative in future studies if the timing of mobile phone use before and after sleep onset was collected.

The Australian Department of Health guidelines for child sleep recommend that “An uninterrupted 9 to 11 hours of sleep per night for those aged 5 to 13 years and 8 to 10 hours per night for those aged 14–17 years”.²¹ We note that the sleep question used in the present study examined whether children obtained 8 hours of sleep on most nights and did not take into consideration the differing age guidelines. Accordingly, recommended guidelines were not met by all those pre-adolescent and some early adolescent who reported obtaining 8 hours or less of sleep most nights. The proportion of children reporting that they rarely or only sometimes obtained 8 hours of sleep increased with age from one in 3 pre-adolescent children to more than half of late adolescent children. The age-related decline in the number of children reporting 8 hours sleep most nights is consistent with previous findings.^{27–29} That a substantive number of pre-adolescent children reported a low likelihood of obtaining 8h sleep most nights, point to the well-recognised gap between recommended and reported sleep in children

Older and especially female children are more likely to report using their mobile phone at night.^{12,13,20} This trend was also evident in the present data. Interestingly, while it may be hypothesised with the increased uptake of mobile phones over time that there would be a concomitant increase in reports of phone use at night, we found that mobile phone use remained relatively consistent (if not decreasing slightly) across years of study (2014–2018). It is possible that the decrease with year of study may be a result of the wording chosen to measure mobile phone use, i.e. ‘receiving or sending text messages and calls’. Current literature suggests that mobile phone activity in children and adolescents is shifting away from text messaging and calls and towards instant messaging, sending emails, interacting on social platforms and web surfing.^{13,20,30} The need for a broader definition of mobile phone use is indicated in future studies.

Although not the focus of the present study, the tendency for children from high compared to low SES backgrounds and male compared to female early and late adolescent children to report a higher likelihood of obtaining eight hours of sleep on most nights is consistent with previous findings.^{31–33}

A limitation of the present study is the restricted range of sleep and mobile phone items available for analyses. We were not able to determine what percentage of children had a phone in their bedroom and therefore allow for this in the analyses. On balance, this is likely to have

inflated the ‘nil’ mobile phone use response and led to an underestimate of the relationship between mobile phone use at night and obtaining eight hours of sleep. In the present study children were also asked about sleep on “most nights” but mobile phone use in the “past week”. Future studies would be strengthened by ensuring that the items used to assess sleep and mobile use were temporally concordant. There is now an emerging literature pointing to ‘smartphone addiction’ as a contributing factor to problematic phone use and poor sleep.³⁴ Although untested, it is likely that a proportion of frequent users in the present study would meet the criteria for ‘smartphone’ addiction. There now exist well-validated scales to assess smartphone addiction whose inclusion would strengthen future studies.³⁵ A further limitation is that this was a cross-sectional study and we are therefore unable to infer causation. There is a clear need for prospective studies examining child sleep pre and post access to a mobile phone device to better determine the impact of mobile phone use at night on sleep. A final limitation is that we relied on self-report but note that responses were directly obtained from the children and that the dataset was very large and representative of the Australian population, with students enrolled in 644 private and public schools across 7546 suburbs throughout different states and regions of Australia.

In conclusion, the present findings suggest that mobile phone use at night is associated with shorter sleep in pre-adolescent children which parallel the findings previously reported in adolescents. As smartphone and tablet devices gain ever more presence in the community, it is likely that any sleep effects will become even more extant and at ever younger ages.^{36,37} As noted by Godsell and White,³⁸ this points to the increased need for community education regarding sleep hygiene and screen time and the development of resources to help parents, children, communities and schools become ‘sleep messengers’ and rule setters and thereby promote healthy sleep.

Declaration of conflicts of interest

KL, JD, and SSC sit on the Scientific Advisory Panel for Resilient Youth Pty Ltd. PW is founder and advisor and AW is the Director of Resilient Youth Australia Pty Ltd.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:[10.1016/j.sleh.2022.02.004](https://doi.org/10.1016/j.sleh.2022.02.004).

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