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Beyond "screentime": reframing bedtime social media use as a social interaction with unique implications for adolescent sleep

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Submitted in fulfilment of the requirements for the degree of
Doctor of Philosophy

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Abstract

There is significant current attention towards the possible impact of social media on adolescent wellbeing, with concerns voiced by parents, educators, practitioners and national policymakers. This includes a focus on social media's influence on *sleep*, which plays a crucial role in supporting physical and mental health, emotional wellbeing and academic performance during this developmental period. However, there are key limitations in the existing evidence base available to support informed decision-making in this area. These include a prevalent techno-centric focus on "screentime" – which is typically measured only in hours per day and often framed negatively or pathologised – and a lack of adolescent voice. This PhD aims to target gaps in current understanding of adolescent social media use and sleep, enriching the evidence and tools available to support future research, practice and policy.

This thesis presents four studies, which contribute to building new understanding of the unique implications that social media interactions – unlike other forms of technology use – have for adolescent sleep. Chapter 3 makes use of data from a large representative UK sample, to establish a normative profile for current adolescent social media use and to quantify links to a range of sleep parameters, controlling for an extensive range of covariates. Chapter 4 uses rich focus group data to provide an adolescent perspective on emotional, social and cognitive drivers for bedtime social media use that can make it difficult for some adolescents to disengage at night. Chapter 5 takes these qualitative findings as a foundation for developing a new validated self-report measure that captures this difficulty disengaging from social media at night due to concerns about staying connected and following etiquette. Chapter 6 considers the practical application of the new knowledge gained from these studies, by consulting with relevant stakeholders to develop and pilot a new school-based lesson programme that specifically targets the role of social influence in adolescent bedtime social media and sleep habits.

These studies advance current understanding by highlighting the unique implications that this inherently social and interactive experience has for adolescent sleep, beyond simply another hour of daily "screentime". Together, these findings indicate that adolescent sleep research and practice need to

reframe social media not simply as a technology-based activity, but as a highly motivating and rewarding source of peer interactions, which understandably competes with sleep during a developmental period of heightened sensitivity to social influences. Adopting this approach can extend current models of adolescent sleep, inform up-to-date interventions and education strategies, support more efficient future research and guide a more constructive narrative in public and policy spheres.

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Abbreviations

AAP	American Academy of Pediatrics
CBTi	Cognitive Behavioural Therapy for insomnia
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CI	Confidence interval
DSM-5	Diagnostic and Statistical Manual of Disorders, 5th edition
EFA	Exploratory Factor Analysis
ESRC	Economic and Social Research Council
FoMOS	Fear of Missing Out Scale
iNOD	Index of Nighttime Offline Distress
KMO	Kaiser-Meyer-Olkin measure
MCS	Millennium Cohort Study
NREM	Non-Rapid Eye Movement
NWAK	Number of nighttime awakenings
OECD	Organisation for Economic Co-operation and Development
OR	Odds ratio
PSG	Polysomnography
RCPCH	Royal College of Paediatrics and Child Health
REM	Rapid Eye Movement
RMSEA	Root Mean Square Error of Approximation
RR	Relative risk
SCI	Sleep Condition Indicator
SD	Standard deviation
SEL	Shut Eye Latency
SMUIS	Social Media Use Integration Scale
SOL	Sleep Onset Latency
SRMR	Standardized Root Mean Square Residual
TLI	Tucker-Lewis Index
WASO	Wake after sleep onset
WEIRD	Western, Educated, Industrialised, Rich, Democratic

Previous publications

The following chapters are presented as manuscripts (either in press or in preparation) as follows:

Chapter 3

Scott, H., Biello, S. M., Woods, H. C. (in press). Adolescent social media use and sleep patterns: evidence from the UK Millennium Cohort Study. *BMJ Open*.

Chapter 4

Scott, H., Biello, S. M., Woods, H. C. (in press). Identifying drivers for bedtime social media use despite sleep costs: the adolescent perspective. *Sleep Health*.

Chapter 5

Scott, H., Biello, S. M., Woods, H. C. (in preparation). Nodding off but can't disconnect: development and validation of the iNOD index of Nighttime Offline Distress.

In addition, arguments outlined throughout this thesis have previously been presented within the following peer-reviewed publication:

Scott, H., & Woods, H. C. (2019). Understanding links between social media use, sleep and mental health: recent progress and current challenges. *Current Sleep Medicine Reports, 5*(3). doi: 10.1007/s40675-019-00148-9

Chapter 1   Introduction to adolescent social media use

Social media is revolutionising the way we interact with each other, by facilitating social interactions at any time of day, with expectations of availability and prompt responses (Fox & Moreland, 2015; Mai, Freudenthaler, Schneider, & Vorderer, 2015). This is especially relevant for today's adolescent generation, who have grown up with the possibility of 24/7 online social connection as an embedded part of everyday life. Like the generations that came before them, today's adolescents continue to place important value on strong peer connection and acceptance during this period of intense psychosocial development (Blakemore & Mills, 2014). Whilst social media platforms offer considerable benefits for connecting with others, it is their potential *negative* impact on adolescent health and wellbeing that has attracted particular attention. Specifically, concerns have been voiced by parents, educators, practitioners and policymakers about the possible harmful effects of social media use on child and adolescent mental health and sleep, with calls to introduce national policy (George & Odgers, 2015; The Guardian, 25 December 2016; UK House of Commons Science and Technology Committee, 2019). At this juncture, it is important to evaluate the evidence base that is available to inform these discussions, identifying gaps in current understanding and enriching these with targeted, high quality research.

This thesis contributes to available evidence and tools to support decision-making and future research on adolescent social media use and *sleep* (one important component of wider health and wellbeing). Before discussing the issue of adolescent sleep in the following chapter, Chapter 1 first presents the rationale for studying adolescent social media use at this juncture. It is divided into three main sections, which outline the following issues:

    1.1 A brief background on social media, defining the scope of 'social media use' for the purpose of this thesis and considering current trends in platforms, features and habits (particularly focusing on adolescents).

    1.2 The rationale for studying social media use in adolescents specifically, considering how biological and psychosocial developmental changes

mean that adolescents are primed to be highly engaged, invested social media users.

1.3 An overview of current interest in social media use and adolescent wellbeing, including common concerns and available evidence, highlighting common limitations of existing research approaches that this thesis will aim to address.

Finally, Section 1.4 recaps these issues in a brief chapter summary.

1.1 Social media use: definition, prevalence & age trends

As of 2019, there are 3.5 billion active social media users worldwide (We Are Social, 2019). Two thirds of the UK population are active social media users, with the most popular tools including image-based platforms (e.g. Instagram, Snapchat), text-based and mixed platforms (e.g. Twitter, Facebook) and messaging services (e.g. Facebook messenger, Whatsapp; We Are Social, 2019).

1.1.1 What *defines* these tools as social media?

Research literature tends to assume an inherent understanding of social media based on current technologies, often relying on illustrative examples of popular platforms (as above) to define its scope (Parks & Howard, 2012). However, there remains no clear consensus on what actually *defines* these tools as social media (Carr & Hayes, 2015). Several formal definitions have been proposed (e.g. Kaplan & Haenlein, 2010; Lewis, 2010; Russo, Watkins, Kelly, & Chan, 2008), often developed based on specific devices and tools available at the time. This techno-centric approach has been criticised for producing definitions that are too broad to distinguish social media from other communication technologies (e.g. email, text messaging), thus failing to capture the unique social affordances of social media (Carr & Hayes, 2015). Conversely, overly *narrow* conceptualisations have arisen from the conflation of social media in general with social networking sites specifically, which represent only a sub-category of social media. In 2007, Boyd and Ellison considered the features of popular sites at the time (such as MySpace, Bebo and Facebook) and seminally defined social networking sites as services where users have a semi-public or public profile and

share connections with a list of other users. Researchers have since often misapplied this as a definition of all social media, resulting in imprecise conceptualisations across existing literature (Carr & Hayes, 2015). This lack of a precise agreed definition becomes increasingly problematic in an ever-evolving social media landscape, with continual introduction of new devices, platforms and features, facilitating more diverse and sophisticated ways of engaging with this range of tools and interacting with each other.

Carr and Hayes (2015) critically reviewed existing definitions of social media, aiming to develop a new definition that would be robust to future technological and social developments, and that balanced breadth and precision to encompass evolving social media tools whilst distinguishing non-social media. After consideration, they defined social media as:

> "Internet-based channels that allow users to opportunistically interact and selectively self-present, either in real-time or asynchronously, with both broad and narrow audiences who derive value from user-generated content and the perception of interaction with others."
> (Carr & Hayes, 2015, p. 50)

This provides a useful definition for the purpose of this thesis, which will focus more on the *social interactions* that social media facilitates, rather than any specific platform(s) or specific features. At this point, it is worth highlighting certain components of this definition that will become relevant when considering adolescents' online peer interactions (and how these can compete with sufficient sleep) throughout this thesis.

Firstly, the potential for *real-time* interactions allows rapid communication, with perceived social expectations of availability and prompt responses (Fox & Moreland, 2015; Thomee, Dellve, Harenstam, & Hagberg, 2010). However, also allowing *asynchronous* interactions distinguishes social media from purely live chat platforms (such as Skype), and effectively means that social media platforms never sleep. These channels for communication are available constantly with content-sharing and interactions continuing regardless of whether an individual is connected at that moment. This presents 24/7 opportunities for engagement, as individuals can share and respond to content when others are not currently online, and continue to receive incoming

messages, feedback and interactions on their shared content even when they are not online. This can magnify concerns about possibly missing out, as individuals are aware that social interactions among their peer group can continue after they go offline (Przybylski, Murayama, DeHaan, & Gladwell, 2013).

Returning to Carr and Hayes (2015) definition above, it is also clear than a defining aspect of social media (in contrast to other internet uses, such as online video streaming) is its inherently *social* and *interactive* nature. Whilst this may seem like an obvious statement – given the 'social' in 'social media' – it nonetheless merits explicit clarification, since much existing literature has taken a techno-centric approach to understanding adolescent social media use, health and wellbeing (the contribution and limitations of which are discussed in section 1.3.1; Scott & Woods, 2019). In contrast, this thesis approaches social media use with a focus on online *social interactions*. Whilst the properties of these interactions (such as 24/7 availability) are facilitated by devices and technological tools, this thesis primarily takes a psychological perspective to understanding the behavioural, cognitive and emotional aspects of this interactive experience.

1.1.2 Changes in popular platforms & their features

The social media landscape is constantly shifting, with the popularity of each platform rising and falling over time. These shifts have followed different trajectories in different age groups, making it especially relevant to consider trends amongst adults, young adults and adolescents separately. For example, according to 2019 figures from a large survey of US adults (Pew Research Center, April 2019), Facebook use remains relatively prevalent from younger to older adults, with 69% of all over 18s (including almost half of over 65s) reporting to use the site. In contrast, there are clear age differences in the popularity of Instagram and Snapchat. These rapidly growing image-based platforms now have the same prevalence as Facebook amongst young adults (with three quarters of 18- to 24-year-olds using each of these platforms; see Figure 1).

Figure 1 - Platform prevalence by age group
Percentage of US adults who use selected social media platforms. 18- to 24-year-olds are labelled in dark blue. Figure is taken from Pew Research Center (April 2019).

Looking at available data from *adolescents* suggests that this trend is further exaggerated amongst this teenage generation. For example, a 2018 survey of 743 US 13- to 17- year olds (drawn from a representative household panel survey) found that only half of these teens reported using Facebook. Instead, Instagram (72%) and Snapchat (69%) were the platforms that teenagers tended to report using most often (see Figure 2; Pew Research Center, May 2018). For adolescents, the growing popularity of platforms like Facebook amongst adults has been part of the reason for their shift towards these 'younger' platforms that offer an online social space with less parental presence (Redden & Way, 2017).

YouTube, Instagram and Snapchat are the most popular online platforms among teens

% of U.S. teens who ...

	Say they use ...	Say they use ___ most often
YouTube	85%	32%
Instagram	72	15
Snapchat	69	35
Facebook	51	10
Twitter	32	3
Tumblr	9	<1
Reddit	7	1
None of the above	3	3

Note: Figures in first column add to more than 100% because multiple responses were allowed. Question about most-used site was asked only of respondents who use multiple sites; results have been recalculated to include those who use only one site. Respondents who did not give an answer are not shown.
Source: Survey conducted March 7-April 10, 2018.
"Teens, Social Media & Technology 2018"

PEW RESEARCH CENTER

Figure 2 - Platform prevalence amongst teenagers
Percentage of US 13- to 17- year olds who use selected social media platforms. Figure is taken from Pew Research Center (May 2018).

These trends in platform prevalence have implications for users' experiences of engagement and interactions. For example, image-based platforms (e.g. Instagram, Snapchat) tend to facilitate interactions with a stronger sense of intimacy and social presence than text-based platforms (Pittman & Reich, 2016). Text-based and mixed platforms (e.g. Twitter, Facebook) are more likely to be used for those seeking information (C. S. Lee & Ma, 2012). Therefore, age trends in preferred platforms have implications for the content and experience of different age groups of users' social media engagement. Furthermore, even when one platform remains prevalent, its specific features evolve over time, facilitating shifts in the social expectations and norms for how people engage with social media. For example, with the introduction of "read receipts", users can now see when a message has been viewed, which contributes to perceived obligation to respond quickly (Mai et al., 2015). Similarly, whilst Snapchat streaks (a metric that tracks consecutive days of interaction between two Snapchat users) can facilitate and validate the closeness of a relationship, they can also contribute to stress over constantly ensuring streaks are maintained to avoid causing offence (Weinstein, 2018).

Therefore, a typical day's 'social media use' for a typical adolescent in 2019 is likely to involve using different platforms and features (which may favour a different type of engagement and social interaction) when compared to just a few years ago. This feeds into ongoing concerns from parents, educators, practitioners and policymakers about the impact of current teenage social media habits on health and wellbeing, as well as presenting a constant challenge for researchers to maintain pace with current trends. For example, platform- or feature- specific research measures can quickly become out-dated and even relatively recent findings may not generalise beyond the specific platforms and devices in vogue at the time of data collection (Hale & Guan, 2015; The Lancet, 2019). These evolving trends in platform prevalence and features have implications for *how* today's adolescents use, experience and perceive social media.

1.1.3 Adolescents' social media habits & experiences

Nine out of ten teenagers say they are online several times a day, including 45% who report that this is "almost constantly" (which has doubled in less than five years, alongside increasing smartphone ownership; Pew Research Center, May 2018). Whilst much of the public narrative on adolescent social media use tends to be generally negative (The Guardian, 25 December 2016), there is no clear consensus amongst teenagers themselves on whether social media has a positive or negative effect on people their age (Weinstein, 2018). In a large survey of US teenagers, 31% reported a mostly positive effect (most often citing connecting with friends and family) and 24% reported a mostly negative effect (voicing concerns over bullying and a lack of in-person contact; Pew Research Center, November 2018). The majority (45%) felt that social media had neither a positive or negative overall effect, suggesting that young people recognise that social media's effect depends on how it is used. It is interesting to note that – whether social media was viewed as positive or negative – adolescents' reasons for this focused on its benefits or drawbacks in the context of *interacting with others*.

This suggests that, unlike many adults, adolescents tend to primarily frame social media use not as a form of technology or device use, but as a form of social interaction. Indeed, young people tend to perceive online social interactions as more 'real' than older generations (Redden & Way, 2017), often

extending face-to-face relationships, with no clear boundary between offline and online social worlds (Assunção & Matos, 2014). Outside of school, today's adolescents are more likely to report spending time with their friends daily *online* rather than in-person (Pew Research Center, November 2018). Therefore, social media platforms provide a *social space* (which happens to be facilitated through screen-based devices) for adolescents to get together with their peers. These online interactions are generally perceived as positive, with most teenagers saying that social media helps them: feel more included, accepted and confident; feel more connected to their friends' lives and feelings; and receive social support (Pew Research Center, November 2018; Weinstein, 2018). Of course, positive experiences of social media are not ubiquitous, with 4 in 10 teenagers reporting that they could feel overwhelmed by drama on social media or pressured to post content that presents themselves well and receives positive feedback (Pew Research Center, November 2018).

Clearly, social media platforms form an important social space where most adolescents interact with their peers on a daily basis, bringing the usual positive and negative experiences of adolescent social interactions. This thesis frames social media use not as a form of technology or device use, but as an inherently social and interactive experience, with important cognitive and emotional components. This is true for users of all ages but becomes particularly salient in adolescence when we consider the biological and psychosocial changes that define this developmental period.

1.2 Why study social media use in adolescents specifically

1.2.1 Defining adolescence

Adolescence is the transitional period from childhood to adulthood (Casey, Getz, & Galvan, 2008). The term was coined in 1904 by G. Stanley Hall, a pioneer in the scientific study of adolescence, but this transition had long previously been recognised as a distinct period of life (Hall, 1904; Institute of Medicine & National Research Council, 2011). It is a period of rapid development, during which there is tension between increasing autonomy and the continued need for oversight and guidance from adults (Institute of Medicine & National Research

Council, 2011). Social media use is just one of many adolescent behaviours that raise concerns amongst adults (parents, educators, policymakers) around how to guide young people as they develop this increasing independence, while still supporting good health and wellbeing.

The World Health Organization defines adolescence as the second decade of life, from 10 to 19 years of age (World Health Organization, 2014). This overlaps with its definitions of *child* (under 18 years) and *youth* (defined by the UN as 15-24 years), with the term *young people* used to cover adolescents and youth from 10 to 24 years. However, there is no clear consensus on an exact age range defining adolescence, and whilst age-based definitions are convenient, chronological age is not the only defining characteristic of this developmental period (Canadian Paediatric Society, 2003). Whereas the start point of adolescence is biologically defined (pubertal onset), its end is socially defined (the point at which individuals take on a stable, independent role in society), with considerable variation between cultures and individuals (Blakemore, 2018b; Canadian Paediatric Society, 2003). The original studies in this thesis present data from 11- to 18- year olds attending Scottish secondary schools. This captures individuals from most of the second decade of life, while they navigate a period of intense psychosocial and academic development. This thesis will primarily refer to this group using the term *adolescents*, at times also using the term *young people*.

1.2.2 A period of heightened sensitivity to social influence

Adolescence has been described as a period of heightened sensitivity to social signals, with social context and social acceptance strongly influencing adolescent behaviour (Blakemore & Mills, 2014). Throughout this period, adolescents spend increasingly more time with peers, and move towards valuing peer acceptance and opinions over those of family members (Brown & Larson, 2009). Peer acceptance becomes central to adolescents' social and personal identity, with peer rejection and exclusion impacting on mood, state anxiety and feelings of self-worth more acutely in adolescents than in children or adults (Brown & Larson, 2009; O'Brien & Bierman, 1988; Sebastian, Viding, Williams, & Blakemore, 2010). Adolescents tend to be more vigilant to possible social evaluation, with higher general levels of self-consciousness (Westenberg,

Drewes, Goedhart, Siebelink, & Treffers, 2004) and heightened stress responses to social scrutiny compared to children (Gunnar, Wewerka, Frenn, Long, & Griggs, 2009).

It has been argued that adolescent behaviour and wellbeing can only be fully understood by taking account of the effect of social influence, which plays a role in many adolescent-typical behaviours (Blakemore & Mills, 2014). For example, risk-taking peaks around the late teens and is particularly heightened (along with reward sensitivity) by the presence of peers for adolescents compared to adults (Chein, Albert, O'Brien, Uckert, & Steinberg, 2011; Logue, Chein, Gould, Holliday, & Steinberg, 2014; Shulman et al., 2016; A. R. Smith, Steinberg, Strang, & Chein, 2015). It has been argued that *social* risk (e.g. possible peer exclusion or negative evaluation) carries more weight for adolescents, who may prioritise avoiding social risk over other risks (e.g. health costs; Blakemore, 2018a; Blakemore & Mills, 2014).

An increased sensitivity to the social context seems to be an inherent characteristic of adolescence. These adolescent-typical behaviours have been noted throughout human history (Blakemore, 2018b), evidenced across cultures (Steinberg et al., 2018), and even demonstrated in non-human animals (Logue et al., 2014). Evidently there is nothing new about today's adolescents strongly valuing peer interactions, acceptance and approval. What *does* distinguish them from previous adolescent generations is their access to 24/7 instant social interactions, facilitated by social media platforms accessible on smartphones (Pew Research Center, May 2018). It is therefore relevant to consider how these well-established developmental characteristics of adolescence are expressed in the context of today's connected world.

1.2.3 Navigating adolescence in today's connected world

Today's adolescent generation continue to conduct adolescent-typical peer interactions, such as forming individual and group identities and navigating frequent friendship formation and break-ups (Brown & Larson, 2009). However, with these peer interactions increasingly taking place in an online social space (Pew Research Center, November 2018), it is timely to consider the unique properties of these online social interactions, compared to offline interactions.

For example, social media interactions are typically more visible and permanent than face-to-face interactions. This includes not only content that is shared publicly or with an individual's entire social network, but also the possibility of private messages being captured and shared by recipients, remaining permanently accessible thereafter in either case (Marwick & Boyd, 2014). This can amplify social 'drama', which many teenagers say they find overwhelming on social media (Pew Research Center, November 2018). This visibility and permanence can also leave some young people feeling pressure to post content that presents themselves well and receives positive feedback via likes and shares (Pew Research Center, November 2018; Redden & Way, 2017).

Furthermore, social media can heighten the sense of urgency of interactions, with expectations of prompt response times and new norms around expected 24/7 connection and availability (Fox & Moreland, 2015; Giedd, 2012; Weinstein, 2018). Together, these properties of online interactions can help keep users engaged, constantly checking their platforms to stay up to date with interactions and popular content within their networks (Vorderer, Kromer, & Schneider, 2016). This is relevant for social media users of all ages, as adults also report feeling strongly attached to platforms and experience anxiety when they are unable to check their devices (Cheever, Rosen, Carrier, & Chavez, 2014; Clayton, Leshner, & Almond, 2015). However, given adolescents' heightened sensitivity to social context, this is especially salient in this developmental stage, during which individuals can feel preoccupied with online interactions, concerned about missing out and unsettled without access (Redden & Way, 2017; Vorderer et al., 2016). Adolescents are therefore primed to be highly engaged, invested social media users.

It is also relevant to consider notable generational differences in the experiences of social interactions between adolescents today compared to those in the (even very recent) past. Whilst today's adolescents experience the same biological and psychosocial developments as previous teenage generations, making them acutely aware of social cues during this period, the properties of the (now online) social context have changed. Adolescents are navigating this online social space during their formative years of social development, with brain structures and functioning for social processing are still very much

developing throughout adolescence (Blakemore, 2018b). In parallel, adults (parents, teachers, practitioners) are also navigating their roles in supporting this generation of young people, often without shared experience or understanding of the devices, platforms and features, or associated social norms and expectations (Redden & Way, 2017). This has given rise to calls for evidence-informed approaches to supporting adolescent wellbeing as they develop autonomy and independence in their online interactions.

1.3 Current attention: concerns vs evidence base

Concerns are being voiced by policymakers, health professionals, educators and parents around the possible negative impact of social media on young people's mental health and sleep (George & Odgers, 2015; The Guardian, 25 December 2016; UK House of Commons Science and Technology Committee, 2019). These concerns are understandable, since adolescents and emerging adults must navigate an intense developmental stage, balancing 24/7 available online social interaction with high academic demands and often insufficient sleep, during a period of increased risk for developing lifelong poor mental health (Carskadon, 2011b; McLaughlin & King, 2015; Orth, Maes, & Schmitt, 2015; J. Owens, 2014). Whilst appreciating valid concerns, it is relevant to also note that worries over the wellbeing implications of media use are not a new phenomenon (The Guardian, 6 January 2017). However, what *is* important is ensuring that – as media devices and habits continue to evolve – we too continually update our to understanding their implications for wellbeing.

With public concern and calls to implement policy, it is therefore timely to consider the gaps in existing evidence that is available to inform these discussions, which can be enriched with targeted, rigorous research. Common limitations of existing approaches to studying adolescent social media use include: (1) a prevalent techno-centric approach that groups social media together with other so-called "screentime" activities; (2) a tendency to pathologise social media use, with assumptions of inherent harmfulness; (3) a continued lack of adolescent perspective in the literature.

1.3.1 Not just another hour of "screentime"

Current debate and research on the impact of social media use often does not distinguish social media from other forms of technology use. Social media is often grouped together with considerably different technology-based activities – such as all types of internet use, smartphone use and even TV viewing – under generic umbrella terms such as "screentime". However, social media's unique social affordances offer a different (inherently social and interactive) experience compared to other activities that also happen to be facilitated by devices (Carr & Hayes, 2015). As discussed, adolescents themselves frame their social media use more as social interactions than technology use (Pew Research Center, November 2018; Redden & Way, 2017; Weinstein, 2018). Therefore, this "screentime" focused techno-centric approach fails to capture the unique social, emotional and cognitive aspects of adolescent social media use that are specifically relevant to an improved understanding of sleep and wellbeing in today's connected world (Scott & Woods, 2019). It is important that research - and evidence-informed decision-making in health, education and policy – acknowledges social media use in its own right, recognising its different properties.

Compared to other forms of technology or traditional media, social media platforms facilitate unique changes not only in how we spend our time but crucially how we interact with each other. Platforms are easily accessible via smartphone apps (facilitating engagement throughout the day and alongside other activities) and are specifically designed to keep users engaged, with continual notifications and no clearly defined end point (Bhat, Pinto-Zipp, Upadhyay, & Polos, 2018; Exelmans & Scott, 2019). Importantly, platforms provide richly varied opportunities for social interactions, allowing individuals to: curate a careful self-presentation through public profiles; quantify peer approval through number of likes and retweets; and extend daytime face-to-face peer interactions with 24/7 availability for individual and group messages (Fox & Moreland, 2015; Woods & Scott, 2016). Together, these features and user experiences contribute not only to increased time devoted to social media use (Pew Research Center, March 2018), but importantly to evolving social norms around expected availability and the urgency of online interactions (Fox & Moreland, 2015; Thomee et al., 2010).

As such, one hour of "screentime" spent using social media platforms could produce very different experiences depending on how the individual interacts with those platforms during that time. This time could feature *passive* social media use, with an individual scrolling through information and posts by other users without responding, contributing or engaging. Alternatively, this time could be spent in very *active* social media use, with an individual engaging in social interactions, sharing content and responding to others' content. This active social media engagement may offer wellbeing benefits through opportunities for positive social interactions (Clark, Algoe, & Green, 2017). However, it may also be more difficult for users to disengage from this more active, socially interactive type of engagement when required, for example when it is time to sleep (Scott & Woods, 2018). The unique implications of passive versus active social media use further reinforce the need for research to move beyond its current focus on simply time spent using devices and platforms.

A core underlying issue that feeds into this continued focus on the screens and devices, rather than the *experiences* of online interactions, is measurement. Existing research often conceptualises social media use as a technology-based activity that can be adequately captured in terms of frequency and duration of use (Jenkins-Guarnieri, Wright, & Johnson, 2013; Seabrook et al., 2016). With studies frequently relying on single item measures of "screentime" or daily social media use (in hours and minutes), it is important to interpret existing evidence within the limits of what it can and cannot tell us. Crucially, to meaningfully inform clinical practice and wider policy, we must remember that conceptualising social media use in minutes and hours only gives one part of the picture. It is important to consider the motivations for and experiences of this time spent using social media, to avoid oversimplification in policy and practice that reduces "social media use" from a complex range of experiences and social interactions to a single number (represented only in hours per day).

1.3.2 Pathologising online social interactions

Another limitation of existing literature is an overall bias towards framing social media negatively. Much of the research literature approaches social media use as a potential threat or inherently harmful activity that should be minimised, using language around social media "addiction" and "problematic use"

(Andreassen, Pallesen, & Griffiths, 2017; Bányai et al., 2017; Bhat et al., 2018; Rozgonjuk, Levine, Hall, & Elhai, 2018; Satici & Uysal, 2015; Vernon, Modecki, & Barber, 2017), which can pathologise social media use despite insufficient evidence for considering it an addiction (Billieux, Maurage, Lopez-Fernandez, Kuss, & Griffiths, 2015). Moralistic judgement can further influence existing research questions, measurements and interpretations, creating an overall bias towards examining only negative outcomes, rather than providing a balanced holistic view of both positive and negative impacts of social media use. This negative view of social media is maintained by a "screentime" mindset that frames social media use as a single technology-based activity, feeding into assumptions that devoting considerable time to this one activity per day must be a sign of poor adjustment (The Guardian, 25 December 2016). This fails to appreciate the valuable potential for social connection, closeness and social support that social media facilitates for many adolescents (Pew Research Center, November 2018; Weinstein, 2018).

This tendency to pathologise social media habits is similarly fuelled by the (un)availability of appropriate measurement tools. Just as many studies rely on single-item non-validated measures of duration or frequency of use (Jenkins-Guarnieri et al., 2013; Seabrook et al., 2016), the multi-item validated measures that *are* available often pathologise social media use (Andreassen, Torsheim, Brunborg, & Pallesen, 2012; Holmgren & Coyne, 2017; van den Eijnden, Lemmens, & Valkenburg, 2016). It is crucial to remember that the measurement tools available to researchers and clinicians limit the questions we can ask participants and patients, the conclusions we can draw and the recommendations we can make. Therefore, if we only ask about participants' and patients' daily duration of social media use or experience of 'addictive' symptoms, then we are limiting our understanding and discussions – as well as wider public dialogue – by missing insight into other relevant aspects of social media interactions.

1.3.3 Where is the adolescent voice?

These approaches by researchers – and dialogue amongst practitioners, policymakers and parents – do not seem to align with the perspectives of adolescents themselves. This view of social media as a technology rather than a

social space (and as something inherently negative or potentially harmful) does not fit with adolescents' generally more balanced take on social media as a tool that facilitates social connections, with both positive and negative potential (Pew Research Center, November 2018; Redden & Way, 2017; Weinstein, 2018). Unfortunately, this adolescent voice is lacking within the literature, helping to maintain a research and policy agenda driven by adult perspectives, which often do not understand current adolescent social media norms and expectations, or fail to consider how these interactions are perceived by an adolescent brain with heightened sensitivity to social cues (Blakemore & Mills, 2014). This can result in unrealistic intervention approaches that focus on restricting access to devices or platforms, rather than opening meaningful and balanced dialogue around adolescents' experiences. It also creates a lack of shared understanding amongst stakeholders, which would be more effective in creating a linked-up approach to supporting healthy habits through self-relevant input and discussions for today's teenage population.

1.4 Chapter summary

This chapter has outlined key context that forms part of the rationale for this thesis, which will be further developed in Chapter 2. Section 1.1 introduced the current social media landscape, giving consideration to what defines social media, age differences in prevalence and platform preference, and the experiences of social media amongst today's adolescents specifically. Section 1.2 outlined key concepts relating to adolescence, highlighting this as a period of heightened sensitivity to social cues, and considering the implications of these developmental changes for adolescents' experiences of social media interactions. Finally, Section 1.3 noted current concerns and calls for policy development, indicating the timeliness of enriching the available evidence base with high quality targeted research that addresses existing limitations of the literature. Together, this chapter has built the rationale for studying social media separately from other technologies and for studying social media use in adolescence specifically. It has highlighted the need to bring new approaches to this area of study, that move beyond measuring social media use in hours per day, to better understand its social, emotional and cognitive aspects (whose specific relevance to adolescent sleep is further considered in Chapter 2).

Chapter 2   Introduction to adolescent sleep

Sleep is a key component of wellbeing, with increasing recognition of its bidirectional and interactive effects with mental and physical health (Reynolds & O'Hara, 2013). Sleep complaints are prevalent and present a significant and well-recognised social, economic and health burden (Hafner, Stepanek, Taylor, Troxel, & Stolk, 2016; McKnight-Eily et al., 2011; J. Owens, 2014). Adolescence in particular has been described as bringing about a "perfect storm" of biological, psychosocial and societal factors that work together to produce short and ill-timed sleep for a majority of this population, where the amount of sleep required for optimal functioning remains high (Carskadon, 2011b; Crowley, Wolfson, Tarokh, & Carskadon, 2018; J. Owens, 2014). Therefore, current concerns over the wellbeing impact of social media include fears that it may contribute to an "epidemic" of poor sleep for today's adolescents (J. Owens, 2014).

Chapter 1 introduced adolescent social media use in a broad context, noting the interest in understanding its implications for health and wellbeing generally. Chapter 2 now builds the rationale for studying adolescent social media use in relation to *sleep* specifically, as one important component of health and wellbeing. It outlines key concepts in the study of sleep, with a specific focus on processes that make disrupted sleep especially prevalent during adolescence and the consequences of this. It then considers evidence to date on associations between social media use and sleep in adolescents, outlining the gaps in existing understanding that the original studies in this thesis will specifically target. This chapter is structured in four main sections, which will review the following aspects of current understanding:

2.1 Approaches to studying sleep, and how different tools have built current understanding of its physiological and behavioural processes and its subjective experience.

2.2 How sleep changes in adolescence, with a 'perfect storm' of bioregulatory, psychosocial and societal pressures that make insufficient and ill-timed sleep the norm for much of the adolescent population.

2.3 The importance of sleep in adolescence, with implications for mental health, physical health and learning.

2.4 Existing research on social media use and sleep, including the contribution and limitations of this literature to date.

Finally, Section 2.5 synthesises key points raised throughout both introductory chapters to outline the rationale and purpose of the original studies in this thesis.

2.1 Understanding sleep: physiology, behaviour and experience

What happens when we sleep has remained a considerable mystery until recent decades (Walker, 2018). Historically, sleep was considered a near-death state, during which the brain was effectively "switched off" (Dement, 1998). However, research has since demonstrated that, far from being a passive state, sleep involves a complex interaction of physiological and behavioural processes:

> "Sleep is a naturally recurring and reversible *biobehavioural* [emphasis added] state characterized by relative immobility, perceptual disengagement, and subdued consciousness." (Tubbs, Dollish, Fernandez, & Grandner, 2019, p. 3)

In their definition, Tubbs and colleagues highlight the typical markers that we use to determine sleep: we tend to recognise that a person is sleeping if they are lying still, not responding to the world around them but can be awoken. Particularly worthy of note is their characterisation of sleep as a *biobehavioural state*, which highlights the interaction between physiological and behavioural processes in producing sleep (Tubbs et al., 2019).

2.1.1 Physiological processes of sleep

2.1.1.1 How sleep and wake are regulated

Sleep and wake are regulated by two biological processes, illustrated in Figure 3: sleep-wake homeostasis (process S) and circadian rhythm (process C; Borbely, Daan, Wirz-Justice, & Deboer, 2016). Sleep-wake homeostasis means that sleep pressure builds across waking hours and dissipates during sleep. In a simple

sense, this means that the longer an individual has been awake, the more likely they are to fall asleep, and the longer they have been asleep, the more likely they are to wake up. However, this process also interacts with the circadian rhythm (process C) which means that – regardless of how long an individual has been awake or asleep – there are times of day when they are naturally predisposed to be sleepy or alert. Circadian rhythms are daily (roughly 24-hour) biological cycles for example in alertness, temperature and hormone levels. They are regulated by environmental cues that act as timekeepers, or *zeitgebers*, with the strongest being the day night cycle of light and dark. Other zeitgebers include eating and socialising, which is particularly valued by the adolescent 'social brain' (Blakemore & Mills, 2014), highlighting the interaction of these physiological processes with behaviour. Both process S and C undergo developmental changes in adolescence, with implications for the typical sleep profile of this population (further discussed in Section 2.2; Crowley et al., 2018).
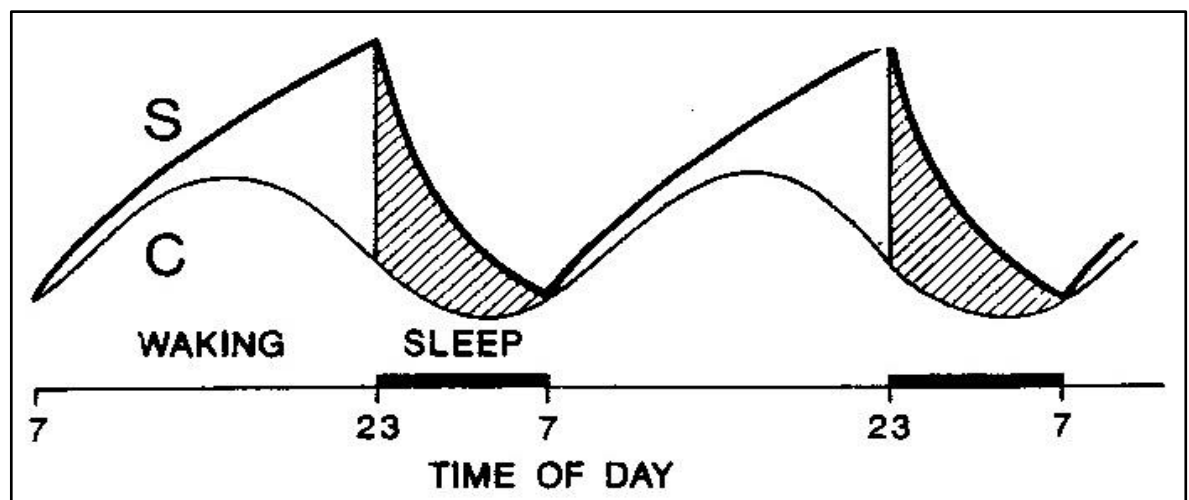
Figure 3 - Two-process model of sleep-wake regulation
The two-process model illustrates how process S (sleep-wake homeostasis) and process C (circadian rhythm) work together to regulate sleep and wake. Figure is taken from Borbely and Achermann (1999).

2.1.1.2 What happens during sleep

Historically, sleep was considered as the absence of wakefulness: a passive state in which the brain was "switched off" (Dement, 1998). This view was challenged in the 1950s, with the discovery of rapid eye movement (REM) sleep sparking new scientific interest in sleep (Aserinsky & Kleitman, 1953). Aserinsky and Kleitman detected this distinct sleep stage by recording electrical signals from participants' brains, muscles and eyes while they slept in a laboratory setting.

This combination of methods became known as polysomnography (PSG), and remains recognised as the gold-standard technique for examining sleep architecture (the electrophysiological changes during sleep; Tubbs et al., 2019) for research and clinical diagnosis. Studies using PSG have since demonstrated that one sleep episode (i.e. one night's sleep) comprises distinct stages of REM and non-REM sleep, each characterised by unique patterns of electrophysiological activity, which show a stable roughly 90-minute cycle (see Figure 4).
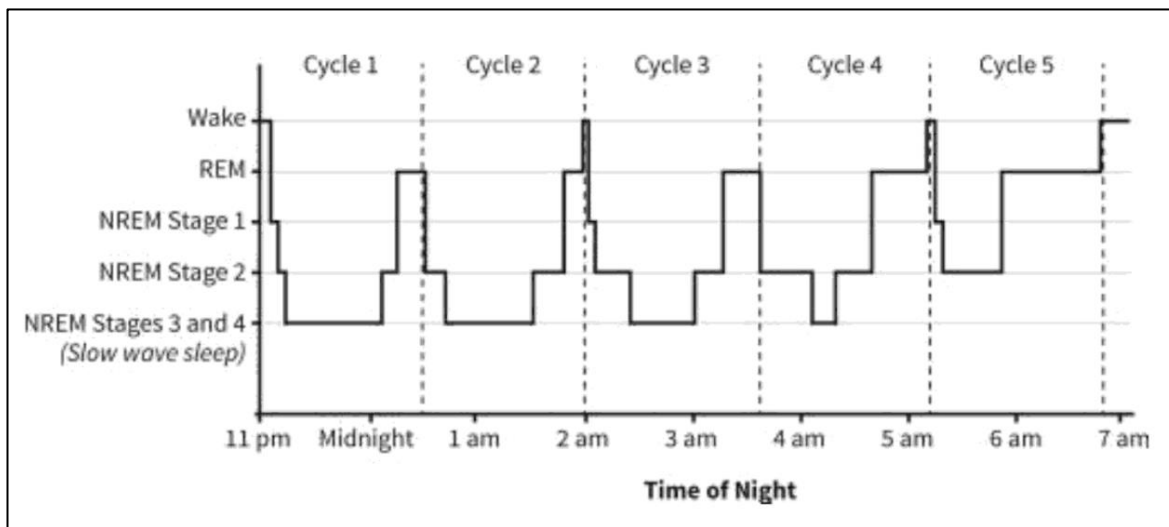
Figure 4 - The sleep cycle
Illustrative sleep cycle showing roughly 90-minute cycles through sleep stages across an 8-hour nighttime sleep episode. REM = Rapid Eye Moment. NREM = Non Rapid Eye Movement. Figure is taken from Walker (2018).

Furthermore, it has become clear that different sleep stages have different roles. For example, the proportion of slow wave sleep (non-REM stages 3 and 4) provides a measure of sleep pressure, as it increases following a period of extended wakefulness and decreases across the night's sleep episode (Dijk, Beersma, & Daan, 1987; Dijk, Brunner, & Borbely, 1990). This has built current understanding of the two-process model of sleep regulation (Borbely et al., 2016), and highlighted changes to sleep pressure during adolescence (further discussed in section 2.2). In contrast, REM sleep takes place mostly in the second half of a night's sleep episode (see Figure 4), and has been implicated in emotional processing (Walker & van der Helm, 2009). This means that cutting a sleep episode short selectively deprives an individual of REM sleep, with negative consequences for emotional functioning and mental health (further

discussed in Section 2.3; Baum et al., 2014; Berger, Widome, & Troxel, 2019; McMakin et al., 2016).

2.1.2 Behavioural processes of sleep

Behavioural processes interact with these physiological processes. For example, whilst the circadian rhythm is endogenous (generated internally), behaviours such as late-night socialising or eating can influence the circadian rhythm (Wehrens et al., 2017). Similarly, whilst a healthy nighttime sleep episode consists of roughly five 90-minute cycles that steadily become richer in REM sleep, behaviours that cut this sleep opportunity short can fundamentally change this physiological sleep architecture. Tubbs and colleagues (2019) note that conceptualising sleep as a *health behaviour* can be useful to highlight those modifiable behaviours – both actions and omissions – that impact individuals' sleep and associated outcomes. For example, they highlight that a person's sleep duration is not purely driven by their physiological sleep need, but also by *sleep opportunity*, or the time they make available for sleep. Therefore, whilst sleep is a basic physiological need for survival and functioning, individuals can also choose to restrict sleep to prioritise other activities, such as more rewarding online social interactions. This is highly relevant in adolescence, considering the heightened sensitivity to social cues (Blakemore & Mills, 2014), which could mean that some adolescents prioritise social media interactions over sleep.

Studies that examine sleep patterns and related behaviours tend to use retrospective self-report measures, sleep diaries or actigraphy. Actigraphs are typically worn on the wrist and monitor an individual's movement, providing a measure of activity and rest from which periods of sleep and wake are inferred (although sedentary wakefulness can be miscategorised as sleep; Grandner & Rosenberger, 2019). As a less resource-intensive tool, actigraphy is better placed than PSG to facilitate field-based continuous assessment over extended periods of time and in larger cohorts (Galland et al., 2018). This has provided normative profiles across childhood and into adolescence of changing bedtimes and rise times on school days and free days, offering insight into circadian and behavioural developments to sleep (further discussed in Section 2.2; Galland et al., 2018). Self-report measures including questionnaires and diaries are more

suitable for even larger cohorts, and have provided most of the available population-based estimates of typical sleep patterns and prevalence of complaints (Grandner, 2019a). These measures can capture reports of sleep timing and also relevant sleep hygiene behaviours (e.g. caffeine consumption) that are not captured by actigraphy, but are highly relevant for understanding of sleep (Mastin, Bryson, & Corwyn, 2006). These measures have the usual limitations of self-reporting for recall and reporting bias (Althubaiti, 2016). However, they not only facilitate data collection in large cohorts, but can also provide valuable insight into the subjective experience of sleep.

2.1.3 The subjective experience of sleep

There is now increasing recognition of the role of cognition and subjective experience in sleep. Qualitative insights into poor sleepers' perceptions have informed approaches to diagnosis and treatment by offering valuable new understanding of the *experience* of sleep (Kyle, Espie, & Morgan, 2010). For example, insomnia is the most prevalent sleep complaint, and its first-line treatment – cognitive behavioural therapy (CBTi) – recognises the importance of individuals' beliefs about and experience of sleep, alongside sleep-related behaviours (Siebern & Manber, 2011). This illustrates that a range of complementary subjective and objective measures is needed to provide a holistic understanding of adolescent sleep that unites physiology, behaviour and experience (Gregory & Sadeh, 2012). This can offer more rounded understanding of phenomena where objective and subjective measures diverge.

For example, depressed adolescents do not differ in physiological measures of sleep compared to healthy controls, but do consistently give poorer ratings of their experienced sleep quality (Bertocci et al., 2005). This led Bertocci and colleagues to speculate that depressed adolescents may have an increased physiological sleep need, meaning that an apparently sufficient amount of objectively measured sleep was not experienced or perceived as sufficient by these adolescents. Indeed, recent work has shown that depressed adolescents required more hours of sleep than healthy adolescents to reach their optimal functioning, in terms of daily mood, the following day (Fuligni, Bai, Krull, & Gonzales, 2017). Therefore, just as social media use cannot be adequately captured by a single number (of hours per day online), sleep is a complex

phenomenon that can only be understood by combining a range of measures to capture sleep physiology, behaviour and experience.

2.1.3.1 The present approach: adolescent perspective on subjective sleep experience

The studies in this thesis aim to contribute new understanding of adolescents' experience of sleep in the social media age. Whilst understanding the subjective experience of sleep is relevant across the lifespan (Kyle et al., 2010), given that a key purpose of adolescence is developing autonomy and independence (Blakemore, 2018b), focusing on adolescents' own perceptions of their sleep and social media experiences is especially relevant during this developmental stage. Gaining insight from an adolescent perspective is crucial to meaningfully inform realistic sleep education and intervention strategies, and to motivate adolescents to develop and maintain healthy habits.

The original studies in this thesis therefore capture the experience of sleep using quantitative and qualitative self-report measures that offer insight into adolescents' perspectives on their sleep. The quantitative self-report measures include single item questions on sleep patterns available for a large UK cohort, plus well-established multi-item validated questionnaires used in original data collection. Together, these measures provide an overview of sleep experience, by capturing aspects of sleep timing, quantity and quality. The qualitative methods allow adolescents to convey their experiences of sleep and social media use, communicating in terms that prioritise their perceptions, rather than being restricted by the questions and response options set by researchers (Braun & Clarke, 2013). This thesis acknowledges the strengths and limitations of self-report measures of sleep experience: whilst they do not provide a verifiable objective measure of sleep behaviour or physiology, they instead offer valuable insight into adolescents' own experience of sleep as they navigate this period of intense psychosocial development with access to 24/7 online social interactions. Throughout this thesis, I will use specific terms where appropriate (e.g. *insufficient sleep* or *delayed sleep onset*) alongside generic terms such as *sleep outcomes* and *sleep patterns* to encompass the wide range of relevant components of sleep experience, including perceived quality, quantity and timing.

Having considered existing understanding and approaches to examining sleep physiology, behaviour and experience in general, the following section now turns to the developmental changes that occur to sleep during adolescence specifically.

2.2 Changes to sleep during adolescence: the Perfect Storm

The amount of sleep that adolescents require for optimal functioning remains high throughout this developmental period, at around 9 hours (Crowley et al., 2018; Fuligni et al., 2017; Short, Weber, Reynolds, Coussens, & Carskadon, 2018). However, studies across different countries have consistently shown that adolescents overall tend to get less than this healthful amount of sleep, with the majority reporting insufficient sleep to function properly or to meet National Sleep Foundation guidelines (Eaton et al., 2010; Galland et al., 2018; Gradisar et al., 2013). The Perfect Storm model (Carskadon, 2011b; Crowley et al., 2018) provides a framework for examining the different pressures that combine to produce insufficient and ill-timed sleep for the majority of adolescents. This model considers *biological* changes to sleep-wake regulation systems and *psychosocial* changes, which together result in delayed bedtimes that directly conflict with *societal* demands of early school day rise times, leading to a typical pattern of short and ill-timed adolescent sleep (Figure 5).
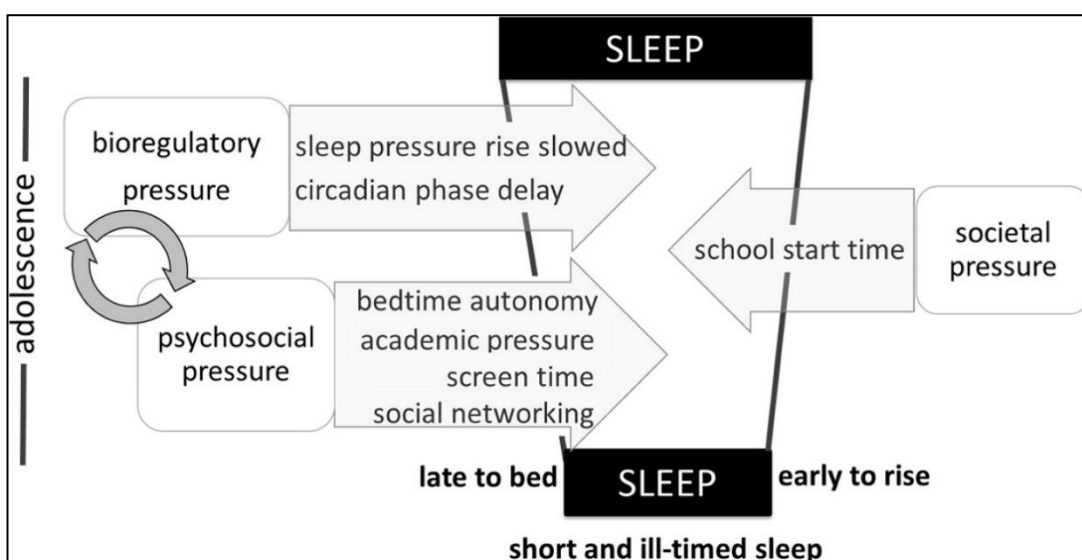
Figure 5 - The Perfect Storm model
This model illustrates how bioregulatory and psychosocial changes during adolescence contribute to delayed bedtimes, which result in short and ill-timed sleep when combined with early rise times on school days. Figure is taken from Crowley et al. (2018).

2.2.1 Bioregulatory pressure

Both processes in the two-process model of sleep-wake regulation (Borbely et al., 2016) undergo developmental changes in adolescence, that together tend to delay sleep onset (Crowley et al., 2018; Jenni & LeBourgeois, 2006). Firstly, sleep pressure builds more slowly during adolescence than in childhood, which allows adolescents to extend their waking day with later bedtimes (Crowley et al., 2014). In contrast, sleep pressure continues to *dissipate* at the same rate (Tarokh, Carskadon, & Achermann, 2012), meaning that adolescents' shorter sleep duration does not reflect a reduced underlying sleep need, which remains stable across adolescence at roughly 9 hours for optimal functioning (Crowley et al., 2018; Fuligni et al., 2017; Galland et al., 2018; Short et al., 2018). Delayed bedtimes from slower build-up of sleep pressure are compounded by developmental changes to circadian rhythms, which rapidly delay through adolescence until around age 20, before slowly advancing back again throughout adulthood (Roenneberg et al., 2004). This delayed circadian rhythm is a defining feature of typical adolescent sleep, and the abrupt change at around 20 years of age (when the body clock stops delaying and starts advancing) has even been proposed as a biological marker for the end of adolescence (Roenneberg et al., 2004).

2.2.2 Psychosocial pressure

The typical delay in adolescent sleep timing does not solely result from these *biological* changes. Adolescents get more sleep in controlled laboratory conditions (~9 hours) than in real-world conditions (~7 hours; Crowley et al., 2018; Galland et al., 2018), highlighting the additional influence of *psychosocial* factors, such as increased bedtime autonomy. This reflects a key purpose of adolescence – developing independence – which includes a shift towards a self-determined bedtime routine and schedule (Carskadon, 2011b). This allows adolescents to delay their bedtime in favour of other more rewarding activities, particularly social interactions with peers, which are facilitated 24/7 by widespread access to social media platforms via smartphones (Dahl & Lewin, 2002; Pew Research Center, May 2018). Whilst this allows adolescents to align bedtimes more closely with their naturally later circadian rhythms, delaying

bedtimes to engage in these stimulating activities at night can reinforce and even further exaggerate this circadian delay (Short et al., 2018).

Online social interactions are highlighted as an important psychosocial pressure in the Perfect Storm model, as a highly engaging activity that can compete with bedtimes (Carskadon, 2011b; Crowley et al., 2018). Importantly, unlike the maturational changes to the biological processes regulating sleep and wake, these bedtime online social interactions are a *modifiable* component of typical adolescent sleep, making them a valuable target when seeking to improve sleep and associated outcomes for this chronically sleep-deprived population. Furthermore, whilst later circadian rhythms are an inevitable characteristic of typical adolescent sleep, addressing these types of stimulating bedtime behaviours can at least avoid further exaggerating this circadian delay, thus working at both a behavioural and physiological level (Short et al., 2018). In their update to the Perfect Storm model, Crowley and colleagues (2018) called for further investigation to understand the role of these psychosocial factors at an individual level. The original studies in this thesis contribute to this, aiming to enrich available evidence with an adolescent perspective on the competition between online social media interactions and sufficient sleep, and develop initial evidence-based support to help young people balance these two important activities while they navigate this transitional period and develop autonomy.

2.2.3 Societal pressure

Directly opposing these bioregulatory and psychosocial pressures for later bedtimes is societal pressure for early rise times due to school schedules. Whereas school day rise times tend to align with typical circadian rhythms for children, they create a state of permanent weekday social jet lag for most adolescents, who must wake up and attend school while their naturally delayed circadian rhythm is still promoting sleepiness (Carskadon, 2011a). This results in a typical pattern of short sleep on school days, accruing a sleep debt over five days of early rise times, followed by extended sleep opportunity on weekends with later rise times allowing longer sleep duration to recover some of this sleep debt (Galland et al., 2018). Therefore, in combination with later bedtimes, these pressures together mean that insufficient and ill-timed sleep is the norm amongst the adolescent population (Carskadon, 2011b; Crowley et al., 2018).

There is an increasing movement promoting and implementing later school start times that better align with typical adolescent circadian rhythms, particularly in the US where 80% of middle and high schools start before the recommended earliest time of 8.30am (American Academy of Pediatrics, 2014; Hafner, Stepanek, & Troxel, 2017; J. Owens, Drobnich, Baylor, & Lewin, 2014). Although the typical UK school start time is slightly later, further delays to a 10am start have been shown to improve school- and health- related outcomes for UK pupils, with recommendations for even later starts where practical to produce optimal results (Kelley, Lockley, Kelley, & Evans, 2017). Whilst there is support for the positive impact of later school start times on adolescent sleep and associated outcomes (Berger et al., 2019; Marx et al., 2017), this process can present logistic challenges, requiring time, investment and involvement from a wide range of stakeholders (Illingworth et al., 2019; J. Owens et al., 2014). Alongside these efforts to extend adolescent sleep opportunity by delaying rise times, it is therefore also valuable to promote earlier bedtimes, targeting modifiable behaviours that compete with sleep, such as online social interactions. This can offer a more immediate route to extending an adolescent's sleep opportunity that is more under the control of the young person and their family than their school schedule.

Given this 'perfect storm' of pressures working against sufficient good quality sleep during adolescence, this is a highly relevant developmental stage in which to further examine and understand potential barriers to healthy sleep. This is particularly important given the crucial role of sleep in maintaining good health and functioning.

2.3 Importance of sleep in adolescence

The purpose of sleep has long mystified scientists. This universal phenomenon – observed in all species studied to date (Kushida, 2013) – has presented a puzzle from an evolutionary perspective, as an apparently unproductive period of increased vulnerability each day. However, it is becoming clear that sleep is a key component of health and functioning, with research increasingly highlighting its role in enhancing a wide range of processes within the body:

> "Through an explosion of discoveries over the past twenty years, we have come to realize that evolution did not make a spectacular blunder in conceiving of sleep. […] Instead, we are now forced to wonder whether there are any biological functions that do *not* benefit by a good night's sleep. So far, the results of thousands of studies insist that no, there aren't." (Walker, 2018, pp. 7-8).

Despite this, the importance of sufficient good quality sleep is often overlooked in education interventions and public health messages (Gruber, Wiebe, Wells, Cassoff, & Monson, 2010; Perry, Patil, & Presley-Cantrell, 2013). Insufficient and poor quality sleep during adolescence is linked to negative outcomes across a range of domains, including mental health and emotional wellbeing, learning and academic performance, and physical health (Carskadon, 2011b; J. Owens, 2014; Shochat, Cohen-Zion, & Tzischinsky, 2014). Poor sleep therefore presents a considerable burden for health and education systems, reinforcing the importance of high quality up-to-date evidence to support healthy sleep for today's adolescents.

2.3.1 Links to mental health & emotional wellbeing

Sleep and mental health are increasingly recognised as two inextricably linked aspects of health and wellbeing. As of 2013, the DSM-5 (Diagnostic and Statistical Manual of Disorders, Fifth Edition) classification of sleep-wake disorders has moved towards recognising the "bidirectional and interactive effects between sleep disorders and coexisting medical and psychiatric illnesses" (Reynolds & O'Hara, 2013, p. 1100). For example, insomnia is now classified as comorbid with – rather than secondary to – a mental health diagnosis. There is considerable comorbidity between sleep complaints and depression, anxiety and stress (Khurshid, 2018), and disturbed sleep is observed across all major psychiatric disorders (Benca, Obermeyer, Thisted, & Gillin, 1992). Treating sleep problems has been shown to independently improve mental health symptoms (Carney et al., 2017; Kalmbach et al., 2019), whereas even short-term sleep disturbance can impair mental health (Krystal, 2012). For example, healthy individuals begin to present symptoms of psychosis after just one night without sleep (Waters, Chiu, Atkinson, & Blom, 2018). Such studies of *clinical* sleep and mental health problems have developed this scientific understanding of these closely linked aspects of health. However, in the current context of adolescent

social media use and sleep, a more appropriate focus is on *emotional wellbeing* in a broader sense.

Adolescence is not only characterised by increased vulnerability for developing mental health *problems* that persist into adulthood (F. S. Lee et al., 2014), but is also a period of rapid psychosocial developments in emotional regulation and wellbeing more broadly (Theurel & Gentaz, 2018). The typical adolescent pattern of shortened weekday sleep and longer, later weekend sleep has important implications for adolescent mental and emotional health. For example, this sleep pattern reduces weekday sleep duration and creates a permanent state of social jet lag (with misaligned weekday and weekend sleep timing), both of which have been independently linked to increased anxiety among adolescents (Mathew, Li, Hale, & Chang, 2019). Adolescent short sleepers are more likely to go on to receive a clinical diagnosis for an anxiety disorder (Roberts & Duong, 2017), and also tend to report higher levels of sub-clinical anxious symptoms, and difficulties with emotions, conduct and peers (Bauducco, Flink, Jansson-Frojmark, & Linton, 2016; Sarchiapone et al., 2014). Furthermore, this artificially curtailed weekday sleep also selectively deprives adolescents of the final hours that are rich in REM sleep, which has been implicated in emotional regulation (Berger et al., 2019; Walker & van der Helm, 2009). It has been argued that this sacrificed REM sleep may explain experimental evidence of increased anxiety, negative affect and anger when adolescents' sleep is restricted (Baum et al., 2014; McMakin et al., 2016). Therefore, during a period of intense psychosocial development and heightened risk of poor mental health, promoting sufficient and consistently timed sleep is crucial to support optimal adolescent emotional wellbeing (Mathew et al., 2019).

2.3.2 Links to learning & academic performance

Adolescence is also a period of high academic demand, during which sleep quantity and quality are linked to pupils' learning capacity and academic performance (Curcio, Ferrara, & De Gennaro, 2006; Dewald, Meijer, Oort, Kerkhof, & Bogels, 2010). Experimentally restricting or optimising adolescent sleep has been shown to worsen or improve academic performance accordingly (Curcio et al., 2006). It is likely that poor sleep impairs academic achievement via a number of pathways. For example, daytime sleepiness resulting from

insufficient sleep contributes to poor concentration, irritability and lack of motivation during the school day (Carskadon, 2011a). Lo and colleagues (2017) found that these daytime cognitive impairments progressively worsened over the course of a five-day restricted sleep schedule, and were not fully recovered by extended weekend sleep opportunities. Furthermore, it has long been recognised that sufficient good quality sleep is important for memory, with recent work characterising sleep as "a brain state optimizing memory consolidation" (Rasch & Born, 2013, p. 681) and recognising the complex contributions of different sleep stages to consolidating different types of memory (Diekelmann, Wilhelm, & Born, 2009). In particular, sleep has been shown to improve adolescents' recall of facts, which is an important component of school performance (Potkin & Bunney, 2012). Therefore, during this period of high academic demand, supporting healthy sleep habits can help optimise adolescents' performance.

2.3.3 Links to physical health

In addition to cognitive functioning and emotional wellbeing, sleep also has important implications for adolescents' physical health. Large epidemiological studies across the world have consistently supported a link between insufficient sleep and increased mortality (Grandner, Hale, Moore, & Patel, 2010). Insufficient and poor quality sleep are believed to play a causal role in the leading causes of death in developed nations, such as heart disease, cancer and obesity (Grandner, 2019c; Spaeth, 2019; Walker, 2018). For example, sleeping less increases appetite, snacking and preference for energy-dense foods (Dashti, Scheer, Jacques, Lamon-Fava, & Ordovás, 2015; Hanlon & Van Cauter, 2011), increasing the risk of being overweight or obese and of developing Type 2 diabetes (Cappuccio et al., 2008). This highlights the role of sleep in one important aspect of adolescent physical health, with rising rates of overweight and obesity amongst adolescents already presenting a considerable burden for current healthcare systems and increasing the risk of developing future health conditions (E. Y. Lee & Yoon, 2018). This illustrates that effectively supporting adolescents to maintain sufficient good quality sleep can not only promote optimal mental wellbeing and academic performance, but also help to tackle important issues in physical health (Fatima, Doi, & Al Mamun, 2018).

Therefore, whilst insufficient and ill-timed sleep is the norm for many adolescents, we must not dismiss the important implications of this typical sleep profile for the health and functioning of the adolescent population. Poor sleep during adolescence has immediate and lifelong consequences, limiting young people's current academic performance and emotional wellbeing, whilst making them more susceptible to future mental and physical health problems. It is therefore crucial to support healthy sleep during adolescence, and this requires a high quality up-to-date evidence base that is fit for purpose in today's connected world. Therefore, it is timely to review existing evidence on sleep and social media use, which has attracted attention from concerned stakeholders and been highlighted as one important factor that can impact on sleep as developing adolescents take more control of their social interactions and bedtimes (Crowley et al., 2018).

2.4 Existing research on social media and sleep

Chapter 1 noted the limitations of the prevalent techno-centric approach to studying adolescent social media use in relation to health and wellbeing generally. This section now focuses on existing research into social media use and adolescent sleep specifically. It outlines the contribution and limitations of approaches to date, and further discusses the specific gaps that this thesis aims to address.

2.4.1 Existing evidence on technology use generally

In the sleep literature, current understanding of social media use has been strongly informed by previous research on traditional media and technology use generally. This techno-centric approach has largely examined outcomes associated with the frequency, duration and timing of technology and media use (Jenkins-Guarnieri et al., 2013). Existing reviews of this evidence indicate that time devoted to social media use – alongside other technology activities like TV viewing, video gaming, computer and smartphone use – is generally associated with poorer sleep patterns, including shorter sleep duration, delayed bedtimes and poorer sleep quality (Cain & Gradisar, 2010; Hale & Guan, 2015; Levenson, Shensa, Sidani, Colditz, & Primack, 2016). This body of work has provided a useful framework for understanding the mechanisms by which technology use

generally – including social media use – can impact sleep, illustrated in Figure 6 (Bartel & Gradisar, 2017; Cain & Gradisar, 2010). These mechanisms include technology use directly delaying bedtimes and/or interrupting nighttime sleep (Exelmans & Van den Bulck, 2017a; Van den Bulck, 2003, 2004). Screen light's delaying effect on circadian rhythms has been highlighted as another potential mechanism; however effect sizes on sleep parameters are relatively modest even after considerable screen exposure in controlled settings (Chang, Aeschbach, Duffy, & Czeisler, 2015). Rather than simply light exposure, it has instead been proposed that this "screentime" may impact more strongly on sleep by increasing cognitive arousal at bedtime (Bartel & Gradisar, 2017; Cain & Gradisar, 2010; Exelmans & Van den Bulck, 2017b).
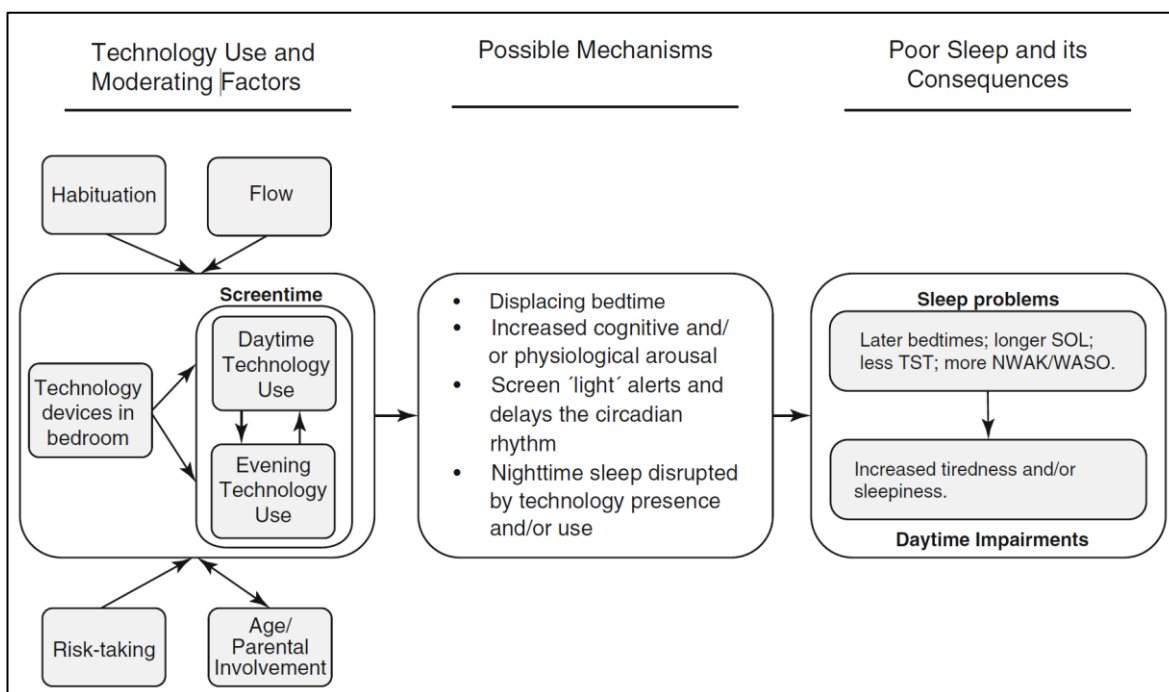
Figure 6 - Mechanisms linking technology use and sleep
This model illustrates proposed mechanisms linking technology use and sleep in children and adolescents. These include displacing bedtimes, increased arousal and screen light exposure. Figure is taken from Bartel & Gradisar (2017).

Existing evidence is largely cross-sectional, with calls for more experimental and longitudinal work to better examine causal mechanisms (Bartel & Gradisar, 2017; Bhat et al., 2018). For example, a causal link is supported by recent experimental evidence of improved sleep outcomes when adolescent phone use was restricted before bedtime (Bartel, Scheeren, & Gradisar, 2019). Furthermore, a recent study followed adolescents over one year, and found bidirectional effects between technology use and short sleep (Mazzer, Bauducco,

Linton, & Boersma, 2018). These are useful approaches to better understanding the underlying mechanisms, with these findings in line with both sleep displacement from technology use and also technology use as a coping strategy or sleep aid among already poor sleepers (Exelmans & Van den Bulck, 2016). However, these recent studies still attend to technology use generally, grouping social media interactions together with other activities under generic terms such as "screentime" and "phone use". A growing number of studies have considered sleep in relation to social media specifically, often continuing to apply a similar techno-centric approach that focuses on duration, frequency and timing of social media activity.

2.4.2 Applying a techno-centric approach to social media specifically

Applying this approach to social media separate from other technology, studies have found support for associations between higher overall social media use and poorer sleep patterns, including shorter sleep duration, later bedtimes and poorer sleep quality (Levenson et al., 2016; Woods & Scott, 2016). The timing of use is highly relevant for sleep, as social media use at bedtime is a strong predictor of poorer sleep, independent of overall use (Exelmans & Scott, 2019; Harbard, Allen, Trinder, & Bei, 2016; Levenson, Shensa, Sidani, Colditz, & Primack, 2017; Orzech, Grandner, Roane, & Carskadon, 2016; Woods & Scott, 2016). These findings are consistent with a sleep displacement mechanism (Bartel & Gradisar, 2017; Cain & Gradisar, 2010; Van den Bulck, 2004), as there are only 24 hours in a day, and an hour devoted to any activity – including using social media – is an hour that is spent awake.

Studying time spent on social media has been informative for understanding it as an activity that may *displace* sleep, like other technologies or media use (Bartel & Gradisar, 2017). However, to now move forward and more meaningfully inform practice and policy, it is crucial to acknowledge the limitations of conceptualising social media use in minutes and hours, as this only provides one part of the picture. An alternative approach is needed to better understand the *unique* mechanisms linking sleep and social media specifically, to avoid oversimplification that reduces a complex range of experiences and social interactions to a single number (represented only in hours per day). There is

potential to develop more in-depth insight by taking a tailored approach to examining social media independently of other technologies: one that focuses on building a fuller understanding of how this inherently social and interactive experience has unique implications for arousal and sleep.

2.4.3 Exploring social media's *unique* implications for sleep

Studies have indeed started to examine how sleep relates to not only the time that individuals spend using social media, but also their experiences of – and motivations for – these interactions (McNee & Woods, 2019; Scott & Woods, 2018; Woods & Scott, 2016). Therefore, alongside the behavioural component (actual social media activity), current understanding of mechanisms linking social media use to sleep has been improved by considering social, emotional and cognitive components of users' experiences. This has offered added insight into the proposed cognitive arousal mechanism linking technology use and sleep (Bartel & Gradisar, 2017), which is likely to be especially salient for social media use compared to more passive media consumption, with platforms offering opportunities for rich social interaction in real time.

For example, different individuals who spend the same amount of time using social media each day – or night – can differ in the level of emotional connection that they feel towards this activity (Jenkins-Guarnieri et al., 2013). This is especially salient for adolescents, for whom social media platforms offer an important social space during a developmental period with heightened value on peer interactions, acceptance and belonging (Blakemore, 2018a). Therefore it is perhaps unsurprising that young people often report feeling disconnected without access to social media and prefer to keep their phones within close reach during the night (Vorderer et al., 2016). This has implications for sleep outcomes, as highly invested users report poorer sleep quality and may find it more difficult to disengage from social media at night (Woods & Scott, 2016). This highlights the need to consider social media use within the broader context of an individual's online *and* offline social interactions, as a strong connection to social media platforms can stem from a more pervasive anxiety about potentially missing out (Przybylski et al., 2013; Scott & Woods, 2018).

This underlying fear of missing out has been linked to shorter sleep duration via both a behavioural pathway (by driving late night social media use, which delays bedtimes) and a cognitive pathway (by increasing pre-sleep cognitive arousal, thus further delaying sleep onset; Scott & Woods, 2018). Therefore, individuals who are concerned about possibly missing out may struggle at bedtime to stop not only *using* social media, but also *thinking* about possible social media interactions. This is further fuelled by concerns over meeting perceived social expectations for 24/7 online availability and prompt responses (Fox & Moreland, 2015; Mai et al., 2015), which may similarly extend social media activity at bedtime and increase arousal even once disconnected. This type of cognitive-emotional arousal is a well-established disruptor of sleep, although the severity of sleep disruption varies across individuals depending on their trait-like degree of 'sleep reactivity' to such psychosocial stressors (Drake, Pillai, & Roth, 2014; Kalmbach, Anderson, & Drake, 2018; Kalmbach, Cuamatzi-Castelan, et al., 2018). Table 1 summarises the range of sleep parameters that have been studied in relation to social media use to date, listing potential mechanisms that this existing research has suggested.

Table 1 – Summary of sleep parameters studied in relation to social media use and potential mechanisms

Sleep parameters examined	Potential mechanisms
• Later bedtime • Later sleep onset • Longer sleep onset latency (SOL) • Poorer overall sleep quality	• Users with a strong emotional connection to social media may have difficulty disconnecting at bedtime • Fear of missing out may increase cognitive arousal even once disconnected from social media • Perceived social expectations for online availability may prolong bedtime use and increase cognitive arousal

This reinforces the added potential insight that can be gained from moving beyond a purely behavioural focus (on hours per day on social media) to also explore individuals' social, cognitive and emotional experiences. This can contribute to a fuller understanding of adolescent sleep and more meaningfully inform practical approaches to interventions and education. For example,

focusing exclusively on reducing nighttime social media activity (e.g. by limiting access) is not only challenging to implement (Bartel et al., 2019; Houghton et al., 2015), but also fails to address these other relevant factors, such as cognitive-emotional arousal and individual vulnerability. Understanding the adolescent subjective experience of sleep in the social media age can therefore enhance available evidence and practical approaches to supporting a balance between social media interactions and healthy sleep.

2.5 Aims of this thesis

The present studies aim to complement and build on the existing evidence outlined above, by targeting remaining gaps in understanding on social, emotional and cognitive aspects of social media experiences that are specifically relevant to adolescent sleep. This seeks to enrich the evidence and tools available to support meaningful, informed decision-making and dialogue amongst stakeholders calling for evidence-based approaches to adolescent social media use and sleep. Each of the present studies have been motivated by identified gaps in existing research literature, which have been raised throughout these introductory chapters, and are summarised again here.

Firstly, existing approaches have largely been techno-centric, grouping social media use together with other technology or media activities under generic terms like "screentime", which is often framed negatively and even pathologised amongst adolescents. Those studies that do examine social media separately from other technologies often continue to focus on the frequency and duration of use. This has limited the scope of potential conclusions and recommendations to date, as this focus on hours per day fails to capture social media's unique social, emotional and cognitive user experiences that have important implications for adolescent sleep. It is now clear that social media use is an inherently social and interactive experience, whose sleep implications merit investigation separate from other technologies or more passive forms of media consumption. Insights from existing studies on adolescent sleep and technology in general have provided a useful building block. However, in order to best understand and support healthy adolescent sleep in today's connected world, there is a clear need to examine the unique experiences of social media, whose

24/7 potential for social interactions offers the adolescent 'social brain' around the clock possibilities of peer acceptance or missing out.

Furthermore, in order to better inform research, practice and policy, there is a clear need to capture the *adolescent voice* to build a more nuanced understanding of the subjective experience of balancing sleep and online interactions while navigating this period of intense biological and psychosocial development in today's connected world. This adolescent perspective is largely lacking from existing evidence on social media use and sleep, but offers a valuable avenue for improving understanding of individuals' motivations for and experiences of engaging with (and disengaging from) social media at night. This can contribute to updating sleep research, education and treatments to remain fit for purpose in a rapidly evolving social media landscape, whose platforms, features and associated norms can add to the existing perfect storm of pressures working against sufficient good quality sleep during adolescence.

2.5.1 Purpose of each study

The four studies presented in this thesis make use of a range of methodologies to provide different perspectives that together help build a more nuanced understanding of the unique implications of social media experiences for adolescent sleep. Table 2 summarises the purpose of each study, both to target identified gaps in current evidence and to build on the new knowledge gained as the studies progress.

Table 2 - Purpose of studies in this thesis

Chapter & study title	Gaps in current literature	Purpose of study
Chapter 3 Adolescent social media use and sleep patterns: cross-sectional findings from the UK Millennium Cohort Study	• Social media largely grouped together with other technologies under generic terms (e.g. "screentime"), which are often framed negatively or pathologised	• To examine associations between adolescent sleep and social media use specifically • To provide a baseline profile of normative social media use and sleep patterns in a representative sample of UK adolescents
Chapter 4 Identifying drivers for bedtime social media use despite sleep costs: the adolescent perspective	• Existing focus on frequency and duration of social media use does not capture its unique experiences and implications for adolescent sleep	• To explore the social, emotional and cognitive drivers underlying bedtime social media habits • To provide the adolescent voice, through rich focus group data, to meaningfully inform research and practice
Chapter 5 Nodding off but can't disconnect: development and validation of the iNOD index of Nighttime Offline Distress	• Available measurement tools limit research questions, conclusions and recommendations to a focus on time spent on social media or pathologising social media use	• To develop and validate a self-report measure that captures difficulty disconnecting from social media at night • To help ensure high quality measurement tools are available for researchers and practitioners to examine core underlying issues beyond just social media behaviours
Chapter 6 Informing evidence-based school practice through stakeholder consultation and a pilot lesson programme	• Meaningful and realistic sleep education and interventions need to address the issues around social media that adolescents themselves identify as important	• To develop and pilot classroom-based sleep education sessions that address self-relevant issues around social media for today's adolescents • To share practical recommendations on updating sleep education and interventions informed by this new evidence-base and stakeholder input

Chapter 3   Adolescent social media use and sleep patterns: evidence from the UK Millennium Cohort Study

3.1 Introduction

There is significant current attention towards the possible impact of screentime and social media on our adolescents' health. However, the lack of empirical evidence to support policy and practice development in this area has been consistently voiced by clinicians and researchers. For example, at the UK House of Commons Science and Technology Committee inquiry into the impact of social media and screen-use on young people's health use in adolescence, the Royal College of Paediatrics and Child Health (RCPCH) urged the UK government as a matter of priority to develop guidance for health practitioners along the same lines as the American Academy of Pediatrics (AAP) but importantly based on UK data (Blakemore, 2018a; UK House of Commons, 2018). They also argue along with other researchers that there is a need to refocus away from correlations between generic terms such as "screentime" and poor wellbeing, towards meaningfully quantifying how various types of technology use impact on different areas of child and adolescent health and wellbeing. This study presents UK data that provide a nationally representative profile of current adolescent social media use, and takes a data-driven approach to quantify sleep patterns for high and very high users relative to average users.

This study focuses on sleep, which – despite often being overlooked in public health messages and education interventions (Gruber et al., 2010; Perry et al., 2013) – is increasingly recognised as a key component of wider health and wellbeing (Walker, 2018). Adolescent sleep is an important public health issue, as insufficient sleep is highly prevalent in this age group and has implications for mental health, obesity, academic performance and safety (J. Owens, 2014). With the majority of adolescents reporting insufficient sleep to function properly or to meet recommended guidelines (Eaton et al., 2010; Gradisar et al., 2013), there is growing concern that social media may be a contributing factor for today's teenagers. For example, the potential for 24/7 social media interactions may exacerbate the existing conflict of early school start times with naturally delayed adolescent rhythms and other social and educational demands(Cain &

Gradisar, 2010; J. Owens, 2014; Vernon, Barber, & Modecki, 2015). As a highly relevant issue for paediatric practice, there is a clear need for UK evidence to inform and update decision making in medical practice and policy to address this current issue in adolescent sleep.

This study responds to this need, presenting large-scale UK data on adolescent sleep and social media use, whilst addressing a number of existing gaps in available international evidence. In addition to providing much-needed UK evidence, the current approach also addresses the need for evidence that: (1) examines social media specifically, rather than generic screentime; (2) isolates effects for a range of sleep parameters by accounting for an extensive range of covariates; (3) frames these effects within the context of current adolescent social media norms to provide meaningful comparisons. The current approach to ensure that this evidence can meaningfully inform policy and practice by addressing each of these needs is discussed further below.

Firstly, it is important for available evidence to examine social media individually, rather than aggregating these interactions and other media use under the umbrella term "screentime". A recent large-scale US study indicated a significant but modest effect for overall screentime and sleep, and called for future research to examine effects for specific technologies (Przybylski, 2018). In particular, the interactive nature of social media presents uniquely relevant issues for adolescent sleep compared to other forms of screentime or traditional media (Gradisar et al., 2013; Hale & Guan, 2015). Although facilitated by screens, social media interactions are underpinned by the same drivers as any social interaction, with a desire for inclusion and belonging mixing with concerns over violating social expectations or etiquette (Scott, Biello, & Woods, in press-a). These concerns can make it difficult to disengage from social media at bedtime, with some adolescents identifying this as a cause of delayed sleep onset and daytime tiredness (Scott et al., in press-a). These unique social and emotional aspects of online interactions underline the importance of examining social media use specifically, in relation to adolescent sleep outcomes.

Secondly, to meaningfully inform an evidence-based response to social media use, research must examine multiple sleep parameters and isolate these effects by controlling for an extensive range of relevant covariates. This is crucial to

assess the practical significance of underlying direct effects (Przybylski, 2018) and to identify which aspects of adolescent sleep merit attention to social media use in practice and policy. Available research on social media use and sleep is often left questioning whether reported effects could be explained by other individual factors: for example if more anxious, depressed or sedentary adolescents may tend to both use social media more and report poorer sleep (Hale & Guan, 2015; Scott & Woods, 2018). Individual studies that have controlled for specific groups of covariates generally suggest that associations do persist (Arora, Broglia, Thomas, & Taheri, 2014; Woods & Scott, 2016). However, there remains a need for large-scale evidence that addresses a wide range of covariates simultaneously, to more robustly establish which dimensions of sleep have a direct association with social media use and which reflect another underlying issue (e.g. anxious or depressive symptoms).

This type of evidence is required to invest time and resources effectively, by identifying which sleep complaints may benefit from directly addressing social media use. For example, a range of sleep complaints from insufficient sleep to problems initiating or maintaining sleep have been examined in relation to social media use. In terms of sleep duration, time spent using social media may displace sleep directly or displace other daytime activities (such as homework) that are then delayed and disrupt nighttime routines (Cain & Gradisar, 2010; Levenson et al., 2017). Social media use may also impact on the quality of sleep via increased arousal, not simply though light exposure (Chang et al., 2015), but particularly via cognitive and social activity (Hale & Guan, 2015; Harbard et al., 2016; Scott & Woods, 2018). Given these different potential mechanisms, it is therefore important to examine social media use in relation to a range of sleep parameters, to identify which of these links have the most practical significance after accounting for relevant factors.

Thirdly, evidence should frame these effects within the context of current norms for adolescent social media use. Research to date has tended to focus on problematic or "addicted" social media users (An et al., 2014; Vernon et al., 2015), or to compare outcomes for the highest users against the lowest users (Arora et al., 2014; Levenson et al., 2016; Levenson et al., 2017). In contrast, first establishing what constitutes typical use and then comparing outcomes for

relatively higher or lower users against this reference point can support more meaningful conclusions. This data-driven approach avoids imposing arbitrary or quickly outdated cut-offs, taking into account recent rapid increases in social media use (Pew Research Center, March 2018). Comparing sleep patterns for higher users against average users can better support practical and realistic discussions on best practice, that consider the context of current adolescent social media norms.

This study targets these existing gaps in available international evidence, while providing much-needed large-scale UK evidence. It examines associations between social media use and multiple sleep parameters in a large, nationally representative adolescent sample: the UK Millennium Cohort Study (Centre for Longitudinal Studies, 2017). It first investigates current norms in adolescent social media use to establish the average level of daily use and the prevalence of comparatively high use. It then examines which sleep parameters are associated with social media use, isolating these effects by controlling for extensive covariates and quantifying effects for higher users relative to average users. This aims to provide rigorous and meaningful evidence to inform practice and policy to support healthy adolescent sleep and social media use.

3.2 Methods

3.2.1 Participants

The UK Millennium Cohort Study is a nationally representative, multidisciplinary survey which aims to explore the influence of family context on child and adolescent development and outcomes. The survey covers a broad range of domains, such as parenting, housing, poverty and health. It consists of a random 2-stage sample drawn from all live UK births in the 12-month period starting 1 September 2000 in England and Wales and 1 December 2000 in Scotland and Northern Ireland, identified through the Child Benefit register (Centre for Longitudinal Studies, 2017). The clustered sample is drawn from a disproportionately stratified sample of electoral wards (local areas) to provide adequate representation of areas with higher concentrations of minority ethnic and disadvantaged families. Parents completed the first survey sweep in 2001 when their child was aged 9 months, with 18,818 cohort members. Children also

completed surveys from age 7 (sweep 4) onwards. The most recent survey (sweep 6 at around age 14) gathered self-report data from 11,872 cohort members, including questions on their typical social media use and sleep patterns. Parents were required to give written consent to complete the parent survey and for the interviewer to invite the cohort member to participate in the young person survey. Cohort members then also had to give verbal consent to complete the young person survey, which was self-completed on the interviewer's tablet.

3.2.2 Materials

The current analyses make use of available data from the UK Millennium Cohort Study, which measured social media use and sleep using single-item self-report questions. Although not validated questionnaire measures, these survey questions do provide a snapshot of the subjective experience of sleep and social media use in this large representative sample, capturing a range of sleep habits and the typical time spent using social media each day.

3.2.2.1 Social media use

Participants indicated how much time they spent using social media on a typical weekday, choosing from 8 response categories (ranging from 0 hours to 7+ hours) to answer the following question: "On a normal week day during term time, how many hours do you spend on social networking or messaging sites or Apps on the internet such as Facebook, Twitter and WhatsApp?"

3.2.2.2 Sleep parameters

Participants reported typical sleep habits through six single items (each with 5 or 6 response categories) that assessed: sleep onset and wake times (on school days and free days, separately), sleep onset latency (time taken to fall asleep) and trouble falling back asleep after nighttime awakening. Appendix A provides a full list of items and response categories.

3.2.2.3 Covariates

In addition, the following relevant covariates (identified based on literature) had available data in the UK Millennium Cohort Study: demographics (ethnic minority status, OECD equivalised weekly family income); family composition (number of siblings in household, presence of both parents, age of primary parent/carer responder); psychosocial adjustment (using the parent-report Strengths and Difficulties Questionnaire; Goodman, 2001); depressive symptoms (using the Short Mood and Feelings Questionnaire; Angold, Costello, Messer, & Pickles, 1995); self-esteem (using a shortened and adapted version of the Rosenberg Self-Esteem Scale; Rosenberg, 1965); general health (single item), social support (three items) and physical activity (single item). Supplementary Table 9 in Appendix A provides illustrative items for covariate questionnaire measures.

3.2.3 Data analysis

Since the aim of the study was to compare sleep outcomes for high and low users versus average users, based on the distribution we initially collapsed responses into three categories: under 1 hour for 'low' users (33.7%), 1 to <3 hours for 'average' users (31.6%), and 3 hours or more for 'high' users (34.7%). Given the broad range covered by this 'high' user category (including responses of 3 to <5, 5 to <7 and 7+ hours), and with sufficient numbers, we separated this into 'high' (3 to <5 hours; 13.9%) and 'very high' users (5+ hours; 20.8%) to allow more detailed exploration.

We collapsed responses for each sleep measure into binary outcomes. For poor sleep quality, these outcomes were: sleep onset latency over 30 minutes (commonly used to indicate poor sleep quality; Espie et al., 2014; Lichstein, Durrence, Taylor, Bush, & Riedel, 2003) and difficulty falling asleep following nighttime awakenings at least 'a good bit of the time'. For late sleep onset and wake times, we took a data-driven approach to identify meaningful cut-off points, which were defined as later than average (including responses in categories later than the median response category). Table 3 summarises the resulting criteria for each sleep outcome and associated prevalence rates.

Table 3 – Social media use and sleep outcomes: criteria and prevalence

Variable	Criteria	Prevalence (%)		
		Male	**Female**	**Total**
Daily social media use				
Low	< 1 hour	43.8	22.8	33.7
Average	1 to <3 hours	32.1	31.1	31.6
High	3 to <5 hours	10.4	17.7	13.9
Very high	5+ hours	13.7	28.4	20.8
Sleep outcomes				
Late sleep onset (school day)	After 11pm	25.5	26.5	26.0
Late sleep onset (free day)	After midnight	35.2	32.1	33.7
Late wake time (school day)	After 8am	5.3	2.7	4.0
Late wake time (free day)	After 11am	22.5	21.5	22.0
Long sleep onset latency	Over 30 minutes	31.5	37.0	34.1
Trouble falling back asleep after nighttime awakening	At least 'a good bit of the time'	16.9	25.7	21.1

Notes: Percentages account for survey design and weights. Criteria for late sleep onset and wake times defined as later than the median response category. Gender difference in daily social media use, late wake time (school day), long sleep onset latency and trouble falling back asleep after nighttime awakening $p < .001$; gender difference in late sleep onset (free day) $p < .01$. For a breakdown of social media use by other demographics (household income and ethnicity), see Appendix A.

Separate binomial logistic regression models predicted Odds Ratios of each sleep outcome for low, high and very high social media users, compared to average users. We ran models that controlled only for exact age and sex, followed by models that further controlled for measures of demographics, family characteristics, psychological wellbeing and health (see Materials section for full details). All analyses allowed for the complex survey design (with its clustered, stratified sample) and used longitudinal weights to account for non-random longitudinal attrition from the sample, using the 'survey' and 'srvyr' packages in R (Ellis, 2018; Lumley, 2004, 2017).

Multiple imputation was performed to account for missing data, reducing bias and increasing power (Sterne et al., 2009). The overall missing data rate was 2.8%, ranging from 0.0% to 6.0% for individual measures, with most measures below 5%. We make the assumption that data are missing at random (i.e. that

patterns of missingness can be explained by other variables available in the data; (Sterne et al., 2009)). All variables, including covariates, were used in the imputation model, which was run using R package 'mice' (van Buuren & Groothuis-Oudshoorn, 2011). Estimates were combined across 10 imputed data sets (each produced through 10 iterations). Results were similar for analyses on multiply imputed and complete case data, so only multiply imputed analysis is presented here.

3.3 Results

The median time spent using social media on a typical day was 1 to <3 hours (32% of adolescents); however, 21% used social media for at least 5 hours. Girls tended to use social media more than boys (see Table 3).

Median sleep onset times were 10-11pm on school days (with 26% falling asleep later than this) and between 11pm and midnight on free days (with 34% falling asleep later; see Table 3). Median wake times were 7-8am on school days (with only 4% waking later than this) and 10-11am on free days (with 22% waking later). Boys were more likely to fall asleep late on free days and wake up late on school days. In measures of poor sleep quality, 34% typically took longer than 30 minutes to fall asleep and 21% reported difficulties falling asleep following nighttime awakenings at least 'a good bit of the time'. Girls were more likely to have long sleep onset latency and trouble falling back asleep after nighttime awakening.

Separate binomial logistic regression models explored whether odds of each sleep outcome differed for low, high and very high social media users, compared to average users (1 to <3 h). First, models controlled for exact age and sex (see Table 4). Very high social media use (5+ h) was associated with higher odds of all six sleep outcomes. High social media use (3 to <5 h) was associated with higher odds of all outcomes except for late rise times on free days. Low social media use (<1 h) was associated with lower odds of late sleep onset on school- and free- days, and late wake times on free days.

Table 4 – Binomial logistic regressions (adjusting only for age & sex)

	Low: <1 h		High: 3 to <5 h		Very high: 5+ h	
	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
Late sleep onset (school days)	0.63 (0.53, 0.75)	< .001	1.38 (1.16, 1.65)	< .001	2.75 (2.38, 3.18)	< .001
Late sleep onset (free days)	0.6 (0.51, 0.7)	< .001	1.44 (1.19, 1.74)	< .001	3.05 (2.63, 3.54)	< .001
Late wake time (school days)	1.12 (0.77, 1.62)	ns	1.63 (1.05, 2.53)	< .05	2.49 (1.62, 3.83)	< .001
Late wake time (free days)	0.81 (0.69, 0.96)	< .05	1.16 (0.97, 1.39)	ns	1.82 (1.54, 2.16)	< .001
Sleep Onset Latency > 30 mins	0.92 (0.8, 1.05)	ns	1.24 (1.04, 1.49)	< .05	1.48 (1.27, 1.71)	< .001
Frequent nighttime awakenings	1.06 (0.9, 1.26)	ns	1.31 (1.07, 1.61)	< .05	2.11 (1.75, 2.55)	< .001

Notes: See Table 3 for criteria and prevalence of each sleep outcome. Odds Ratios measure how much higher or lower the odds of a given sleep outcome are for each category of social media user (Low, <1h; High, 3 to <5h; Very high, 5+h) compared to the reference category (Average users, 1 to <3h). Odds Ratios and 95% Confidence Intervals greater than 1 indicate higher odds; those below 1 indicate lower odds. Odds Ratios are adjusted to control for exact age & sex. ns = non-significant.

Further modelling then controlled for a more comprehensive set of covariates (see Table 5, with note detailing list of covariates). High social media use was no longer significantly associated with long sleep onset latency or frequent nighttime awakenings. Very high social media was no longer significantly associated with long sleep onset latency; however, its association with frequent nighttime awakenings remained significant but smaller. Patterns of significant associations for late sleep onset and wake times remained unchanged, although effect sizes were reduced, particularly for very high social media use.

Table 5 – Binomial logistic regressions (with further adjustments for covariates)

	Low: <1 h		High: 3 to <5 h		Very high: 5+ h	
	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
Late sleep onset (school days)	0.61 (0.51, 0.73)	< .001	1.23 (1.02, 1.49)	< .05	2.14 (1.83, 2.5)	< .001
Late sleep onset (free days)	0.57 (0.49, 0.68)	< .001	1.32 (1.09, 1.6)	< .01	2.41 (2.08, 2.79)	< .001
Late wake time (school days)	1.04 (0.71, 1.5)	ns	1.56 (1.02, 2.4)	< .05	1.97 (1.32, 2.93)	< .01
Late wake time (free days)	0.79 (0.67, 0.93)	< .01	1.12 (0.92, 1.35)	ns	1.57 (1.32, 1.87)	< .001
Sleep Onset Latency > 30 mins	0.9 (0.78, 1.04)	ns	1.11 (0.92, 1.34)	ns	1.12 (0.96, 1.32)	ns
Frequent nighttime awakenings	1.04 (0.88, 1.24)	ns	1.08 (0.87, 1.35)	ns	1.36 (1.1, 1.66)	< .01

Notes: See Table 3 for criteria and prevalence of each sleep outcome. Reference category is Average (1 to 3h). Odds Ratios are adjusted to control for: exact age, sex, ethnic minority status, family income, number of siblings in household, presence of both parents in household, parent age, Strengths and Difficulties score, Mood and Feelings score, self-esteem, general health, social support and physical activity. ns = non-significant.

For ease of interpretation, we also transformed the resulting adjusted Odds Ratios from these covariate models into adjusted Relative Risks (see Table 6; Zhang & Yu, 1998). These summarise differences in *probabilities,* as opposed to odds, and can be interpreted more intuitively. For example, the adjusted relative risk of 1.68 indicates that an adolescent with very high social media use is 68% more likely to fall asleep after 11pm on school nights than a comparable adolescent (controlling for covariates) with average social media use.

Table 6 – Relative Risks (from covariate-adjusted models)

	Low: <1 h		High: 3 to <5 h		Very high: 5+ h	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Late sleep onset (school days)	0.67 (0.58, 0.78)	<.001	1.17 (1.02, 1.33)	<.05	1.68 (1.52, 1.84)	<.001
Late sleep onset (free days)	0.66 (0.58, 0.75)	<.001	1.2 (1.06, 1.35)	<.01	1.69 (1.57, 1.81)	<.001
Late wake time (school days)	1.03 (0.72, 1.48)	*ns*	1.54 (1.02, 2.29)	<.05	1.91 (1.3, 2.76)	<.01
Late wake time (free days)	0.83 (0.72, 0.95)	<.01	1.09 (0.94, 1.26)	*ns*	1.41 (1.24, 1.59)	<.001
Sleep Onset Latency > 30 mins	0.93 (0.84, 1.03)	*ns*	1.07 (0.94, 1.21)	*ns*	1.08 (0.97, 1.2)	*ns*
Frequent nighttime awakenings	1.03 (0.89, 1.19)	*ns*	1.07 (0.89, 1.28)	*ns*	1.28 (1.09, 1.5)	<.01

Notes: Relative Risks transformed from Odds Ratios in covariate-controlled binomial logistic regression models (see Table 5). Reference category is Average (1 to 3h). E.g. RR of 1.68 means very high users are 68% more likely to fall asleep late on school days than comparable average users. ns = non-significant.

3.4 Discussion

This study aimed to address calls from those working in policy and practice to establish a UK data driven profile of current adolescent daily social media use, and to examine links to a key component of wider adolescent health and wellbeing using multiple sleep parameters whilst accounting for a wide range of covariates, using data from a large nationally representative sample of UK adolescents. The results highlighted a wide range of reported daily social media use, with tertiles defining low, average and high use on a typical school day as <1 hour, 1 to <3 hours and 3+ hours respectively. This indicates generally heavier social media use compared to young adults (Levenson et al., 2016) and provides a current normative profile for UK adolescents. One in five adolescents were classed as very high users, spending 5+ hours using social media on a typical school day, whereas two thirds of the sample used social media for less than 3 hours. This provides a data-driven profile of use to support decision-making,

rather than relying on assumptions around prevalence of high use. In line with previous studies, girls tended to spend more time on social media than boys (Herring & Kapidzic, 2015; Pew Research Center, November 2018) and report poorer sleep quality (Galland et al., 2018; Hysing, Pallesen, Stormark, Lundervold, & Sivertsen, 2013). This reinforces the importance of controlling for gender when examining these associations, and highlights the need for continued work to explore the sleep implications of *how* adolescent boys and girls spend their time on social media (with previous evidence of gender differences in preferred platforms, motivations and self-presentation; Herring & Kapidzic, 2015; Kuss & Griffiths, 2011; Pew Research Center, November 2018).

In terms of sleep timing, social media use remained significantly associated with late sleep onset and wake times after controlling for covariates, with the strongest effect for sleep onset. Very high social media users were roughly 70% more likely than comparable average users to fall asleep later than average, i.e. after 11pm on school days and after midnight on free days. Low social media users were least likely to fall asleep late, indicating that unlike mental wellbeing, optimal outcomes for sleep are associated with minimal – not moderate – use (Przybylski & Weinstein, 2017). These findings are consistent with the idea that social media displaces sleep: either directly or indirectly (Cain & Gradisar, 2010; Levenson et al., 2017). Direct sleep displacement may be particularly likely on school days, especially for very high users, since limited social media access during school hours means that at least part of this daily time on social media is likely to take place close to bedtime. Bedtime social media use can delay sleep onset (Scott & Woods, 2018), with some adolescents reporting difficulties disengaging from social media to sleep (Scott et al., in press-a). A similar process could also indirectly delay sleep onset, if other daytime activities (e.g. homework) are delayed due to a sense of urgency to check and respond to social media notifications. This link to later sleep onset is a particular concern on school days, as late school day bedtimes longitudinally predict poorer academic and emotional outcomes (Asarnow, McGlinchey, & Harvey, 2014). Whilst the survey question aimed to measure sleep onset time by asking what time participants "go to sleep", some participants may have reported the time that they get into bed, in which case actual sleep onset would be even further delayed (Exelmans & Van den Bulck, 2017a).

Social media use was also associated with later wake times on school days (for both high and very high users) and on free days (for very high users). This overall pattern of later sleep timing amongst heavier social media users could be driven partly by circadian factors, if adolescents with a natural preference for later sleep timing use social media to fill time in the late evening until they feel sleepy. This possibility merits further investigation. Alternatively, this later sleep timing could suggest that heavier social media users may compensate for later sleep onset with later wake times that still allow sufficient sleep. This compensation may be possible on free days, with flexible rise times. However, on school days only 4% of adolescents reported late wake times (after 8am), as fixed rise times mean that later sleep onset effectively equates to shorter sleep opportunity on school days (Asarnow et al., 2014; J. Owens, 2014). Consequently, these slightly later rise times are unlikely to fully compensate for delayed sleep onset on school days and suggest sleep restriction in a population where sleep need is high (J. Owens, 2014). Across the sample, this observed pattern of later sleep onset and rise times on free days compared to school days is consistent with well-established delays to the circadian rhythm during this developmental period (Carskadon, 2011b; Roenneberg et al., 2004), with growing pressure on policymakers to delay school start times to better align with adolescent body clocks (J. Owens et al., 2014).

Delayed sleep onset is therefore a key issue to target in relation to adolescents' social media use. The current cross-sectional study cannot establish causality; however, some adolescents do report delaying bedtimes as a result of social media use (Espinoza & Juvonen, 2011; Scott et al., in press-a). Adolescent sleep interventions should therefore consider assessing the impact of social media use on sleep schedules as standard. Further research can explore adolescents' motivations for prioritising social media over other needs, including sleep (Scott et al., in press-a), and identify factors that lead some individuals to struggle with this more than others. This can inform efforts to effectively support young people to balance online interactions (and the benefits they can offer; Davis, 2012, 2013; Weinstein, 2018) with an appropriate and consistent sleep schedule across the week, particularly to allow sufficient sleep on school nights. By helping to combat insufficient sleep, this can have a positive impact on adolescent physical and mental health, daytime functioning and academic

performance, addressing a significant health and educational burden (J. Owens, 2014).

In terms of sleep quality, very high social media users were more likely to experience nighttime awakenings than comparable average users, whereas the effect for long sleep onset latency was fully explained by covariates. Previous studies have found a significant association between social media use and measures of sleep disturbance (including long sleep onset latency and difficulty falling asleep) when controlling for: age and sex (Harbard et al., 2016); sociodemographic measures (Levenson et al., 2016); and sleep hygiene behaviours (Arora et al., 2014). The current more extensive set of covariates also included measures of psychological wellbeing (depression and psychosocial adjustment), which were strong predictors of long sleep onset latency and have been shown to be linked to generic screentime in previous work (Przybylski & Weinstein, 2017). Therefore, considering previous and current findings together, this suggests that although adolescents who spend more time on social media do tend to take longer to fall asleep, both these behaviours could reflect underlying aspects of wellbeing, with depression and anxiety linked to both poor sleep quality and social media use (Woods & Scott, 2016). This is consistent with evidence that sleep onset latency and pre-sleep cognitive arousal is predicted by underlying concerns about potentially missing out, rather than social media behaviour itself (Scott & Woods, 2018). Since the purpose of this study was to isolate and quantify associations between social media use and sleep, the current approach of including wellbeing measures as covariates provided this insight into which sleep associations do and do not persist independent of wellbeing and other covariates. However, future studies can specifically examine in more detail which aspects of mental health and wellbeing may mediate or moderate these associations. Given the increasing recognition of sleep and mental health as two inextricably linked aspects of health (Reynolds & O'Hara, 2013), the current findings lay the foundation for more complex model testing to examine the likely bidirectional and interactive effects between social media use, sleep, mental health and other associated measures, such as school performance. Applying this approach to longitudinal and experimental data will be particularly valuable to elucidate these complex mechanisms, and to build a

more holistic and balanced understanding of social media's links to both positive and negative aspects of health and wellbeing.

In contrast, the association between social media use and nighttime awakenings was only partly explained by covariates, with very high social media users still 28% more likely to have frequent difficulties with nighttime awakenings than comparable average users. Social media notification alerts may disrupt sleep during the night, particularly if users then respond by re-engaging with social media. Adolescents who use social media more also tend to have a stronger emotional connection to platforms and experience more fear of missing out (Przybylski et al., 2013; Scott & Woods, 2018). Therefore, it is possible that very high users are more likely to remain vigilant for incoming social media alerts or to respond to these during the night, increasing arousal and contributing to difficulties falling asleep again. Further research can focus on this type of specific social media behaviours during the night, to examine whether they explain the link between higher overall use and nighttime awakenings. If incoming alerts are indeed mostly responsible, interventions can promote simple practical steps such as setting 'do not disturb' periods on social media apps.

3.4.1 Limitations

These findings should be considered within the limitations of the current study. Given the broad scope of the UK Millennium Cohort Study, sleep and social media use were measured using individual questions rather than validated multi-item questionnaires. This limits the current analyses to a single measure of social media use - defined as the amount of time spent using social media on a typical day - which does not capture the different experiences of individual users (Fox & Moreland, 2015), for example in terms of content, context, timing and emotional engagement. Future research should carefully consider a range of measures to provide a more holistic view of adolescents' experiences of using social media, particularly since evidence highlights the importance of emotional and cognitive aspects of social media use for sleep (Scott & Woods, 2018; Woods & Scott, 2016). To support future research, there is a clear need to establish *validated* measurement tools that move beyond hours per day to capture these more nuanced aspects of social media engagement. This is a key area for future development, as available tools limit the scope of potential research questions,

conclusions and recommendations. Improved measurement tools moving forward can enhance understanding of the mechanisms linking social media use and sleep, as well as providing a more balanced view of both positive and negative impacts of social media experiences.

These analyses make use of six available reported sleep parameters from this representative cohort, which do allow a rounded picture of timing and quality, but future research would benefit from including validated measures of sleep duration and quality, as well as circadian preference. The current self-reported sleep measures offer valuable insight into adolescents' *subjective experience* of sleep, which is one important component of sleep, but this can diverge from verifiable objective measures of sleep parameters provided by other methods, such as the gold-standard polysomnography (Fernandez-Mendoza et al., 2011; Tubbs et al., 2019). In particular, sleep state misperception in both good and poor sleepers can result in poor self-report estimates of sleep onset latency, (Fernandez-Mendoza et al., 2011) although these differences in sleep onset latency estimates from self-report and polysomnography tend to be small (Silva et al., 2007). The current analyses therefore contribute one part of the picture, with a continued need to triangulate insight from multiple methodologies (both subjective and objective) to build a more nuanced, holistic understanding of adolescent social media use and sleep (Gregory & Sadeh, 2012; Tubbs et al., 2019).

Furthermore, this study presents cross-sectional data, which precludes conclusions of causality. Cross-sectional analyses are prevalent in this research area, with calls for longitudinal and experimental work to enrich current understanding (Bartel & Gradisar, 2017; Bhat et al., 2018). Recent studies on general technology use have supported bidirectional links between higher technology use and shorter sleep in adolescents (Mazzer et al., 2018), with evidence that restricting phone access can advance bedtimes and extend sleep opportunity (Bartel et al., 2019). Restricting adolescent social media use is likely to be especially challenging, as this is a developmental period of increasing autonomy during which peer interactions, belonging and acceptance are highly valued (Blakemore, 2018a). Therefore, an important avenue for future research is establishing how best to support young people to balance these rewarding

online social interactions with an appropriate and consistent sleep schedule, to optimise associated health- and school- outcomes.

Finally, we note that research in this area is constantly contending with rapidly evolving social media platforms and associated norms and expectations for online interactions. This can be particularly challenging for this type of large national cohort data, which in this case provides a snapshot of UK adolescents' social media use in 2015.

3.4.2 Conclusions

This study provides robust evidence on associations between social media use and sleep outcomes, controlling for an extensive range of covariates, in a large nationally representative sample of UK adolescents. It provides a normative profile of adolescent social media use and sleep in the UK, which can be used as a baseline to support evidence-based decision-making policy and practice rather than relying on assumptions around prevalence of high social media use. The findings indicate statistically and practically significant associations between social media use and sleep patterns, particularly late sleep onset. Future research should explore the context and experience of time using social media, to inform more meaningful discussions around best practice and updating sleep education and interventions to meet the needs of today's society. Interventions should focus on addressing delayed sleep onset, by supporting young people to balance online social interactions with an appropriate and consistent sleep schedule that allows sufficient sleep on school nights, with benefits for health and educational outcomes.

Chapter 4   Identifying drivers for bedtime social media use despite sleep costs: the adolescent perspective

4.1 Introduction

Adolescents tend to be highly driven social media users: nine out of ten 13-17 year olds now use social media (Pew Research Center, April 2015) and young people often report a strong attachment to their online communication (Vorderer et al., 2016). By enabling 24/7 interactions, social media platforms can facilitate competition between social interactions and sufficient, good quality sleep (Levenson et al., 2016; Levenson et al., 2017; Orzech et al., 2016), with incoming alerts and perceived social expectations of 24/7 availability presenting unique challenges for sleep compared to other forms of technology (Thomee et al., 2010). Indeed, children as young as 11 report losing sleep due to social media sites (Espinoza & Juvonen, 2011) and adolescents consistently identify social media use as the primary barrier to their sleep health (Godsell & White, 2019; Quante et al., 2018). Understanding and tackling the sleep impact of social media is highly relevant for the adolescent population, since this developmental stage is characterised by a 'Perfect Storm' of biological and psychosocial changes that promote later bedtimes, which mean that short and ill-timed sleep are the norm when combined with early rise times for school (Carskadon, 2011b; Crowley et al., 2018). This is an important area of concern for parents, educators, practitioners and policymakers, since insufficient and poor quality sleep have negative consequences across a range of dimensions, including mental health, academic achievement and interpersonal functioning (Alfano, Zakem, Costa, Taylor, & Weems, 2009; Fredriksen, Rhodes, Reddy, & Way, 2004; Kyle et al., 2010; J. Owens, 2014). Sleep interventions for today's adolescents must therefore address social media habits as part of supporting sufficient, good quality sleep, which may also bring about associated improvements in school experiences and mental health (Vernon et al., 2015; Vernon et al., 2017). In order to effectively support healthy social media habits for sleep, we first need to understand the cognitive, emotional and social drivers that underpin adolescents' bedtime social media engagement.

Available evidence now clearly supports associations between adolescent sleep patterns and social media use, with young people who spend more time using social media (especially at bedtime) and those who feel more emotionally connected to platforms reporting later bedtimes, longer sleep onset latency, shorter sleep duration and poorer sleep quality (Harbard et al., 2016; Orzech et al., 2016; Scott, Biello, & Woods, in press-b; Scott & Woods, 2018, 2019; Woods & Scott, 2016). Several likely mechanisms have been proposed to explain this link between adolescent sleep and bedtime social media use, alongside other technologies (Bartel & Gradisar, 2017; Cain & Gradisar, 2010). Firstly, social media (and other technology use) may directly displace sleep by delaying bedtimes, resulting in shorter sleep duration (Cain & Gradisar, 2010; LeBourgeois et al., 2017; Orzech et al., 2016; Scott & Woods, 2018). This is particularly relevant during adolescence, since school timetables typically prevent adolescents from using later rise times to compensate for delayed bedtimes (J. Owens, 2014; Tavernier & Willoughby, 2014). Secondly, bedtime social media use may also increase cognitive arousal before sleep, lengthening the time taken to fall asleep and impacting on sleep duration and quality (Harbard et al., 2016; Nicassio, Mendlowitz, Fussell, & Petras, 1985). In addition, exposure to screen light (which is particularly rich in blue light) can have an alerting effect and delay the circadian rhythm (Chang et al., 2015; Figueiro & Overington, 2016), although it is important to note the small effect sizes reported and to consider screen light alongside the content and quality of screen-based activities and online interactions (Woods & Scott, 2019). Furthermore, associations between social media use and sleep are complex, likely involving interactive and bidirectional effects, for example including the use of social media as a sleep aid or coping strategy amongst poor sleepers (Exelmans & Scott, 2019; Exelmans & Van den Bulck, 2016). Although some recent examples of longitudinal and experimental work have supported causal links (in both directions) between general technology use and adolescent short sleep (Bartel et al., 2019; Mazzer et al., 2018), the field remains limited by its reliance on cross-sectional data that precludes conclusions of causality and tends to examine only the frequency and duration of social media use, often grouped together with other technologies (Scott & Woods, 2019). This has limited our understanding of the unique mechanisms linking adolescent sleep and *social* media use specifically, whose inherently social and interactive nature presents unique implications for sleep

processes (Carr & Hayes, 2015). There is an opportunity to extend current understanding by bringing an alternative approach to this research area: employing qualitative methods to explore underlying motivations, thus adding the missing adolescent voice to this literature. This can build on existing evidence that bedtime social media use is linked to adolescent sleep patterns (Harbard et al., 2016; Orzech et al., 2016; Scott & Woods, 2018; Woods & Scott, 2016), to offer novel in-depth insight into what actually *drives* these bedtime social media use habits.

Research on adolescent social media use has reached an important juncture in its evolution: despite widespread media and public attention to its possible negative impacts on sleep and other areas of wellbeing, there is also important work highlighting potential benefits, such as increased social connectedness and belonging (Davis, 2012, 2013). This presents a challenge for educators, practitioners and policymakers, with available literature highlighting both positive and negative associated outcomes, based largely on evidence that is limited by its focus only on frequency and duration of use (Woods & Scott, 2016). In response to this, the current study takes a novel approach to studying adolescent sleep and social media use, by using in-depth analysis of focus group data to provide a deeper insider understanding of what actually *drives* adolescents' social media engagement at bedtime. It explores how these underlying drivers influence bedtime social media habits and experiences that negatively impact on sleep. This responds to the need to first understand what is driving bedtime social media use, before we can successfully support healthier social media habits that maintain sufficient, good quality sleep during adolescence. Our approach aims to give adolescents a voice in the literature on sleep and social media use, which has so far been underrepresented, but which has the potential to inform research, policy and practice in this area.

4.2 Methods

4.2.1 Participants

Participants were 24 adolescents (12 male, 12 female) aged 11-17 years (mean = 14.3 years) attending a large state Scottish secondary school (broadly equivalent to US grades 6 to 11). The study was advertised to classes by a teacher, and was

open to all pupils (regardless of their social media or sleep habits). The only inclusion criterion was sufficient English language ability to participate in a focus group. Participants were not reimbursed for taking part in the study.

4.2.2 Data collection

Participants took part in one of four focus groups, each with six participants, in a quiet room at their school. Focus groups were stratified by gender and age (11-14 and 15-17 years). The purpose of this stratification was not to identify different themes by gender or age, but to encourage participants to speak freely in a group of similar individuals (Lindlof & Taylor, 2011). Participants were also informed that no identifying information would be shared, to encourage free speaking. HS moderated the focus groups using open ended questions and prompts where necessary to facilitate a group discussion around social media habits (particularly around bedtime), motivations for social media engagement and any perceived impact on sleep. Table 7 provides the initial questions and example prompts used to guide focus group discussions. Follow up questions were used to further explore relevant participant comments, allowing for unexpected insights around the topic. A second researcher made detailed notes to aid speaker identification during transcription and to capture non-verbal agreements between participants. Focus groups lasted between 45 minutes and 1 hour.

Ethical approval was granted by the University of Glasgow Science and Engineering Ethics Committee and the relevant Local Education Authority. Consent was given by all participants, including signed parental consent for those under 16. Participants were encouraged to seek support from their assigned pastoral care teacher (responsible for student wellbeing) if they had any concerns about their sleep or social media use.

Table 7 – Focus group question guide

Initial topic question	Potential follow up questions / prompts if required
Do you use social media?	What sites/apps? How often? When? What for?
Why do you use social media?	
How do you feel when you are not using social media?	Pleasant or unpleasant? Why is that?
Could you tell us about your social media habits around bedtime?	
Do you think that social media affects your sleep?	If so, how? If not, what makes you say that? Does it affect what time you go to bed at / how long it takes you to fall asleep? Do alerts keep you awake or wake you up at night?
Do you ever use social media when you can't sleep or to help you sleep?	Do you ever use it to pass time until you fall asleep? If so / if not, why is that?

Notes: the facilitator referred to this guide of questions and follow up prompts to start and maintain a group discussion that covered the intended topics. These questions were used flexibly to facilitate discussion, not as a strict list of verbatim questions.

4.2.3 Data analysis

Focus group discussions were digitally audio recorded and transcribed orthographically by HS, assigning each participant a pseudonym. The transcript data were entered into NVivo 11 (QSR International, 2015) to facilitate analysis. Data were analysed using Braun and Clarke's method for reflexive thematic analysis (Braun & Clarke, 2006, 2013), which aims "to provide a coherent and compelling interpretation of the data, grounded in the data" (Braun, Clarke, Hayfield, & Terry, 2019, p. 848). We carried out our analysis within an experiential, contextualist framework to focus on participants' experiences and interpretations as expressed through their own language (Willig, 2001), for example what they felt constituted 'normal' teenage behaviour. This analysis took an inductive approach to coding and developing themes that were closely linked to the data, remaining open to unexpected insights, given the scarcity of existing qualitative research on this topic. The analysis involved complete coding, working systematically through each focus group transcript, identifying and labelling all data chunks that were relevant to the research question (Braun & Clarke, 2013). Codes were then grouped into candidate themes that reflected

"pattern[s] of shared meaning, organized around a core concept or idea" (Braun et al., 2019). These were reviewed, revised and refined to ensure that the final theme names and definitions coherently and faithfully represented the coded data excerpts and the dataset as a whole (Braun & Clarke, 2006). HS carried out the coding and initial theme generation, engaging in regular discussion and critical reflection with SMB and HCW throughout all analytical stages (Braun et al., 2019). The authors also discussed the analysis in-depth with colleagues with expertise in qualitative research methods. These steps ensured a rigorous analytical approach that produced final themes that provide a faithful and meaningful interpretation of the data in relation to the research question (Braun et al., 2019). Presented illustrative quotes have been edited to facilitate reading ease, indicated by […].

4.3 Results

Participants reported using popular social media platforms (e.g. Snapchat, Instagram, Facebook, Twitter, WhatsApp) in line with prevalence statistics for this age group (Pew Research Center, May 2018), but their natural language then tended to focus more on the social interactions facilitated by these platforms rather than specific platforms themselves. Our analyses produced two overarching themes that captured underlying drivers for social media engagement, with a specific focus on how these were expressed in bedtime social media behaviours with consequences for sleep habits. *Missing Out* reflects the constant perceived threat of missing out on social media content and interactions when offline, which motivated participants to initiate and maintain bedtime social media engagement to avoid negative consequences for real-world relationships. *Norms and Expectations* captures the shared sense of how a perceived 'normal' teenager should use social media (e.g. being active, engaged and available online) which led some participants to continue interactions late at night to avoid social disapproval from violating etiquette. Therefore, whilst both themes capture difficulties disengaging from bedtime social media use due to considerations around social connection and inclusion, they each retain a unique focus: *Missing Out* looks inwards to capture the individual's own desire to stay connected, whereas *Norms and Expectations* looks outwards to capture perceived expectations from others. Table 8 summarises the structure and scope of these two overarching themes and their sub-themes. Table 9 and Table 10

provide illustrative verbatim quotes for each sub-theme of *Missing Out* and *Norms and Expectations*, respectively.

Table 8 – Theme structure and definitions

Overarching theme	Sub-themes and definitions
Missing Out	**Offline costs** Online interactions support later face-to-face interactions through shared references and group jokes. Not being active on social media (especially at 'peak time' late at night) creates a perceived risk of later offline exclusion.
	Constant threat Fear of real-world exclusion means that not being connected to social media is experienced as a state of threat, with a constant worry and bedtime rumination about potentially being left out when offline.
	Can't disengage The desire to avoid missing out online (with 'real-world' offline costs) initiated and maintained social media engagement past intended bedtimes, making it difficult to disengage and delaying sleep onset.
Norms & Expectations	**Normal teenager** According to shared norms and expectations, a 'normal' teenager should be an active, engaged social media user, with online availability and prompt responses (including late at night).
	Violating etiquette Violating unspoken expectations around online availability and interactions (e.g. with slow responses) is judged to be 'incorrect' behaviour, creating anxiety and guilt for some and a sense of rebellion for others.
	Obligation An awareness of these norms and expected behaviours can maintain online social interactions past intended bedtimes, despite tiredness, out of a sense of obligation rather than enjoyment.

4.3.1 Missing Out

4.3.1.1 Offline costs

There was a shared concern with the offline consequences of not being active on social media, especially during peak time around bedtime when participants reported that peers were most active. This reflected the lack of perceived boundary between online and offline social worlds, with online interactions and content providing shared references and group jokes in later face-to-face settings. Not being active on social media at bedtime meant that one risked missing online conversations, resulting in feeling left out of face-to-face peer

interactions the following day, accompanied by feelings of frustration, loneliness and paranoia.

4.3.1.2 Constant threat

Being offline was therefore experienced as a state of constant threat, with some reporting intrusive thoughts and an inescapable worry about potentially missing out on interactions or information. This created a particular tension between social media use and sleep habits, since continuing online interactions delayed bedtimes for many, but disengaging from social media could also impact on sleep by fuelling cognitive arousal and rumination around potentially missing out.

4.3.1.3 Can't disengage

The desire to neutralise this perceived threat initiated and maintained social media engagement beyond intended bedtimes, driving participants to check accounts and also making it difficult to disengage. Participants reported delayed sleep onset due to difficulties disengaging from social media at bedtime and resisting the temptation to re-engage with incoming notifications, despite attempts to self-regulate use.

Table 9 – 'Missing Out' sub-themes and illustrative quotes

Sub-theme	Illustrative quotes
Offline costs	"If like the night before something big happened and then the next day everyone is talking about it and if you've not seen it you're kind of just like 'oh, I've not seen that or I've not been involved'. So it affects the next day as well." (Olivia, 14) "If you've not seen something that everybody else has seen […] then they have a joke between them, it's sort of annoying because you don't know what they're talking about. You think 'maybe they're talking about me, maybe they're talking about somebody else'. You sort of feel a bit paranoid." (Harry, 16) "Yeah then it sort of leads to exclusion and you feel paranoid that you're not included in that." (Daniel, 15)
Constant threat	"It's like the worst thing ever […] You try to like do other things just to occupy you but it's always at the back of your mind that you don't have your phone in your hand or in your bag somewhere." (Jessica, 16) "Yeah and you always think something's going on and you're missing out on everything." (Megan, 15) "As soon as you give into that temptation you're on it for an hour, two hours at least and then- so yeah, I would say it always affects your sleep. And then you're always wondering 'what's everyone else doing? Are they speaking to each other? Am I missing out? Should I be on this? Should I be up?' And then yeah- it affects my sleep." (Daniel, 15) "if you're not on [social media], something could happen" (Olivia, 14) "it's always in the back of your head and it's sort of like if you've forgotten to do something and it keeps picking at you and you just feel like you need it or you need to do it" (Sophie, 15) "there might be something going on and you want to hear about it" (Matthew, 13)
Can't disengage	"When you're trying to go to sleep and you say 'right I'm going to put my phone down' and then you hear a buzz so you keep checking it […] You just feel like sometimes you can miss something big […] and then they ask, your friends ask 'oh yeah, you missed out' or like 'what happened? What happened?' and you're like 'well, I went to sleep'. I think that you feel the need to so that you feel like you are part of something." (Katie, 13) "Once everything is checked you are like 'okay finally now I can sleep' so it's good when it's done" (Lauren, 14) "You feel like you have to answer at night even though you're trying to sleep. It might be important or you might miss out on something" (Benjamin, 16) "Like when you're done talking to someone or you're done checking Snapchat or something, the stories, you're done with that. Then you go on to Instagram, you have to look at everything there. Then you have to go back on Snapchat because someone has messaged you or there's more stuff. So this keeps on happening and then there is like Facebook or something you have to check. It's stuff like that, it just keeps going until like 12." (Lauren, 14)

4.3.2 Norms and Expectations

4.3.2.1 Normal teenager

There was a shared agreement of how the perceived 'normal' teenager uses social media. These unspoken norms included being an active, engaged social media user who is available online and has a sense of immediacy in checking new content and responding to messages, including around bedtime. This formed an expected etiquette around social media interactions, with a sense of being different from the perceived typical adolescent if one went against these norms of responding immediately and being constantly available.

4.3.2.2 Violating etiquette

Disengaging from social media at bedtime and failing to respond to messages promptly was therefore acknowledged as 'incorrect' behaviour, by violating etiquette and norms around expected online availability. For some participants, this was experienced as a sense of independence and rebellion against norms, despite possible social disapproval. For others, this was associated with feelings of guilt, anxiety or self-doubt, including questioning whether one should re-engage on social media at bedtime.

4.3.2.3 Obligation

An acute awareness of these social rules governing online interactions meant that some participants felt disempowered to disengage from social media in order to sleep, as ending an ongoing interaction was simply not an option due to the etiquette constructed around social media use. There was a shared concern about causing offence to peers by failing to respond to messages, leading some to maintain online interactions, despite tiredness, out of a sense of obligation rather than enjoyment.

Table 10 – 'Norms & Expectations' sub-themes and illustrative quotes

Sub-theme	Illustrative quotes

Normal teenager	"It's rare that you get a teenager that wouldn't be so into the internet and social media and stuff like that."
	   "I think everyone probably has a basic Facebook."
	     "Yeah, it's like unheard of." (Emily & Jessica, both 16)
	
	 "If you're left out and stuff and you don't have social media it would be kind of awkward … if you're one of those few people that don't have it then it's a bit difficult" (Katie, 13)
	
	 "We're so engaged in social media now and we're so used to it. We're just like 'yeah, this conversation can't wait' … it's kind of consuming." (Emily, 16)
	
	 "You're so used to using it [in bed] and all the people you're in contact will be as well. So you take it for granted. You don't think about sleep or what time it is." (Luke, 12)

Violating etiquette	"I'm so bad at like messaging and stuff like that. I'll just leave you for like three, four days and then get back to you, which is why I like their pictures to let them know that I'm still here, I'm alive." (Jessica, 16) "After a certain point I just stop reading my notifications. I just do my own thing, like watch something and I just don't care about what anyone says." (Ellie, 16) "I'm guilty of this but sometimes if it's not someone special, like that I don't want to talk to, I just kind of ignore it for a bit […] but if it's someone like I do want to talk to then I'm like 'OK yeah' so I open it straightaway." (Lauren, 14) "You're always wondering 'What's everyone else doing? […] Should I be on this? Should I be up?' And then yeah- it affects my sleep." (Daniel, 15)

Obligation	"If you send someone a picture and then they send you one back and it just goes on for ages and you just send random pictures to each other and then it keeps going on I feel like that might keep you up or-"
	   "Yeah because if the conversation is going good you need to keep it going, you can't ignore them or else that's just rude"
	     "You feel rude"
	       "Very rude" (Olivia & Lauren, both 14)
	
	 "You also don't want to offend the other person by leaving […] You'll think 'have I upset them? Is there a way where I can justify leaving? Can I say "look, I'm tired"?' […] Somebody else will message you being 'everybody's gone to sleep, wanna stay up and chat?' and you don't really want to say 'no' and you can't just leave them because you've already read it and they've seen that you read it. So you sort of get stuck talking to a person." (Harry, 16)

4.4 Discussion

This study adds to current understanding of adolescents' social media and sleep habits, by using qualitative methods to uncover powerful drivers and concerns underlying bedtime social media use and difficulties disengaging. The current analyses produced two overarching themes – *Missing Out* and *Norms and Expectations* – that offer fresh insight, from an adolescent perspective, into why young people may choose to prioritise social media use over even the basic physiological need for sleep (Redden & Way, 2017). Firstly, concern over missing online interactions and experiencing exclusion in later face-to-face peer settings can contribute to difficulties disengaging from social media, with delayed sleep onset and increased arousal at bedtime. Secondly, perceived social expectations around online availability and etiquette can cause some adolescents to continue online interactions despite tiredness or a desire to sleep, for fear of causing offence to peers. Together these themes highlight powerful socially-driven motivations for maintaining bedtime social media interactions despite potential sleep costs, leading some adolescents to continue interactions at night either to satisfy their own desire to feel connected and involved (Missing Out) or to maintain esteem by meeting perceived expectations from others (Norms and Expectations).

Overall, these findings suggest that adolescents' difficulty disengaging from social media at night is underpinned by concerns over negative consequences for peer relationships. Continued social media activity – often beyond intended bedtimes and despite tiredness – seems to be largely driven by the same well-established underlying factors that influence face-to-face interactions, such as a desire to feel included and pressure to follow group norms (Hogg & Reid, 2006; Sheldon & Bettencourt, 2002). These social drivers are likely to become especially salient during adolescence, when self-esteem is particularly contingent on social acceptance and approval (Wouters, Verschueren, Briers, & Janssen, 2016). Whilst these social processes are not a new phenomenon, now the possibility of 24/7 connection via social media platforms allows social activity to easily compete with sleep, as individuals can maintain these interactions in bed, increasing arousal and delaying sleep onset (Scott & Woods, 2018). Therefore, whilst there is nothing new about the current teenage generation's desire for social connection and peer acceptance (Blakemore,

2018a; Blakemore & Mills, 2014), a rapidly evolving media landscape *has* altered how these processes directly compete with sleep opportunity. Smartphone ownership is now an almost ubiquitous feature of adolescence (Pew Research Center, May 2018) and this increased access to personal hand-held devices means that it is especially challenging for today's parents to limit online interactions at bedtime (Godsell & White, 2019).

These findings extend current understanding of the unique processes affecting sleep during adolescence specifically. They add deeper insight into the role of social media use, which is one of the sleep-delaying psychosocial factors identified in the 'Perfect Storm' model of adolescent sleep (Carskadon, 2011b; Crowley et al., 2018). Together with biological changes to sleep regulation processes, bedtime social media use and other psychosocial factors tend to promote later sleep onset during adolescence, which results in short and ill-timed sleep when combined with typical early school day rise times (Carskadon, 2011b). The Perfect Storm model notes that adolescence is a period characterised by increasing independence, which includes autonomy over sleep timing and bedtime habits. In addition to increased independence, the current findings highlight the need to also consider how adolescent sleep is shaped by this period's characteristic heightened sensitivity to social influences (Blakemore & Mills, 2014). Since adolescents are primed to avoid social risk and tend to weigh this more heavily than other risks (e.g. health costs; Blakemore, 2018a), it is understandable why some may choose to prioritise staying connected and following perceived etiquette over getting sufficient sleep. This new insight therefore supports an approach to researching and treating adolescent sleep within a holistic model of adolescent development and functioning more widely, since social processes clearly play an important role in the sleep behaviours and experiences of young people navigating this period of intense development in today's 24/7 connected world.

Furthermore, our findings indicate that this overarching concern over possible relationship costs of disconnecting at night seems to focus primarily on the impact on 'real-world' offline peer interactions. This builds on existing evidence that adolescents tend not to distinguish between online and offline worlds (Redden & Way, 2017), instead seeing social media interactions as an extension

of their face-to-face relationships (Assunção & Matos, 2014). This highlights the value of bringing the adolescent voice to the sleep research literature, since this focus on the social interactions – rather than the devices or platforms themselves – contrasts with the prevalent "screentime" focused research often with measures that focus on the device or specific platform (Scott & Woods, 2019). Furthermore, whilst adults also report feeling anxious, unpleasant and disconnected without access to their devices (Cheever et al., 2014; Vorderer et al., 2016), this negative experience may be particularly intense for adolescents who tend to consider social media interactions as more 'real' than older generations (Redden & Way, 2017). Efforts aiming to support adolescents in developing healthy social media habits for sleep must therefore approach bedtime social media engagement not as a form of technology use, but instead as an embedded social experience. Such approaches should consider the likely distress arising from disconnecting, with an associated increase in pre-sleep cognitive arousal, which could be tackled with cognitive behavioural- or mindfulness- based techniques (Cincotta, Gehrman, Gooneratne, & Baime, 2011; Peterman et al., 2016).

These novel insights can help reconcile existing evidence of both positive and negative health and wellbeing outcomes associated with social media use, as research has demonstrated that heavier users tend to report poorer sleep patterns (Harbard et al., 2016; Levenson et al., 2016; Orzech et al., 2016; Woods & Scott, 2016), but also benefits such as increased social connectedness and sense of belonging (Davis, 2012, 2013). The current findings suggest that adolescents face a trade-off between these benefits and costs of using social media at night, and must balance the desire for inclusion and belonging in offline peer settings the following day with the need for sufficient sleep, avoiding delayed bedtimes and daytime tiredness. Whilst continuing nighttime online interactions provides an opportunity for immediate social connection, if the associated delayed sleep onset results in insufficient sleep (particularly likely on school nights; Carskadon, 2011b) then this could have an indirect impact on daytime functioning, including interpersonal functioning .(Kahn-Greene, Lipizzi, Conrad, Kamimori, & Killgore, 2006; Kyle et al., 2010). This highlights the importance of uniting research that has to date largely examined social media's links to sleep and to other aspects of wellbeing or interpersonal

functioning in isolation, to now move forward and build a more holistic understanding of social media's role in adolescent functioning as a whole (Scott & Woods, 2019).

Interestingly, our analyses highlighted individual differences in how adolescents balanced social media and sleep. Some participants reported delayed bedtimes, insufficient sleep and daytime tiredness, resulting from ongoing social media activity at night – despite attempts to self-regulate, as has been previously documented (Tzavela et al., 2015) – due to a sense of obligation or concern over possible exclusion. In contrast, others reported less difficulty in disengaging from social media to sleep, despite expressing an awareness of possible social disapproval. This is consistent with existing evidence of different profiles of adolescent internet user: from those who feel 'stuck online' and unable to disengage, to those who feel able to balance internet use with other activities and needs (Tzavela, Karakitsou, Halapi, & Tsitsika, 2017). Differences in adolescents' level of difficulty disengaging from social media at night may be driven by underlying individual factors: for example, those who are more concerned about ostracism have been shown to experience a stronger sense of obligation to respond to social media messages (Mai et al., 2015). This can extend current models of adolescent technology use and sleep, by adding to identified factors that influence sleep-relevant technology behaviours. For example, Cain and Gradisar's (2010) model – recently updated by Bartel and Gradisar (2017) – notes parental involvement and flow as likely factors that influence technology habits that have implications for child and adolescent sleep. The current findings indicate that in the case of *social* media specifically, a crucial determining factor is the extent to which individuals experience concerns about staying connected and following etiquette.

Overall, the current findings suggest that – rather than time spent using social media sites – sleep research and practice should focus more on the extent to which individuals experience difficulties disengaging and the drivers that underpin this negative experience. This would shift the focus away from setting time limits on daily or nightly use, towards facilitating a healthier overall relationship with social media platforms, which optimises wellbeing by maximising benefits like connectedness (Davis, 2012, 2013) whilst minimising

disruption to sufficient, good quality sleep (Harbard et al., 2016; Levenson et al., 2016; Orzech et al., 2016; Woods & Scott, 2016).

These findings should be interpreted within the limitations of the current study, including its relatively small sample of adolescents attending a single school in Scotland. The purpose of this type of qualitative analysis is not to achieve generalisability in a statistical sense, but instead to gain rich insight and in-depth understanding (Braun & Clarke, 2013). However, given that the current results reflect existing evidence on both online communication (Cheever et al., 2014; Redden & Way, 2017; Vorderer et al., 2016) and broader social processes (Hogg & Reid, 2006; Sheldon & Bettencourt, 2002), the issues highlighted by these findings are likely to be relevant for adolescents more broadly. These insights can contribute to available evidence and help to inform future work that explores these issues further.

4.4.1 Conclusions

This in-depth qualitative analysis highlights common cognitive, emotional and social drivers that can maintain bedtime social media engagement despite negative sleep consequences. These findings suggest that researchers and practitioners can respond to the evolving needs of today's adolescents by approaching social media use not as a technology-based activity, but as an extension of face-to-face interactions, underpinned by the same underlying social drivers and concerns. For example, future research can build on these findings to develop methods to quantify the extent to which individuals experience this difficulty disengaging from social media at night. Further work can also explore what individual differences explain this variation, whereby some adolescents can easily disengage from social media to sleep, whilst others experience a strong preoccupation with possible consequences of disengaging, reporting delayed bedtimes and increased arousal. In terms of practice, efforts to encourage healthy social media habits for sleep should consider the difficulty and possible distress associated with disconnecting at night, for example by incorporating cognitive behavioural- or mindfulness- informed approaches.

Chapter 5 Nodding off but can't disconnect: development and validation of the iNOD index of Nighttime Offline Distress

5.1 Introduction

By providing adolescents with 24/7 opportunities for interaction, social media directly competes with sleep during a developmental period when the amount of sleep needed for optimal functioning remains high, but individuals are primed to prioritise peer interactions, acceptance and belonging (Blakemore & Mills, 2014; Short et al., 2018). Social media has been highlighted as one important factor contributing to typically delayed bedtimes amongst adolescents, which – in combination with early school day rise times – make insufficient and ill-timed sleep the norm for this population (Carskadon, 2011b; Crowley et al., 2018). Sleep is a key component of adolescent wellbeing, with important implications for academic performance and lifelong mental and physical health (Carskadon, 2011b; F. S. Lee et al., 2014; J. Owens, 2014). Therefore, there is considerable current interest in the possible negative impact of social media on adolescent sleep, with concerns and calls for evidence being voiced by parents, educators, health practitioners and policymakers (The Guardian, 25 December 2016; UK House of Commons Science and Technology Committee, 2019). However, current evidence on adolescent social media use and sleep has been limited by available measurement tools, which to date have largely focused on the frequency and duration of social media use, without capturing sleep-relevant aspects of this inherently social and interactive experience. The current study builds on recent qualitative insights from an adolescent perspective (Scott et al., in press-a), to rigorously develop and validate a new self-report measure that quantified the extent to which individuals struggle to disengage from social media at night: the *Index of Nighttime Offline Distress (iNOD)*. This aims to provide a measurement tool that supports researchers and practitioners to move beyond conceptualising social media in hours per day, to build a more in-depth understanding of its unique implications for adolescent sleep.

Available literature on adolescent sleep has largely studied social media use through a techno-centric lens, grouping it together with other technology under generic umbrella terms like "screentime" or "phone use". Furthermore, studies

that *do* examine social media specifically often continue to treat this as a technology-based activity, focusing on the frequency and duration of use (Scott & Woods, 2019). This approach to date has provided insight into some of the mechanisms linking social media use – alongside other forms of technology – to adolescent sleep (Bartel & Gradisar, 2017; Cain & Gradisar, 2010). For example, an hour spent using social media is an hour spent awake, and with only 24 hours in the day, social media use is one of many activities that can contribute to sleep displacement (Exelmans, Gradisar, & Van den Bulck, 2018; Van den Bulck, 2004). However, this techno-centric approach fails to capture the unique social, emotional and cognitive aspects of social media use that are specifically relevant to adolescent sleep, beyond simply another hour of total daily "screentime". An updated approach to social media interactions is needed moving forward to ensure that adolescent sleep research, education and treatment remain fit for purpose in a rapidly evolving social media landscape (Scott & Woods, 2019).

Recent work has explored social media's unique implications for adolescent sleep, by providing an in-depth insider perspective on the experience of balancing sleep and online interactions whilst navigating adolescence (Scott et al., in press-a). These qualitative findings highlighted the powerful motivations that lead some adolescents to prioritise social media over sleep, often struggling to disengage despite acknowledging sleepiness and impaired daytime functioning. These drivers included concerns about missing out on social media interactions at night – with negative consequences for "real world" peer relationships the next day – and perceived social expectations of online availability. Adolescents framed social media not as a form of technology, but as an extension of face-to-face interactions, underpinned by the same drivers, such as a desire to feel included and to follow group norms (Assunção & Matos, 2014; Hogg & Reid, 2006; Sheldon & Bettencourt, 2002). Given the heightened sensitivity to social cues during this developmental period, it is perhaps unsurprising that the adolescent 'social brain' would prioritise the opportunity for peer acceptance and belonging via online interactions over the need for sufficient sleep (Blakemore, 2018a; Blakemore & Mills, 2014). This insight can help ensure that adolescent sleep models and intervention strategies remain up to date with the current challenges that adolescents themselves identify as

important. This requires appropriate measurement tools that capture not simply time spent on social media but also these underlying concerns about disengaging at night.

Researchers and practitioners wishing to explore these uniquely relevant aspects of social media experiences for sleep are currently limited by the measurement tools available to them. Much of the existing literature relies on unvalidated single-item measures of frequency and duration of social media use (Jenkins-Guarnieri et al., 2013; Seabrook et al., 2016). Furthermore, available multi-item measures are often specific to one platform and its features, meaning that they can quickly become outmoded (The Lancet, 2019). For example, given its prevalence in the past decade, several available measures are specific to Facebook (Andreassen et al., 2012; Ellison, Steinfield, & Lampe, 2007; Ross et al., 2009), which has now been overtaken amongst adolescents by image-based platforms Snapchat and Instagram (Pew Research Center, May 2018), whose features facilitate qualitatively different social interactions and user experiences (Pittman & Reich, 2016). Maintaining pace with current platforms and features is an inevitable challenge in this field, but perhaps more worrying is the tendency for available measures to *pathologise* social media use, aiming to capture social media "disorder" or "addiction", despite insufficient evidence for considering it as such (Andreassen et al., 2012; Holmgren & Coyne, 2017; van den Eijnden et al., 2016). Existing validated measures of fear of missing out (Przybylski et al., 2013) and emotional connection to social media use (Jenkins-Guarnieri et al., 2013) have proved useful to date in starting to examine the cognitive-behavioural aspects of social media use that are particularly relevant for sleep (Scott & Woods, 2018; Woods & Scott, 2016). To move forward, a targeted sleep-specific measure is now required that targets the concerns that adolescents themselves identify as causing difficulties disengaging from social media at night.

To date, the choice of available measures has limited the scope of research questions, conclusions, recommendations and wider dialogue, maintaining a focus on time spent using social media, which is often framed negatively (The Guardian, 25 December 2016; UK House of Commons Science and Technology Committee, 2019). This study targets this gap by developing and validating a

new self-report measure of difficulty disengaging from social media at night due to underlying concerns, which is crucial to draw conclusions about the sleep-specific implications of adolescent social media use. Drawing on recent qualitative findings, this study first develops data-driven candidate items whose content and wording capture the concerns that adolescents identify as driving nighttime social media habits that impact on sleep (Scott et al., in press-a). It uses data from a large adolescent sample to select items for the final measure – the *Index of Nighttime Offline Distress (iNOD)* – and to examine its factor structure, validity and reliability. Finally, we explore to what extent individuals differ on this difficulty disengaging construct, and how it is associated with nighttime social media habits and a range of sleep measures. Based on literature to date, we expect that adolescents who experience these concerns more strongly will tend to use social media for longer in bed and after the time they feel they should be asleep, and report later bedtimes, shorter sleep duration and poorer sleep quality.

5.2 Methods

5.2.1 Participants and procedure

Participants were 3008 adolescents attending Scottish secondary schools (51.1% female), aged 10-18 years old (mean age = 14.6 years). This online survey study was advertised online to recruit partner schools. Each school received a tailored summary of typical sleep and social media habits in their school, to support evidence-based school policy and curriculum development. Each school invited its pupils to complete the online survey: often this was the whole school, or in some cases only certain year groups took part based on their curriculum and availability. Participating pupils completed the online survey, which included candidate items for the new measure and other established questionnaire measures (see Measures, section 5.2.2). Most schools invited pupils to participate during classes, while a few schools invited pupils to complete the survey using their own devices outside of class times. Average completion time was 15 minutes.

Parents received advance information on the study, with the option to opt-out their child. The first page of the online survey provided a plain English summary

of pupils' rights to non-participation and confidentiality, with the researcher contact details. Pupils had to indicate consent via a tick box before proceeding to the survey. This study was approved by the University of Glasgow College of Science and Engineering Ethics Committee, a senior staff member from each participating school, and relevant local authorities where research approval procedures were in place. Partner schools and participating pupils did not receive monetary reimbursement.

5.2.2 Measures

Participants reported their date of birth and sex and completed the candidate items (details below). The survey also included existing measures that capture related constructs to test convergent and discriminant validity: emotional connection to social media, fear of missing out and personality traits. Participants also reported on typical sleep patterns and completed a measure of sleep quality. Details of each measure are provided below.

5.2.2.1 iNOD candidate items

We developed candidate items for the new measure based on the theme structure identified in the focus group thematic analysis in the previous chapter. Table 11 presents the candidate items, according to the sub-themes they were intended to capture. These items were discussed amongst the research team and in consultation with three external researchers with expertise in media engagement (two of whom had additional expertise in sleep and one of whom had additional expertise in scale item generation). This process refined the content and wording of candidate items to ensure they captured the intended construct. We included deliberate redundancy with multiple wordings of similar underlying concepts (DeVellis, 2016).

The questionnaire instructions were: "Thinking about how you use social media at night, please rate each of the following statements from 'not at all true of me' to 'extremely true of me'." The candidate items were then listed in randomised order. The response options were: "not at all true of me" (0), "slightly true of me" (1), "moderately true of me" (2), "very true of me" (3) and "extremely true of me" (4).

Table 11 – All 28 original candidate items from focus group themes

Theme	Sub-theme	Candidate items
Missing Out	**Offline costs** Perceived negative impact on offline relationships (e.g. peer exclusion) from missing social media content & interactions	1. I worry that I might miss something that my friends have seen on social media 2. I worry that I will be left out from my friends the next day if I don't see something on social media that night 3. It's important to me that I've seen the same things on social media as my friends 4. I would feel left out from my friends if I couldn't use social media at night
	Constant threat State of threat/unpleasantness when offline: intrusive thoughts & bedtime rumination about possibly missing out	5. When I'm not using social media, I feel like I don't know what's going on 6. I feel like I'm missing out on something if I'm not on social media around bedtime 7. It's always in the back of my head when I'm not on social media 8. If I'm not on social media around bedtime, I wonder if my friends are 9. When I'm trying to fall asleep, I think about social media
	Can't disengage Difficulties disengaging from social media (& resisting temptation to re-engage with incoming notifications / new content)	10. I need to be up to date with things on social media before I can relax at bedtime 11. I feel like I have to check my account(s) for anything new before I can sleep 12. I listen/look out for notifications while I'm trying to sleep 13. It's important for me to check notifications and new content before I go to sleep 14. I would find it difficult not to check a notification when I'm trying to sleep
Social Expectations	**Normal behaviours** Perceived 'normal' or typical teenager/peer social media habits (available at night, prompt responses)	15. I feel like my friends expect me to be on social media around my bedtime 16. I feel like my friends expect me to be on social media throughout the night 17. I feel like my friends expect me to answer messages quickly 18. I feel like my friends expect me to have seen the latest things on social media 19. I feel like normal people my age use social media late at night
	Internalised norms Feeling of guilt / being rude when not responding quickly or maintaining interactions	20. I worry that I will offend someone if I leave a conversation 21. I feel like a bad friend if I don't answer a message quickly 22. If I don't answer a message quickly, I feel rude 23. If I end a conversation, I feel like a bad friend 24. I feel rude if I end a conversation 25. I feel like I'm letting my friends down if they can't contact me on social media
	Obligation Continuing online interactions out of obligation, not choice (i.e. when tired but 'stuck talking to someone')	26. I feel like I have to answer messages even if I'm trying to sleep 27. I feel like I have to continue a conversation even if I'm tired and want to fall asleep 28. I feel like I have to respond to things on social media even if I'm sleepy and don't feel like it

5.2.2.2 Emotional connection to social media

We used the Social Integration and Emotional Connection subscale of the Social Media Use Integration Scale (Jenkins-Guarnieri et al., 2013), slightly modified by replacing the original "Facebook" with "social media" in the item wordings. Items included "I get upset when I can't log on to social media" and were rated on a 6-point Likert scale from "strongly disagree" to "strongly agree". Items scores were summed to give a total subscale score of 6–36, with higher scores indicating higher levels of emotional connection to social media. The measure had good reliability in the current sample (Cronbach's alpha = .84).

5.2.2.3 Fear of missing out

The Fear of Missing Out scale captures the extent to which an individual experiences a "pervasive apprehension that others might be having rewarding experiences from which one is absent" (Przybylski et al., 2013, p. 1841). It consists of 10 items, such as "I get anxious when I don't know what my friends are up to", which are rated on a 5-point scale from "not at all true of me" to "extremely true of me". The overall score (from 1-5) is calculated by averaging all 10 item scores. The scale had good reliability in the current sample (Cronbach's alpha = .89).

5.2.2.4 Big Five personality traits

To assess the discriminant validity of the new measure, we used the mini International Personality Item Pool (mini-IPIP; Donnellan, Oswald, Baird, & Lucas, 2006) to measure the Big Five personality traits: Extraversion, Agreeableness, Openness, Neuroticism and Conscientiousness. Each four-item measure had acceptable reliability in the current sample (Cronbach's alphas >= .67).

5.2.2.5 Nighttime social media use

Participants provided estimates of how long (in hours and minutes) they typically use social media in bed at night, and after they feel they should be sleeping.

5.2.2.6 Sleep parameters

Participants reported the times at which they typically went to bed, and closed their eyes to sleep ("shuteye time"; Exelmans & Van den Bulck, 2017a). They also provided estimates of their typical total sleep duration, not counting any periods of wake during the night.

5.2.2.7 Sleep quality

We used the Sleep Condition Indicator (SCI; Espie et al., 2014) to measure sleep quality. It has eight items that capture difficulties initiating and maintaining sleep, perceived sleep quality and daytime functioning, and the duration and frequency of sleep problems. Items are scored out of 4 and summed to give a total score between 0 and 32, with lower scores indicating poorer sleep quality. Scores of 16 or below are used to indicate possible insomnia. It had good reliability in the current sample (Cronbach's alpha = .83).

5.2.3 Data analysis

Data analysis was completed using R version 3.5.1 (R Core Team, 2018). We randomly split the candidate item data into a calibration sample and a holdout sample (DeVellis, 2016).

The calibration sample was submitted to Exploratory Factor Analysis (EFA) using maximum likelihood extraction and promax (oblique) rotation. To identify the most appropriate number of factors to extract, we consulted multiple criteria including: Eigenvalues > 1 (Kaiser, 1960); the inflection point from a visual inspection of the scree plot (Cattell, 1966); adjusted Eigenvalues > 0 from parallel analysis (Glorfeld, 1995; Horn, 1965); and the interpretability of resulting factor solutions (Jenkins-Guarnieri et al., 2013). After extracting factors, we retained items with primary factor loadings >= .5 and secondary factor loadings < .3, to produce a clean factor structure. We then reduced the number of items by considering the content, wording and performance of items in the factor solution (DeVellis, 2016). We re-examined the factor structure of this final solution and calculated Cronbach's alpha to assess its reliability (alpha > .7 is "good", >.8 is "very good", and > .9 is "excellent"; P. Kline, 2000).

The holdout sample was submitted to Confirmatory Factor Analysis to test the fit of this model. We computed a mean- and variance- adjusted Diagonal Weighted Least Squares statistic with robust standard errors (Rosseel, 2012). The following criteria were used to determine acceptable model fit: comparative fit index (CFI) and Tucker-Lewis index (TLI) > .90 (Hu & Bentler, 1999); and root-mean-square error of approximation (RMSEA) and standardised root mean square residual (SRMR) < .08 (M. W. Browne & Cudeck, 1992; R. Kline, 2005). A significant Chi-square value is used to indicate poor model fit in small samples (R. Kline, 2005), but this is common in larger samples and can be disregarded when n > 200 (Hair, Tatham, Anderson, & Black, 1998).

We examined the properties of the final measure using data from the whole sample together. We tested age differences with Spearman's correlation coefficients and gender differences with Yuen's bootstrap t-test (a robust alternative to standard independent samples t-test; Wilcox, 2012). Convergent and discriminant validity (Hubley, 2014) were tested using Spearman's correlations between the final measure and existing measures that should show medium to large associations (fear of missing out, emotional connection to social media, nighttime social media use) or small to no associations (the Big Five personality traits). Finally, we examined associations between the new measure and nighttime social media habits and sleep measures, first using Spearman's correlations and then using multiple regressions that controlled for age and gender.

5.3 Results

We first examined the distributions of each item and removed items 9 and 12 due to unacceptable skew and kurtosis, respectively. The remaining 26 items all had skew and kurtosis within the acceptable range (between -2 and +2; Gravetter & Wallnau, 2014). There were complete case data for these 26 items from 2866 participants. These were randomly split into a calibration and a test sample, each with 1433 participants (an "excellent" sample size for factor analysis; Comfrey and Lee, 1992).

5.3.1 Calibration dataset: Exploratory Factor Analysis & Item Analysis

The factorability of the calibration dataset was supported by Bartlett's Test of Sphericity ($p < .001$) and the Kaiser-Meyer-Olkin measure (KMO = .970; Kaiser, 1974; Watson, 2017). We considered the multiple criteria outlined in the Data Analysis section for identifying the number of factors to extract. Different criteria suggested different numbers of factors, so we examined the interpretability of each factor solution and established that extracting two factors (with Eigenvalues of 12.44 and 1.23 respectively) produced the most meaningful solution. This was consistent with the Kaiser rule of retaining those factors that have Eigenvalues > 1 (Kaiser, 1960).

We performed EFA to extract two factors and considered the resulting loading patterns against criteria in Data Analysis section. This resulted in 20 of these 26 items being retained. Items 17, 19, 25, 26, 27 and 28 were all discarded due to primary factor loadings < 0.5. The resulting 20-item two-factor solution was stable and did not change when subjected to another iteration of EFA. This produced a clean and interpretable factor structure. Table 12 shows the factor loadings for the 20-item two-factor solution.

Table 12 – Factor loadings for the 20-item two-factor solution

Item	Item text	Factor 1	Factor 2
		Factor loadings	
6	I feel like I am missing out on something if I am not on social media around bedtime	**0.846**	-0.073
10	I need to be up to date with things on social media before I can relax at bedtime	**0.776**	-0.060
4	I would feel left out from my friends if I could not use social media at night	**0.775**	-0.035
11	I feel like I have to check my accounts for anything new before I can sleep	**0.754**	-0.065
5	When I am not using social media, I feel like I do not know what is going on	**0.751**	-0.040
3	It is important to me that I have seen the same things on social media as my friends	**0.729**	0.027
13	It is important for me to check notifications and new content before I go to sleep	**0.717**	-0.058
1	I worry that I might miss something that my friends have seen on social media	**0.706**	0.081
7	It is always in the back of my head when I am not on social media	**0.699**	0.036
2	I worry that I will be left out from my friends the next day if I do not see something on social media that night	**0.676**	0.070
15	I feel like my friends expect me to be on social media around my bedtime	**0.633**	0.067
8	If I am not on social media around bedtime, I wonder if my friends are	**0.628**	0.108
18	I feel like my friends expect me to have seen the latest things on social media	**0.592**	0.106
16	I feel like my friends expect me to be on social media throughout the night	**0.584**	0.142
14	I would find it difficult not to check a notification when I am trying to sleep	**0.576**	0.073
22	If I do not answer a message quickly, I feel rude	0.088	**0.702**
21	I feel like a bad friend if I do not answer a message quickly	0.083	**0.728**
20	I worry that I will offend someone if I leave a conversation	0.066	**0.738**
23	If I end a conversation, I feel like a bad friend	-0.041	**0.888**
24	I feel rude if I end a conversation	-0.065	**0.856**

Notes: Calibration sample, n = 1433. Factor loadings for the 20 retained items after iterative Exploratory Factor Analysis (with oblique promax rotation) of the 26 original candidate items. We retained items with primary factor loading >= 0.5 and secondary factor loading < 0.3.

Factor 1 (15 items) and factor 2 (5 items) had Cronbach's alphas of .94 and .93, respectively. Any Cronbach's alpha above .9 is considered excellent (P. Kline, 2000). We therefore considered whether the number of items could be reduced whilst retaining good reliability. This aimed to produce the most useful final measure by balancing strong reliability with minimal respondent burden (DeVellis, 2016). We considered the conceptual consistency of item content, the length of item wordings and how each item performed in item analysis. For factor 1, we removed items 1, 3, 5, 7 and 18, whose wordings did not specifically mention bedtime or sleep, to maximise consistency of the intended construct. We removed item 2, whose wording was considerably longer than other items, to optimise readability. The remaining ten items had an unchanged Cronbach's alpha value of .94. We then iteratively removed items with the lowest item-total correlation, to produce a final six-item subscale which retained excellent reliability (Cronbach's alpha = .91). For factor 2, we removed item 22 – since it had the lowest item-total correlation – to produce a final four-item subscale, which also had excellent reliability (Cronbach's alpha = .92).

We once again performed EFA to these ten items, which retained a clean factor structure. The factor loadings for this 10-item two-factor solution are shown in Table 13. Factor 1 explained 32.2% of the variance. Factor 2 explained 25.0% of the variance.

Table 13 - Final 10-item two-factor solution

		Factor loadings	
Item	Item text	Factor 1	Factor 2
6	I feel like I am missing out on something if I am not on social media around bedtime	**0.830**	-0.062
4	I would feel left out from my friends if I could not use social media at night	**0.790**	-0.041
15	I feel like my friends expect me to be on social media around my bedtime	**0.732**	-0.005
16	I feel like my friends expect me to be on social media throughout the night	**0.674**	0.071
10	I need to be up to date with things on social media before I can relax at bedtime	**0.669**	0.019
8	If I am not on social media around bedtime, I wonder if my friends are	**0.661**	0.089
21	I feel like a bad friend if I do not answer a message quickly	0.129	**0.669**
20	I worry that I will offend someone if I leave a conversation	0.091	**0.715**
23	If I end a conversation, I feel like a bad friend	-0.030	**0.901**
24	I feel rude if I end a conversation	-0.039	**0.842**

Notes: Calibration sample, n = 1433. Factor loadings for the 10 final retained items after iterative EFA and reducing items based on item analysis. Factor 1 = 'Staying Connected' subscale; factor 2 = 'Following Etiquette' subscale.

5.3.2 Holdout sample: Confirmatory Factor Analysis

We then performed Confirmatory Factor Analysis of the 10-item two-factor model in the holdout sample of 1433 participants. The chi-square test was significant ($X^2[34]$ = 307.67, p < .001), although this is common in large samples (Hair et al., 1998). The remaining goodness of fit indices met the criteria outlined in the Data Analysis section, supporting acceptable fit of the model (CFI = .984, TLI = .979, RMSEA = .075, SRMR .031).

Both subscales had excellent reliability in the holdout sample, with Cronbach's alpha of .91 for factor 1 and .92 for factor 2. Based on the item content for each factor, we named factor 1 *Staying Connected* and factor 2 *Following Etiquette*.

5.3.3 Final measure: correlations and distribution

The remaining analyses examined the properties of the final subscale scores and how they related to other measures. For these remaining analyses, we used data from the whole sample with pairwise deletion.

Table 14 – Means and sex differences for all measures

	Overall		Boys		Girls		
	Mean	SD	Mean	SD	Mean	SD	*p*
iNOD subscales							
Staying Connected	5.36	5.83	4.83	5.70	5.86	5.91	***
Following Etiquette	3.76	4.26	3.24	4.09	4.25	4.36	***
Convergent validity measures							
Fear of missing out	2.38	0.94	2.22	0.94	2.53	0.91	***
Emotional connection to social media	20.83	7.48	19.57	7.46	22.01	7.32	***
Discriminant validity measures							
Conscientiousness	12.17	3.04	12.18	2.83	12.16	3.22	*ns*
Extraversion	12.68	3.63	12.41	3.45	12.93	3.78	***
Neuroticism	11.85	2.78	10.89	2.57	12.73	2.68	***
Agreeableness	14.33	3.13	13.57	3.09	15.03	3.00	***
Openness	14.16	2.94	14.15	2.95	14.18	2.93	*ns*
Nighttime social media habits							
Nighttime social media use	15.38	7.25	14.48	7.29	16.25	7.11	***
Social media use in bed (mins)	82.55	89.47	75.24	84.93	89.69	93.16	***
Social media use after feeling like should be asleep (mins)	40.61	52.80	38.11	53.22	43.06	52.38	**
Sleep measures							
Bedtime (decimal hours)	10.34	1.51	10.48	1.61	10.21	1.40	***
Shut eye latency (mins)	64.03	80.81	60.75	79.61	67.21	81.94	*ns*
Shuteye time (decimal hours)	11.33	1.63	11.42	1.77	11.24	1.47	**
Wake time (decimal hours)	7.09	1.02	7.16	1.19	7.02	0.81	**
Sleep duration (hours)	7.52	1.57	7.59	1.66	7.46	1.47	*ns*
Sleep quality	22.54	7.24	23.61	6.75	21.51	7.53	***

Notes: Sex differences tested by Yuen's bootstrap t-test (1000 bootstrap iterations), **p < .01, ***p < .001.

5.3.3.1 Demographic associations

Table 14 presents means and standard deviations for all measures, including a breakdown by sex (with significant sex differences tested by Yuen's bootstrap t-test). Girls scored higher on both iNOD subscales, fear of missing out and emotional connection to social media. Girls also tended to use social media for longer in bed and after the time they felt they should be asleep. There was no gender difference in sleep duration, although boys tended to go to bed and wake up later than girls. Girls had poorer sleep quality than boys.

Age was not significantly associated with *Staying Connected* (r_s = .01, *p* = .454). There was a very small but statistically significant association between age and *Following Etiquette* (r_s = .06, *p* < .01). Compared to younger adolescents, older adolescents tended to go to bed later (r_s = .18, p < .001), but wake up at the same time (r_s = .04, p = 0.053), therefore reporting shorter sleep duration (r_s = -.21, p < .001). Older adolescents also tended to use social media for longer in bed (r_s = .14, p < .001) and after the time they felt they should be asleep (r_s = .14, p < .001).

Although skew statistics for both subscales were within an acceptable range (1.27 for Staying Connected subscale and 1.24 for Following Etiquette subscale; Gravetter & Wallnau, 2014), visual inspection of their distributions identified a positive skew (see Figure 7). There was a floor effect on both subscales, with considerable percentages of participants scoring zero on *Staying Connected* (24.1%) and *Following Etiquette* (30.4%).
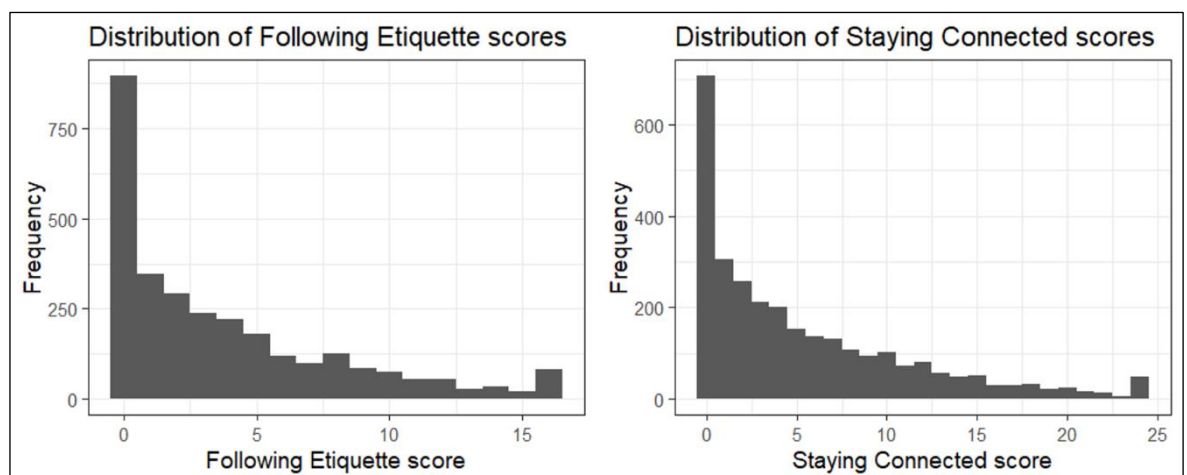

Figure 7 - Distributions of iNOD subscale total scores

5.3.3.2 Convergent and discriminant validity

Both subscales showed patterns of convergent and discriminant validity consistent with the intended construct (see Table 15 for correlations). For convergent validity, the iNOD subscales had medium to large correlations with related measures of emotional connection to social media, fear of missing out and nighttime social media use. For discriminant validity, the iNOD subscales had smaller (or no) correlations with the Big Five personality traits (highest r_s = .23), and the effect sizes of these personality associations were comparable for existing validated measures (FoMOS and SMUIS).

Table 15 - iNOD subscale correlations with related measures and personality traits

	1	2	3	4	5
1. iNOD$_1$: Staying Connected	-				
2. iNOD$_2$: Following Etiquette	.59***	-			
3. Fear of missing out	.63***	.53***	-		
4. Emotional connection to social media	.59***	.43***	.57***	-	
5. Nighttime social media use	.47***	.30***	.37***	.46***	-
6. Conscientiousness	-.17***	-.15***	-.16***	-.20***	-.26***
7. Extraversion	.12***	ns	.11***	.15***	.17***
8. Neuroticism	.23***	.22***	.29***	.22***	.20***
9. Agreeableness	.06**	.14***	.18***	.11***	ns
10. Openness	-.19***	-.15***	-.13***	-.19***	-.20***

Notes: Spearman correlation coefficients. After pairwise deletion, sample size n for individual correlations ranges from 2570 to 2948. **p<.01, ***p<.001, ns = non-significant. Significance levels calculated using Holm-Bonferroni correction for multiple comparisons (Haynes, 2013; Holm, 1979).

5.3.3.3 Associations with nighttime social media use and sleep measures

Table 16 shows correlations between the iNOD subscales, bedtime social media habits, sleep patterns and sleep quality. Those who scored higher on *Staying Connected* and *Following Etiquette* tended to get into bed later, have longer shut eye latency and later shuteye times, but did not differ in their wake times. They also tended to use social media for longer in bed and after the time they felt they should be asleep. They tended to have shorter sleep duration and poorer sleep quality. *Staying Connected* showed stronger associations with bedtime social media habits and sleep measures than *Following Etiquette*. These associations remained significant in multiple regression models that controlled for age and sex.

Table 16 - Correlations with sleep and nighttime social media

	1	2	3	4	5	6	7	8	9
1. iNOD Staying Connected	-								
2. iNOD Following Etiquette	.59***	-							
3. Bedtime	.16***	.11***	-						
4. Shut eye latency	.14***	.07***	-.30***	-					
5. Shuteye time	.28***	.17***	.58***	.46***	-				
6. Wake time	ns	ns	.21***	.07***	.23***	-			
7. Social media use in bed	.37***	.20***	.20***	.37***	.52***	.12***	-		
8. Social media use after feeling like should be asleep	.41***	.26***	.28***	.33***	.57***	.10***	.76***	-	
9. Sleep duration	-.24***	-.17***	-.34***	-.28***	-.58***	.18***	-.38***	-.44***	-
10. Sleep quality (SCI)	-.33***	-.31***	-.17***	-.20***	-.34***	ns	-.25***	-.36***	.43***

Notes: Spearman's correlation coefficients. All reported coefficients in this table are significant at p < .001. Significance levels calculated using Holm-Bonferroni correction for multiple comparisons (Haynes, 2013; Holm, 1979).

5.4 Discussion

This study developed a new data-driven, validated self-report measure of difficulty disengaging from social media at night: the *index of Nighttime Offline Distress* (iNOD). The final 10-item measure has two subscales with excellent reliability that capture concerns about *Staying Connected* to peers via social media at night and *Following Etiquette* by continuing ongoing interactions at night. The iNOD moves beyond existing measures to capture a unique construct that is highly relevant given current interest in better understanding and supporting adolescent sleep in an evolving social media context. It provides a rigorously developed tool that is informed by the adolescent voice (Scott et al., in press-a) and allows researchers and clinicians to target these core underlying concerns to explore social media's unique implications for adolescent sleep. In the current study, individuals who experienced these concerns more strongly also tended to use social media for longer in bed, and reported later shuteye times, shorter sleep duration and poorer sleep quality.

5.4.1 A new measurement tool: a unique construct & contribution

The iNOD provides a new tool that targets the sleep-specific issues around social media that are highly relevant to today's adolescents, by using recent qualitative findings from young people as the foundation for its constructs and items (Scott et al., in press-a). The *Staying Connected* subscale measures concern over remaining connected to friends via social media at night, to avoid missing out on online interactions. In the previous qualitative findings, adolescents valued the social connection that social media afforded them at night: "so that you feel like you are part of something" (Scott et al., in press-a). Consistent with a cognitive-behavioural perspective on nighttime social media use (Scott & Woods, 2018), adolescents voiced how this concern about being absent from online interactions could interfere with efforts to relax at bedtime once disconnected: "you're always wondering 'what's everyone else doing? Are they speaking to each other? Am I missing out? Should I be on this? Should I be up?" (Scott et al., in press-a). The *Following Etiquette* subscale measures concern about causing offence or appearing rude by not responding and continuing nighttime social media interactions. Previous qualitative findings highlighted this shared perception of expected social media etiquette: "if the

conversation is going good you need to keep it going, you can't ignore them or else that's just rude" (Scott et al., in press-a). This could leave some adolescents struggling to disengage from ongoing interactions at night, beyond intended bedtimes: "you don't want to offend the other person [...] so you sort of get stuck talking to a person".

The iNOD therefore offers more in-depth insight into adolescent sleep and social media use, allowing researchers to move beyond the prevalent current focus on simply *time spent* using devices. Indeed, the current patterns of convergent and discriminant validity support the uniqueness of its construct. Moderate to large correlations indicated that adolescents who were more concerned about Staying Connected and Following Etiquette did also experience stronger overall fear of missing out and general emotional connection to social media, but that these measures did not fully overlap. Smaller associations between the new subscales and personality traits indicated that the iNOD does not simply tap into more generalised underlying levels of concern (e.g. neuroticism), but specifically captures the more targeted intended construct of concerns about disengaging from social media at night. This novel sleep-specific measure can therefore provide new understanding of the *nature* of distress and unease that some adolescents can experience when disconnecting from social media at night, which is a key issue for understanding and supporting adolescent sleep in today's connected world.

This fills a gap in previously available measurement tools, which to date have limited the scope of research questions and conclusions, and therefore evidence-based decision-making in policy and practice. With existing measures often focusing on the frequency and duration of social media use, or apparently "addictive" symptoms, this has limited scientific understanding and wider public dialogue by missing insight into other potentially relevant aspects of social media use. The iNOD addresses this gap within the context of adolescent sleep, capturing specifically sleep-relevant aspects of this inherently social and interactive experience. This allows researchers and practitioners to move beyond the current focus on "screentime" to examine the unique processes of sleep as an adolescent in a 24/7 connected world. By addressing this gap, the

iNOD can help support efforts to tackle several challenges currently facing this field (for a review see Scott & Woods, 2019), as outlined below.

Firstly, it provides a measure with better longevity than platform- or feature-specific measures in a rapidly evolving social media landscape, which is especially relevant given calls for longitudinal work (Bhat et al., 2018). Secondly, it can support efforts to develop more effective interventions to promote healthy sleep, by moving beyond (often unsuccessful) attempts to limit device access (Bartel et al., 2019), to meaningfully target underlying concerns. Thirdly, by providing an alternative to measures that pathologise social media use, it supports researchers and practitioners to consider a more balanced, holistic model of social media interactions in the context of adolescent sleep and psychosocial development. Finally, it can help future efforts to build on current models of sleep and technology use generally (Bartel & Gradisar, 2017; Cain & Gradisar, 2010), to add new understanding of the unique implications that social media in particular has for adolescent sleep.

5.4.2 Individual differences in difficulty disengaging

The current distribution of iNOD scores indicated that a considerable proportion of adolescents *do not* struggle to disengage from social media at night, which challenges the prevalent narrative of universally highly engaged or "addicted" teenage social media users. The measure is therefore useful to distinguish the smaller proportion of adolescents who *do* experience moderate to high levels of concerns about disengaging, and to quantify the extent of their difficulty. To minimise floor effects that simply reflected the characteristics of item wordings or response options (DeVellis, 2016), we avoided generating candidate items with overly strong or negative wordings (e.g. "I get upset about…", "I struggle with…"), and used response options consistent with existing measures (Przybylski et al., 2013). Therefore, the current distribution is less likely to be an artefact of the item or response wordings, and more likely to indicate that a majority of adolescents genuinely do not find disengaging from social media particularly problematic, but that a smaller proportion do struggle with this, to varying extents.

It is also possible that some low iNOD scorers were simply under-reporting the extent to which they experience these concerns. This possibility would be consistent with previous apparently contradictory self-reports from adolescents who did describe examples of social media affecting their sleep but did not explicitly label this as such when asked directly whether social media affects their sleep (Scott et al., in press-a). This is an inevitable challenge for all self-report measures, and highlights the value of triangulating subjective and objective insight into nighttime social media use and sleep. However, we stress the importance of understanding this subjective experience, even where it diverges from objective measures. For example, when supporting adolescents to implement healthier nighttime social media habits, the extent to which they *perceive* their social media use to be problematic will be an important factor in determining their level of motivation to change, which is a key component for the success of youth sleep interventions (Cain, Gradisar, & Moseley, 2011). Therefore, the iNOD may present a useful screening tool for practitioners to capture the extent to which an individual identifies social media as a source of sleep disturbance and also to start a dialogue around these underlying concerns, for example as part of a motivational interviewing approach that focuses on promoting autonomy (Cassoff, Rushani, Gruber, & Knäuper, 2014).

5.4.3 New understanding of sleep models

Beyond providing a new measurement tool that can support future research and practice, the current findings also have more immediate implications for our understanding of social media use and sleep in adolescence. Scores on both *Staying Connected* and *Following Etiquette* were associated with more time using social media in bed (including after intended bedtimes), later shuteye times, shorter sleep duration and poorer sleep quality. These findings build on existing models of general technology use and adolescent sleep (Bartel & Gradisar, 2017; Cain & Gradisar, 2010), to add additional understanding for social media specifically that takes into account its unique social and interactive affordances (Carr & Hayes, 2015). Specifically, this can inform Cain and Gradisar's (2010) existing model – updated in 2017 by Bartel and Gradisar – by (1) adding to the identified factors that moderate sleep-relevant technology use (e.g. parental involvement) and (2) refining the possible mechanisms linking it to poor sleep (e.g. increased arousal). Firstly, it is now clear that an important

factor in determining sleep-relevant social media behaviour is the extent to which an individual is concerned about the negative consequences of disengaging at night, whether for losing social connection or violating perceived etiquette. Secondly, we now have novel understanding of the *nature* of increased arousal that may link social media use to poor sleep, with a strong social influence on individuals' cognitive-emotional response to bedtime social media interactions. Together, these new insights can guide efforts to develop effective sleep intervention and education strategies, which should aim to address these social, emotional and cognitive aspects of bedtime social media use in order to remain fit for purpose in the changing sleep environment of today's adolescents. This builds on a cognitive-behavioural perspective on adolescent bedtime social media use and sleep, which suggests that interventions focusing purely on reducing time spent using social media are not only challenging to implement (Bartel et al., 2019), but also fail to address the parallel influence of cognitive arousal from potential distress of being disconnected (Scott & Woods, 2018).

The current findings also support the need to update our thinking about sleep in general, to account for the way in which bedtime media use has altered the typical sleep environment and processes. Exelmans & Van den Bulck (2017) recently argued for sleep displacement to be recharacterised as a two stage process, with media activities such as social media use not only delaying the time individuals get into bed (stage 1 sleep displacement) but also extending the time spent awake in bed before actually deciding to go to sleep (stage 2 sleep displacement). They introduced the concept of shuteye latency, as the time between getting into bed and actually closing one's eyes and deciding to sleep. In the current adolescent sample, this shuteye latency was on average 1 hour 4 minutes, which is roughly 20 minutes longer than previously noted in a representative adult sample (Exelmans & Van den Bulck, 2017a). This reinforces the importance of clearly defining whether research measures and findings apply to bedtimes or shuteye times in today's often media-rich sleep environment, and this consideration may be even more important for adolescents. For some young people, this extended period of wakefulness in bed before attempting to sleep could reflect a mismatch between parental expectations around appropriate bedtimes and bioregulatory pressure for later sleep onset given delayed

circadian rhythm and slower build-up of sleep pressure during adolescence (Carskadon, 2011b; Crowley et al., 2018).

Furthermore, the current findings could indicate an even more fragmented process of sleep displacement – beyond just two consolidated stages – for adolescent social media users. Participants reported spending on average 1 hour 23 minutes using social media in bed at night, which is longer than the average shuteye latency (1 hour 4 minutes). This suggests additional sleep interruptions after initial shuteye times, if these adolescents were re-engaging with social media again after the time that they *first* closed their eyes and decided to go to sleep, consistent with previous self-reports (Scott et al., in press-a). Incoming alerts and notifications may therefore further fragment the process of sleep displacement, by not only delaying bedtimes and initial shuteye times (Exelmans & Van den Bulck, 2017a), but also interrupting and resetting sleep onset latency for individuals who re-engage with social media after first deciding to sleep. Indeed, on average participants reported using social media for 41 minutes after the time they felt they should be asleep. This is consistent with previous findings that adolescents find it difficult to follow intended self-regulation strategies to limit their nighttime use, struggling to avoid re-engaging with social media due to incoming alerts (Scott et al., in press-a). These findings extend existing evidence highlighting the need to rethink and update sleep measures and models, since typical sleep habits may now involve an increasingly fragmented process of sleep displacement, facilitated by highly prevalent hand-held devices with integrated social media apps that are accessible 24/7 and push through notifications designed to re-capture users attention.

5.4.4 Strengths & limitations

The strengths of this study include its large, diverse sample of adolescents from schools across Scotland and its rigorous methods for item generation and selection (DeVellis, 2016). Using self-report is a strength of the iNOD measurement approach, as this is crucial to capture adolescents' cognitive and emotional experience of difficulty disengaging from social media due to social concerns. However, when estimating social media duration or sleep patterns, the current study's reliance on self-report can be considered a limitation. This type of self-report estimate is common in the literature, but is subject to bias in

recall and reporting (Althubaiti, 2016), for example with sleep state misperception resulting in less accurate estimates of sleep parameters compared to objective measures (Fernandez-Mendoza et al., 2011; Silva et al., 2007). The current findings therefore offer valuable insight into the *subjective experience* of sleep from an adolescent perspective, with the potential for future work to combine the iNOD's insight alongside more objective, verifiable measures of social media activity and sleep parameters to build a more holistic understanding of adolescent sleep that unites physiology, behaviour and experience (Gregory & Sadeh, 2012; Tubbs et al., 2019).

5.4.5 Conclusions

This study provides a rigorously developed and validated new self-report measure that captures difficulty disengaging from social media at night: the index of Nighttime Offline Distress (iNOD). Its two subscales allow researchers and practitioners to move beyond measuring the frequency and duration of social media use, to instead meaningfully examine the extent to which individuals struggle to disconnect due to concerns voiced by adolescents around *Staying Connected* and *Following Etiquette*. By filling a gap in currently available measurement tools and capturing a novel construct, the iNOD can support efforts to build more nuanced understanding of the sleep-specific implications of online social interactions for those navigating adolescence in today's 24/7 connected world. The current findings indicate that extended wakefulness in bed before attempting to sleep is typical for today's adolescents, reinforcing the importance of considering not only sleep onset latency but also shut eye latency (Exelmans & Van den Bulck, 2017a). These results further indicate a fragmented process of sleep displacement for those who struggle to disconnect – and stay disconnected – from potential online interactions to allow an uninterrupted sleep opportunity. Whilst many adolescents do not experience considerable difficulties disengaging from social media at night, those who do struggle with these concerns tend to use social media for longer than intended, reporting shorter sleep duration and poorer sleep quality. Efforts to update sleep education and interventions should aim to target these underlying concerns about staying connected and following etiquette, rather than simply restricting social media or device access.

Chapter 6   Informing evidence-based school practice through stakeholder consultation and a pilot lesson programme

6.1 Introduction

The studies presented thus far in this thesis have advanced our understanding of social media use in the context of adolescent sleep, highlighting the unique implications that this inherently social and interactive experience has for sleep, beyond simply another hour of daily "screentime". Our results to date have indicated: (1) robust associations between social media use and sleep patterns, especially delayed sleep onset; (2) concerns about missing out or violating social norms and expectations when disconnecting from social media at night; and (3) shorter sleep duration and poorer sleep quality amongst adolescents who experience these concerns more strongly and thus struggle to disengage from social media. Together, this new insight indicates the need for adolescent sleep research and practice to reframe social media not simply as a technology-based activity, but as a highly motivating and rewarding source of peer interactions, which understandably competes with sleep during a developmental period of heightened sensitivity to social influences (Blakemore & Mills, 2014).

6.1.1 Opportunities to work with stakeholders to translate evidence into practice

The process of carrying out these studies and disseminating their results not only produced this new knowledge, but also developed partnerships with secondary schools and Local Education Authorities across Scotland. Through engaging with these partners within our research and at related events, it became clear that many saw social media and sleep as important issues that they wanted to support their pupils with, but felt that there was a lack of available curriculum materials and support. This echoes recent national recommendations to develop and signpost high-quality curriculum resources that help young people navigate current issues around social media (UK House of Commons Science and Technology Committee, 2019). We were approached by one school and one Local Education Authority, each looking for our input on incorporating up-to-date evidence on social media use into their ongoing development of curriculum

resources and strategies to support pupil sleep and wellbeing. This presented the chance for us to: (1) consult with teachers and other school and Local Education Authority stakeholders on facilitators and barriers to implementing this evidence in a school context, and (2) develop and pilot curriculum materials for a five-week lesson block with an entire secondary school. We wanted to maximise this opportunity to work in partnership with relevant stakeholders to establish the next steps needed to ensure that the new knowledge gained in this PhD can inform real-world practice and policy.

6.1.2 School-based health promotion

The school curriculum offers a useful way to reach almost all adolescents with health promotion, which is defined as "the process of enabling people to increase control over, and to improve, their health" (World Health Organization, 1986). School-based health promotion has been demonstrated to positively influence a range of health behaviours, such as smoking (Thomas, McLellan, & Perera, 2015), physical activity (Kriemler et al., 2011) and mental health (Weare & Nind, 2011). Curricula can produce long-term positive effects, particularly when they move beyond simply providing information to also support young people to develop awareness, skills, strategies and self-control (Thomas et al., 2015). School-based programmes offer the benefit of providing almost universal access to evidence-based health information, with a focus on prevention and early intervention (Whitley, Smith, & Vaillancourt, 2013). However, there are challenges with delivering this in schools, as even programmes supported by international evidence do not always replicate positive outcomes when implemented within the practical limitations of a local context, such as school timetables, resources and workload (Humphrey et al., 2016). Therefore, researchers have argued that exploring barriers and facilitators to implementation *before* investing in producing and rolling out a school-based health programme is crucial to maximise effectiveness (Durlak, Weissberg, Dymnicki, Taylor, & Schellinger, 2011; Weare & Nind, 2011).

6.1.3 Existing school-based sleep promotion programmes

Given evidence supporting the effectiveness of school curricula in promoting a range of health behaviours, there have been recent efforts to implement and

evaluate school-based programmes to support healthy adolescent sleep (Blunden & Rigney, 2015; Gruber, 2017). Overall, these programmes have been shown to effectively improve sleep *knowledge*, but they do not produce sustained improvements in sleep *practices* (Cain et al., 2011; De Sousa, Araújo, & de Azevedo, 2007; Moseley & Gradisar, 2009). It has been argued that a key factor preventing this knowledge from translating into behaviour is motivation (Cassoff, Knäuper, Michaelsen, & Gruber, 2013). Even if adolescents know about the importance of adequate sleep, motivational barriers – such as social influence – can prevent them from implementing and maintaining sleep behaviour changes (J. Owens, Stahl, Patton, Reddy, & Crouch, 2006). Several health behaviour change models have been applied to sleep promotion and these consistently highlight the importance of identifying and overcoming this type of motivational barrier (Grandner, 2019b; Knowlden, 2019). For example, the attitude-social influence-self-efficacy model (De Vries & Mudde, 1998) draws together common aspects from the theory of planned behaviour (Ajzen & Madden, 1986), social learning theory (Bandura, 1986) and the transtheoretical model (Prochaska & Velicer, 1997). This has been used as a conceptual framework for school-based sleep promotion (Cassoff et al., 2013), with social influence highlighted as one of its especially salient motivational elements for adolescent populations, given the characteristic heightened sensitivity to social influence during this developmental period (Blakemore, 2018a; Blakemore & Mills, 2014). This is closely linked to self-efficacy (another common component) since addressing perceived social norms and pressures is crucial to help adolescents feel able to implement changes to their sleep behaviours.

Therefore, one reason for the observed lack of sustained improvement in sleep practices may be that existing programmes have not specifically targeted and fully addressed the role that social influence plays in adolescents' sleep patterns within today's 24/7 connected online social context. Indeed, adolescents identify social media interactions as a major barrier to healthy sleep habits (Godsell & White, 2019; Quante et al., 2018). Findings from our focus group study (Chapter 4) indicated that some adolescents could feel helplessly 'stuck' in social media interactions at night – due to a sense of obligation or fear of exclusion – despite reporting sleepiness, delayed sleep onset and impaired daytime functioning. This highlights the very powerful motivational barriers that

can stand between adolescents recognising the need for adequate sleep and actually implementing appropriate bedtimes, since this would involve overcoming concerns about violating etiquette and missing out.

6.1.4 Targeting social media concerns as a barrier to healthy sleep

This is an important gap in existing school-based sleep promotion efforts, with a need to develop targeted input that addresses these concerns raised by adolescents about the difficulties of balancing social interactions and sufficient sleep. Effectively tackling this issue will require more than an information-only strategy that simply instructs young people to reduce nighttime technology use, since previous efforts have found that many adolescents are not willing to engage with this approach (Bartel et al., 2019). Instead, it should aim to promote self-efficacy by providing meaningful support that helps young people feel more able to engage in dialogue about these concerns and take control of their bedtime social media habits. Rather than immediately creating and evaluating the outcomes of such a programme, we first sought to maximise available opportunities for stakeholder engagement to assess barriers and facilitators to implementing this in a school setting. This is a crucial first step that builds the foundation for a fully developed programme that maximises effectiveness (Gruber, 2017).

We therefore worked together with our partner school and Local Education Authority to take two evidence-based steps towards this: (1) consulting with teachers, recent school leavers and wider education stakeholders; and (2) using this to inform the development of a pilot curriculum programme and gaining feedback from participating pupils. These are important evidence-based steps towards addressing a gap in existing sleep promotion approaches, which need to be updated in light of new evidence in order to stay relevant for the main issues that today's adolescents identify as affecting their sleep.

6.2 Stakeholder consultation

We consulted with stakeholders – including teachers, recent school leavers and school senior management – to gain a range of perspectives on likely facilitators

and barriers when implementing this approach in a school setting. This aimed to inform our development of pilot materials and recommendations that were meaningful and realistic for schools to put into action.

6.2.1 Methods for stakeholder consultation

We took opportunities to engage with a range of stakeholders. This involved phone interviews with teachers and focus groups with recent school leavers, both of which were recorded, transcribed and coded. Finally, a workshop event with a range of education stakeholders from schools and a Local Education Authority allowed further discussion and produced summary points. We then looked across these different data sources to develop themes that summarised salient points that could meaningfully inform our pilot lesson programme and recommendations.

6.2.1.1 Guidance teacher phone interviews

Phone interviews were conducted with five experienced Guidance teachers at one of our research partner schools in Scotland. These teachers are responsible for delivering Personal Social and Health Education lessons to pupils in all year groups (from age 11 to 18 years). They had an average of 14 years' experience in this role. Each teacher took part in a 30-minute one-to-one phone interview on what would make a successful classroom-based lesson programme on sleep and social media use. Interviews aimed to draw on teachers' experience delivering this type of health and social education lessons, to explore likely facilitators or barriers to effective design and delivery. The interviewer explained the purpose of the study, summarising the project to date and explaining the aim of informing new curriculum development with input from experienced teachers. The interview aimed to help teachers draw on their experiences of delivering similar lessons to identify facilitators and barriers that could be relevant to the current lesson programme.

Participating teachers received information and a consent agreement via email in advance, and verbally confirmed consent at the start and end of the audio recorded phone call. This study was approved by the University of Glasgow College of Science and Engineering Ethics Committee.

6.2.1.2 Recent school leaver focus groups

Two small focus group discussions were conducted with a total of seven university students (six female, one male) who had left a UK secondary school in the last year. In each focus group, the facilitator began by explaining the purpose of the consultation, by briefly summarising the project to date and outlining the aim of informing our development of a classroom-based sleep and social media lesson programme. Focus groups lasted between 30 and 50 minutes, with the facilitator guiding discussions to cover intended topics whilst also remaining open to unexpected insights and using follow-up questions to help participants expand and develop points. The focus group questions supported participants to reflect on their experiences of similar Personal Social and Health Education lessons, to discuss what elements facilitated or prevented engagement, and to consider how these could be relevant to the proposed pilot programme. Participants provided signed consent to participate and were given the opportunity to withdraw from the study (or to retract specific comments) at the end of the audio recorded focus group discussion. This study was approved by the University of Glasgow College of Science and Engineering Ethics Committee.

6.2.1.3 Analysis of phone interviews and focus groups

Phone interviews and focus groups were audio recorded, transcribed (assigning pseudonyms) and analysed using reflexive thematic analysis (Braun & Clarke, 2006; Braun et al., 2019). The research team met regularly to discuss emerging codes and theme development. This approach followed Braun and colleagues' (2019) recommendations for effectively utilising reflexive thematic analysis with multiple researchers. This involves regular discussion to maximise insights by sharing perspectives on the data, codes and themes. In line with their recommendations, our approach recognised the analysis as an active process, with themes and theme structure evolving and reshaping throughout ongoing interpretation, discussion and critical reflection (Braun & Clarke, 2006; Braun et al., 2019).

6.2.1.4 Workshop discussions

Finally, workshop events added an additional opportunity to engage with a wide range of education stakeholders, allowing further reflection and refinement of key points identified to date, by adding additional perspectives and highlighting any gaps. We held three workshop sessions in February 2019 at a Scottish secondary school, as part of a one-day Health and Wellbeing Learning Festival event. For the event, delegates from across the Local Education Authority were able to sign up to attend sessions of their choice with various speakers. We held the same workshop session at three time slots throughout the day, with a total of 42 delegates attending across these three sessions. These included primary and secondary school teachers and senior management, teaching assistants, school nurses, parent-teacher council members and senior staff from the Local Education Authority. Each session first presented the research project, summarising the context and findings to date. Then small groups discussed the role of schools in supporting healthy adolescent social media habits for sleep, possible strategies and perceived challenges. We facilitated feedback into a larger group discussion, and took notes to produce a brief summary of the points discussed. This was displayed as bullet points via a digital projector and updated as the workshop session progressed, serving as a form of immediate respondent validation by allowing delegates to further discuss, expand or clarify points (Torrance, 2012).

6.2.1.5 Analysis of workshop discussions

Despite the different context (a workshop event, compared to dedicated interviews or focus groups), we therefore still applied a similar approach of actively reflecting on salient points from these discussions to capture relevant stakeholder perspectives. Unlike transcribing and coding audio recordings, for the workshops this reflective analytical process happened during the sessions, with stakeholders actively contributing to this process of constructing meaning. This process continued after the sessions, with the research team discussing and reflecting on the produced summary points across all three sessions.

The final step of our reflexive analysis was discussion and reflection on the summary points from these stakeholder workshops and the candidate themes

from teacher interviews and school leaver focus groups together. This drew together the most salient points that were informative to the research question around barriers and facilitators for this type of proposed educational programme. The final analyses presented here therefore weave together insights from the full range of stakeholders. This seeks to faithfully communicate insights from these sources in a coherent and meaningful way (Braun et al., 2019), which can inform our approach to developing pilot materials and recommendations for future programmes.

6.2.2 Results & brief discussion of stakeholder consultation

Table 17 presents a summary of the themes produced from the stakeholder consultation process as a whole, noting associated action points to incorporate into our pilot curriculum materials based on these insights. We then briefly discuss each theme in turn, incorporating illustrative quotes and existing literature into a narrative summary of our interpretation (Braun & Clarke, 2006, 2013). Illustrative quotes have been edited for ease of reading (indicated by […]).

Table 17 - Themes and action points from stakeholder consultation

Theme	Summary	Action points
Bridging the generational gap	Teachers and education stakeholders recognise the need to 'speak the same language' as pupils about current issues in social media, but can easily feel out of touch in a rapidly evolving media landscape. Pupils feel that teachers do not understand the issues they face and cannot identify.	Provide teachers with survey results from their school so they feel equipped with up-to-date evidence on trends and pupils' experiences.
Self-relevant content	Pupils often feel alienated and not addressed by topics and content that does not feel relevant and relatable to their experiences. Teachers especially recognise the challenge of ensuring input remains current, as dated material leads to poor pupil engagement. Pupils want to see how information relates to them and how they can actually apply it in their lives (not just facts).	Incorporate discussion of pupil survey results from their school specifically to show sessions relate to their experiences. Include time for pupils to create their own strategy in the final session, planning what changes they will implement.
Balancing pupil-led and teacher-led	Teachers recognise the benefit of having pupils engage, comment and lead discussions, rather than teachers simply 'lecturing'. Pupils value the chance to interact and add their voice, rather than being 'preached to' and feeling alienated and disengaged. However, pupils also recognise the need for support and guidance.	Include fewer directive activities to make more space for pupil-led discussion and interaction. Communicate to teachers that pupils are the experts in their own experiences.
Need to engage parents	Teachers and other education stakeholders (and some pupils) recognise that engaging parents and carers is crucial to promote healthy sleep and social media habits. This reflects a 'powerless' feeling around the limits of what schools can achieve without pupils receiving a consistent at home.	Include take-home activities that focus on pupils engaging their families.

6.2.2.1 Bridging the generational gap

Teachers, school leavers and wider stakeholders alike recognised a gap in inter-generational shared understanding of social media as a key challenge in delivering a successful classroom-based programme around this topic. Recent school leavers reflected that this could leave lessons feeling "outdated", arguing that teachers often "can't really relate to us on a personal level" around these issues because "everything's changed since they were younger, especially to do

with social media" (Kate, school leaver). Teachers similarly recognised how "a changing landscape in terms of the technology that is available" to pupils had altered the experience of being a teenager now compared to "back in the day" (Andrew, teacher). Feeling that "kids are way above us in regards to understanding [social media]" (Carol, teacher) could limit some teachers' confidence in delivering input on this topic. For example, David argued that – as part of "a generation that didn't really engage in social media" – despite his best efforts to "keep on top of what the latest kind of forums are", the main barrier he faced as a teacher when addressing social media was his "own ignorance" (David, teacher). Ellen reinforced that her unfamiliarity with the most current platforms and norms could undermine her "credibility" as a teacher: "I don't know that, and [pupils] know I don't know that, and I think if they suspected that I'm talking in over my head then they won't listen" (Ellen, teacher). Wider stakeholders also recognised the importance – and challenge – of "keeping up to date" and "staying current" in order to "speak the same language" as young people (workshop summary points).

This insight highlighted an important potential barrier to effective delivery of the proposed programme, since this perceived generational gap could undermine teachers' confidence and credibility in addressing concerns about social media interactions with their classes. We therefore considered how our pilot materials could help to bridge this gap, by equipping teachers with appropriate knowledge on this specific topic, to complement their extensive expertise in delivering health education lessons and their existing rapport with pupils. As a result, we planned to provide teachers with a summary of current social media trends and typical adolescent habits, from our recent work with partner schools across Scotland. Equipping teachers with this evidence – including the most popular platforms, typical daily habits and common concerns – aimed to empower them to discuss this topic with their classes while "speaking the same language".

6.2.2.2 Self-relevant content

Reflecting on their experiences of Personal Social and Health Education, recent school leavers criticised schools' approaches to setting lesson topics and content that felt irrelevant to pupils' lives. There was a shared feeling that "a lot of the issues […] weren't that relevant" to pupils, who "were never asked how it was

relevant to us. I don't even think it was considered" (Amy, school leaver). School leavers reflected on the added potential to consult with pupils on what topics would be interesting and informative for them, since "a lot of stuff that they do teach is what the government or what the school wants to put across rather than what people want to know about" (Sam, school leaver). Specifically, a tailored approach was suggested that prioritised the experiences of pupils "from the school you're actually in", since evidence and opinions from other young people from "just a school you don't even know" still felt "just not relevant to you" (Kate, school leaver). Wider stakeholders agreed that this "local evidence is important to make it self-relevant" (workshop summary point). Without deliberate efforts to highlight the self-relevance of lessons, pupils often couldn't see links between the information they were receiving in classes and their own lives: "if they're just telling you facts and stuff but it's got nothing to do with me" (Rose, school leaver). Instead, classes engaged best with lesson content where they could recognise "that some of the things would affect them" (Sam, school leaver). This theme was most strongly voiced by school leavers, although teachers also noted the challenge of ensuring that input remains relevant for the current issues in adolescents' lives, since available lesson materials could become "out of date quickly", leading to poor engagement (Carol, teacher).

Based on this finding, we adapted our pilot approach to incorporate a school survey before weekly lessons began, to build a profile of social media trends and typical habits that was specific to this school (rather than drawing on data from multiple existing partner schools). This aimed to demonstrate that the lesson content related to the experiences of participating pupils, which has been highlighted as facilitating effective school-based sleep education (Gruber, 2017). Furthermore, we decided to include time for pupils to create their own strategy in the final lesson session, summarising what they have learned and planning what changes they will implement. This aims to help pupils link the information in classes to their own lives, seeing how the lessons can apply to their own habits moving forward.

6.2.2.3 Balancing pupil-led and teacher-led

School leavers disliked lessons that were entirely teacher-led, which felt "preachy" (Amy, school leaver). Instead, they especially praised classes where

they had learned through engaging in group discussions with their peers, which allowed them to hear "perspectives from other people [...] and it made it more fun and interactive and it didn't really feel like you were in class but you were still learning" (Hazel, school leaver). Teachers also highlighted the value of this more pupil-led approach: "I want to get their feedback and their thoughts, I don't want it to just be teacher-led [...] I don't just stand up at the front and tell them about it [...] what credibility is there behind that, you know?" (Andrew, teacher). Wider stakeholders also emphasised the importance of a "pupil-led approach" to addressing social media habits and sleep, but with "buy-in and support" from teachers and parents (workshop summary points).

School leavers and teachers also touched on this need to balance both pupil-led and teacher-led input. Whilst teachers agreed they are "not there to lecture" pupils, they acknowledged their role in providing guidance and support: "I'm talking from experience and I'm giving them real life advice" (Beth, teacher). School leaver Kate echoed this need for balance, agreeing that "telling [pupils] to just outright don't go on [social media] as much, that's not a realistic thing and they won't listen", whereas there was still a valuable role for "teaching [pupils] stuff like" phone features to track and limit use (Kate, school leaver). In particular, school leavers acknowledged that pupils were more receptive to advice from teachers "if it seems like they are really invested in trying to help you or give you tips and not just 'here's something we have to teach'" (Rose, school leaver). Therefore, there was a shared sense that effective lessons could provide an opportunity for both pupils and teachers to share their perspectives based on their experiences. Carol summed up this balance, noting the role of teachers to provide information but also the reality of adolescent pupils who are building autonomy: "you can give children as much information as possible [...] but at the end of the day you are leaving that decision to the young people" (Carol, teacher).

Based on this finding we refined our pilot lesson programme in two ways. Firstly, we included fewer directive, teacher-led activities to make more space for pupil-led discussion and interaction, to bring more balance to the sessions. This also aimed to facilitate peer discussion, which is crucial given the inherently social nature of concerns about staying connected online at night. Interactive

pupil-led activities have also been highlighted as effective approaches for sleep education (Blunden & Rigney, 2015; Gruber, 2017) and outperform information-only teacher-led approaches in other areas of health promotion (Thomas et al., 2015). Secondly, we ensured that lesson materials clearly communicated to teachers that a key purpose was to support the pupil voice in leading discussions on their own experiences and perspectives, reminding teachers to recognise pupils as the experts in adolescent life in 2019. This aimed to move the focus away from simply instructing pupils to restrict their nighttime device use, towards a more meaningful effort to understand the concerns that could make it challenging for pupils to implement this change in habits.

6.2.2.4 Engaging parents

Education stakeholders consistently voiced that "involving and engaging parents is crucial, but a challenge in itself", with schools often feeling "powerless" since they "can't tell parents what to do outside of school hours" (workshop summary points). Teachers reinforced this feeling of "fighting a losing battle" in class if pupils "aren't getting the right messages from home", whilst struggling with a perceived "lack of engagement" from parents (David, teacher). Teachers consistently highlighted the need for parents to provide a consistent message around boundaries for nighttime social media use, but also acknowledged that this could be challenging and a source of potential parent-child conflict, as removing device access "leads to war" (Ellen, teacher). School leavers also suggested engaging parents to help build a consistent message across school and home: "I think if you can engage pupils and parents as well it like reinforces the behaviour at home as well and I think that would be useful" (Sam, school leaver). Amy agreed that as well as classroom-based input, "it would be better to have a discussion with parents and kids as well" to help parents understand how and why young people use and enjoy social media, to combat some of the "panic" and "fear" around its possible negative impact (Amy, school leaver).

In discussing whether to involve parents, school leavers therefore highlighted that this was an opportunity to have dialogue that was led by young people rather than adults: "maybe having a conversation the other way to the parent" (Kate, school leaver). Having pupils start these conversations was seen as a way to support a sense of self-efficacy and autonomy: "I think you want to get the

students to want to do it by themselves" (Rose, school leaver). Teachers echoed the value of young people leading conversations at home, noting that younger pupils in particular often acted as health messengers to their parents around the topics covered in class: "if you give them the information about smoking, they go home like little warriors and badger their parents to stop smoking" (Ellen, teacher). For example, Ellen highlighted the value of a pupil-led approach to involving parents, with her suggestion for families to develop mutually agreed boundaries for social media use at bedtime: "[pupils] can take home a contract that they can sit down with their parents and discuss, you know- 'if I'm expected to not have my phone, I'm going to expect you not to have your phone in your room as well'" (Ellen, teacher).

As a result of this insight, we identified an opportunity to incorporate take-home activities into our pilot lesson programme, to spread the message beyond school and into the home. This aimed to involve parents and carers whilst letting young people take the lead, as pupils were encouraged to engage their families in these discussions and changes for take-home activities. Engaging parents can maximise the impact of a curriculum based approach (Weare & Nind, 2011) and has been identified as an important aspect to enhance sleep education, aiming to support sustainable changes (Blunden & Rigney, 2015; Gruber, 2017). Incorporating take-home activities in our pilot programme recognised that, whilst in-class peer discussions were valuable to challenge concerns about perceived negative consequences of disconnecting, pupils would likely require support from family to help implement and maintain changes to bedtime habits at home.

6.3 Pilot testing lesson programme

We incorporated this stakeholder insight – alongside our previous findings – into the design of our pilot lesson materials, which we trialled with our partner school in Scotland. There were five weekly 50-minute sessions, including a pre-programme survey to build a tailored school profile of typical sleep and social media habits, three in-class lessons (with take-home activities), and a post-programme feedback survey. Table 18 summarises each session, outlining the mix of activities designed to specifically target concerns about disconnecting

from social media at night, which can be an important motivational barrier to implementing and maintaining healthier sleep behaviours.

Table 18 - Summary of each session

Session	In-class activities	Take-home activities
Pre-programme school survey	Pupils complete an online survey. They report their typical sleep schedule and bedtime social media habits. They rate to what extent they experience different concerns about disengaging (items from the iNOD index of Nighttime Offline Distress). We produce summary statistics for tailored PowerPoints sent to teachers for the lessons.	
Lesson 1	A PowerPoint with summary statistics from the school survey and key questions is used to facilitate pupil-led discussions around three topics: • How much sleep pupils need, get & want • Whether and how social media affects their sleep habits • What can make it difficult to disengage from social media to sleep	Pupils are instructed to pay attention to household habits around social media and sleep, ready to discuss this next week. Pupils are encouraged to discuss the programme and what they notice with family.
Lesson 2	Pupils discuss what habits they noticed at home. The teacher delivers input on the importance of sleep for functioning. Pupils and teacher collaboratively produce practical 'top tips' for balancing social media with sufficient sleep.	Pupils choose one 'top tip' that they will try out at home this week. Pupils are encouraged to involve their family in trying out a change.
Lesson 3	Pupils discuss their experience of trying a habit change at home this week. Pupils work on a cognitive reframing task in groups. They identify typical worries about disconnecting and then reframe these in a more neutral/helpful way. Pupils and teacher discuss strategies for continuing this dialogue about social media norms and expectations with friends and family.	Pupils are encouraged to consider their own strategy for balancing social media and sleep – based on the information and tools throughout the sessions – and to discuss this with friends and family.
Feedback survey	Pupils provide feedback on their experience of the lessons via an online survey.	

6.3.1 Programme content

Given the inherently social nature of previously identified concerns about disengaging from social media at night, our lessons focused on supporting peer discussion throughout. This allowed pupils to challenge assumptions around others' habits and expectations, and the perceived negative social consequences of disconnecting from social media at bedtime (e.g. causing offence). Furthermore, the activities responded to the need to move beyond a purely behavioural approach, to also address the cognitive and emotional experience of balancing bedtime social media interactions with sleep. Therefore, pupils not only created and tried out practical tips to change their bedtime social media *behaviours*, but also discussed what challenges they had experienced in implementing this, including concerns about the social implications of disconnecting. As well as using peer dialogue, lessons also targeted this issue with a cognitive reframing task (D. A. Clark, 2013), in which groups worked together to challenge common examples of worries about disengaging, as identified in the school survey. For example, by considering alternative ways to interpret the situation, groups may have reframed the unhelpful belief that "my friend will think I'm rude if I don't answer" to a more balanced thought that "I'll explain tomorrow that I was sleeping and my friend will understand". Finally, pupils finished the last lesson by creating their own strategy (drawing on the tools and discussions from all three lessons) which targeted the specific barriers that they had personally identified, but was developed with peer support. Together these activities aimed to promote self-efficacy – by equipping pupils with appropriate skills and tools to adjust their bedtime social media habits to support healthy sleep – whilst recognising the challenges presented by this highly motivating and rewarding source of peer interactions that can easily compete with sufficient sleep.

We provided teachers with introductory information on the evidence base, rationale and aims of the programme. This included a tailored summary of their school's survey results, outlining typical social media and sleep habits and experiences for their pupils. This targeted the perceived generational gap in understanding and experiences of social media between teachers and pupils. Accordingly, it aimed to empower teachers by equipping them with up-to-date evidence on pupils' preferred platforms, usual daily habits and common

concerns, to help teachers "speak the same language" as their pupils. Our introductory information for teachers also stressed the focus on pupils leading discussions, as experts in their own experiences. We provided teachers with PowerPoint presentations with detailed notes to support them to deliver each lesson.

6.3.2 Methods for gaining pupil feedback

Participants were pupils attending a Scottish secondary school, aged 11-18 years old. Almost all classes in the school participated in the lessons, subject to availability. A total of 518 pupils completed the post-programme feedback survey after the lessons (51.3% girls; mean age = 14.6 years). The survey asked pupils to provide some feedback using tick-boxes and open text boxes to report what impact they felt the lessons had for them and what worked well or could be improved.

Parents received advance information on the study, with the option to opt-out or later withdraw their child. This study was approved by the University of Glasgow College of Science and Engineering Ethics Committee and a senior staff member from the participating school.

6.3.3 Results & brief discussion of pupil feedback

6.3.3.1 Pupil-reported outcomes

Pupils were asked to report whether they felt the programme had changed their awareness, habits or dialogue around social media and sleep. Table 19 summarises the percentage of pupils who reported each outcome as a result of the programme.

Table 19 - Percentage of pupils who reported each outcome

Outcome	% who agreed
Felt more aware of how their social media habits affect their sleep	52
Made changes to their bedtime social media habits to sleep better	28
Felt more able to talk to *family* about their social media and sleep habits	28
Felt more able to talk to *peers* about their social media and sleep habits	26
Felt more able to talk to *teachers* about their social media and sleep habits	22

6.3.3.2 Pupil feedback on what worked and what to improve

Pupils had the option to expand on their experience of the lesson programme with short open text responses on what they felt worked well and what could be improved, respectively. Most pupils chose not to answer these, but 107 pupils did identify a positive aspect and 98 pupils identified an area for improvement. Of the 107 responses that identified an aspect that worked well, the three most common areas were: learning new information about social media use and sleep (31%), engaging in group and class discussions (31%), and the PowerPoint slides showing statistics from the school's survey (22%). Specifically, pupils reported that the survey results and group discussions helped them to reflect on their own habits, question assumptions about others' habits and consider how the lesson content directly related to them (see Table 20 for selected illustrative responses).

Table 20 – Illustrative pupil responses on what worked well

Area that "worked well"	Illustrative responses
Learning about sleep and social media use	"Talking about how we can improve our sleep and how to not use social media as much late at night" (girl, 13) "They gave people tips on how they can balance social media and sleep" (girl, 13)
Group and class discussions	"I got to see what was normal for other classmates by discussing with them" (girl, 14) "Asking questions I don't ask myself" (boy, age not provided) "It got everyone thinking about themselves and talking about their own experiences" (girl, 14)
Survey results	"Survey results were interesting" (boy, 14) "I liked knowing the statistics and knowing that I'm not the only one" (girl, 14)

Of the 98 responses that identified an aspect to improve, the three most common areas were: changing the survey to include fewer/different questions (41%), making lessons more fun (30%), and having more interactive elements (14%).

Reviewing the pupil feedback comments suggested that the lessons had not always been delivered as intended, as two comments mentioned how much writing was involved in lessons, which was not part of the materials provided. This reflects the flexibility of our approach, as we provided detailed supporting materials but also allowed teachers to implement these autonomously, drawing on their expertise and knowledge of what works well with different classes.

6.4 Discussion

The findings presented in previous chapters of this thesis indicated that sleep research and practice should reframe adolescent bedtime social media use as a highly motivating and rewarding source of peer interactions, rather than simply another technology-based activity. This new insight highlighted a gap in existing school-based sleep promotion programmes, suggesting that specifically targeting adolescents' concerns about disengaging from social media at night may help them to overcome this motivational barrier between recognising the importance

of sleep and actually implementing healthier sleep practices. This chapter has outlined our approach to maximising available opportunities for stakeholder engagement, to explore facilitators and barriers to implementing this in a school setting, aiming to ensure that these PhD findings can meaningfully inform practice and policy.

We used phone interviews, focus groups and workshop events to consult with teachers, recent school leavers and a range of relevant education stakeholders - including management and support staff in schools and a Local Education Authority - on facilitators and barriers to addressing this issue in a school setting. These consultations raised the need to bridge the teacher-pupil generational gap in social media experiences, balance teacher-led and pupil-led input, ensure pupils view content as self-relevant, and engage parents. This insight informed our approach to designing curriculum materials for three lessons that were piloted by teachers in a partner school. Half of participating pupils reported feeling more aware of how social media affects their sleep and a quarter reported making changes to their habits as a result of the lessons. Participating pupils praised the opportunity to learn new information about social media and sleep, to engage in group discussions and to discover survey results on typical habits for their school within these lessons. Pupils recommended reducing the survey length and making lessons more fun and interactive. Feedback suggested that teachers did not always deliver the lessons as outlined in our materials. We now reflect on the insights gained from this process - alongside consideration of previous chapter findings and wider literature on school-based health promotion - to outline recommendations for next steps.

6.4.1 Reflections and recommendations

Our pilot lesson programme aimed to target a key motivational barrier to healthy sleep practices for adolescents: difficulty disengaging from social media at night due to concerns about staying connected and following etiquette. This sought to enhance existing programmes that tend to simply recommend reducing nighttime technology use, by exploring how to provide more in-depth support to help young people overcome the challenges of implementing this change. Specifically, our lesson programme incorporated a range of in-class and take-

home activities that supported pupils to: reflect on their current habits; select and try out a change to their behaviours; explore the role of social influence in making this change challenging to implement or maintain; consider how to reframe unhelpful social worries; and co-create their own strategy with peer support. Together, these steps aimed to promote awareness and self-efficacy to help pupils tackle the challenge of balancing opportunities to continue online social connection at night with the need for appropriate bedtimes that allow sufficient sleep for optimal functioning.

Given the limited lesson time available and our unique focus on targeting these concerns, we therefore dedicated a relatively modest proportion of time to presenting information on the benefits of sleep. This may have resulted in some pupils lacking motivation to engage in discussions and activities to consider how to implement changes, if they were not convinced of the benefits it would offer them (Blunden & Rigney, 2015). Lack of space in a busy school timetable is a common barrier to implementing comprehensive school-based sleep promotion programmes (Humphrey et al., 2016). However, where feasible, a promising strategy would be to incorporate the current approach into an extended programme that could dedicate more time to presenting information on sleep first, before providing this more targeted support on identifying and overcoming barriers to change.

An extended approach could therefore incorporate a broader range of information and strategies to meet the needs of pupils at different 'stages of change' within the transtheoretical model of health behaviour change (Prochaska & Norcross, 2018; Prochaska & Velicer, 1997). For example, although Bartel et al. (2019) found that participants who agreed to restrict phone use in the hour before bedtime reported improved sleep duration, many of the adolescents they approached were reluctant to participate. They note that this type of intervention addresses the 'action' stage of change, where individuals are ready to implement a change, having moved on from 'contemplation' and 'preparation' by recognising the potential benefits and considering their own behaviours and values (Knowlden, 2019). A similar effect may be at work in our pilot, where 28% of pupils did report making changes to their bedtime social media habits to improve their sleep as a result of the programme. Considering

the transtheoretical model, the pilot's intended support to overcome motivational barriers to change may have been appropriate for this set of pupils who were already willing to implement a change (i.e. at the 'action' stage). In contrast, it is likely that pupils who were at the 'precontemplation' stage - not having considered making any change to their bedtime social media habits - would first benefit from more educational input on the importance of sleep (e.g. for health and learning), to highlight the benefits of altering bedtime social media habits for sleep (Bartel et al., 2019; Knowlden, 2019).

This highlights the challenge of how to adequately personalise input in a classroom setting. Our pilot approach aimed to promote some degree of personalisation, within the constraints of a classroom setting, using school statistics and pupil-led discussions to ensure content was self-relevant and based on pupils' own experiences and opinions. Our results from a representative UK cohort (Chapter 3) and from Scottish schools (Chapter 5) highlight wide-ranging variation in social media habits and experiences, with considerable individual differences in how much time young people spend using social media and the extent to which they worry about staying connected and following etiquette. Therefore, whilst 28% of pupils did report changing their social media habits to improve sleep as a result of the pilot, future programmes could be more effective for a wider range of adolescents if they could be meaningfully tailored to individuals (Weare & Nind, 2011).

Peer mentoring could present an effective way to make this input more personalised, enhancing this brief set of in-class lessons by targeting individuals likely to benefit from more ongoing support. This typically involves training senior pupils to mentor younger pupils, using adapted health curricula that incorporate individual and group activities and providing ongoing social support to help mentees implement and maintain health behaviour changes (Petosa & Smith, 2014). Peer mentoring has been shown to effectively and sustainably improve knowledge, behaviour and self-efficacy across a range of health behaviours in schools (L. H. Smith, 2011). This approach capitalises on social influence as a route to promoting health, as adolescents are more likely to imitate the behaviour of similarly aged individuals (McAlister et al., 2008). Considering the impact that social influence has on adolescent behaviour

(Blakemore, 2018a), peer mentoring therefore presents an opportunity to shift this influence away from creating pressure to stay connected at night despite tiredness, towards promoting the acceptability of disconnecting from social media to *prioritise* one's sleep. In our pilot, pupils reported that they enjoyed the chance to discover norms for peers' social media and sleep habits, highlighting the potential to apply a peer mentoring approach to this topic. Adolescents also tend to view peer mentors as more credible, with a better understanding of young people's concerns (Petosa & Smith, 2014). This makes a peer-led approach particularly promising when aiming to address concerns around social media interactions, as our consultation highlighted perceived generational gaps in understanding of social media that could undermine teachers' perceived credibility. Furthermore, mentors also benefit from participating, by developing skills and experience in coaching and leadership and also improving their own health behaviours to lead by example (Petosa & Smith, 2014). This highlights the potential value of schools looking beyond teachers for delivering school-based sleep promotion that adequately supports young people with current issues around online social interactions.

As well as providing training for *pupils* to promote a healthy balance between social media use and sleep amongst their peers, our pilot highlighted the need to provide adequate training for *teachers* delivering these lessons. Our pilot aimed to strike a balance between providing structured materials – consistent with a more prescriptive 'top down' approach to health education – and allowing some flexibility, in line with 'bottom up' strategies that promote local ownership and autonomy (Weare & Nind, 2011). We provided teachers with full lesson materials and accompanying guidance that explained the programme's purpose and rationale. For example, this guidance outlined the evidence base to support the importance of framing bedtime social media use as a rewarding source of peer interactions, rather than simply a screen that pupils can easily switch off at night. However, we did not want supporting materials and guidance to limit teachers' flexibility in facilitating each lesson based on what worked well for that group, drawing on their expertise and existing relationships with pupils. Striking the appropriate balance is a common challenge in developing and evaluating evidence-based school-based health promotion, since a flexible and autonomous local approach has benefits, but presents difficulties when

synthesising results (Weare & Nind, 2011). Previous work indicates that evidence-based programmes only reproduce positive effects if they are implemented fully and accurately, as intended by the developers, and this requires investment in teacher training and ongoing support (G. Browne, Gafni, Roberts, Byrne, & Majumdar, 2004; Durlak et al., 2011). In this case, such training and support should effectively communicate the rationale of the approach to ensure that teachers deliver the lessons in line with the spirit of the programme, embracing pupil-led contributions and avoiding pathologising or negative language around social media use. This is especially relevant given the perceived gap between teachers' and pupils' experiences and opinions of social media, as highlighted by our stakeholder consultation.

Whilst appropriate training can therefore support teachers and peer mentors to address this issue within the *school* setting, a key area for future development is extending this message into the *home* environment by effectively engaging with parents and families. In our consultation, education stakeholders strongly voiced the importance – and challenge – of engaging parents, as they reported feeling "powerless" to improve pupils' social media and sleep habits from their school-based roles without families being onboard and providing a consistent message at home. Existing evidence shows that parents influence adolescent sleep habits, as young people with parent-set bedtimes have higher sleep duration and improved daytime functioning compared to individuals who set their own sleep schedule (Short et al., 2011). Therefore, researchers have noted that parental inclusion in school-based efforts is likely to support positive outcomes for sleep behaviour change (Azevedo et al., 2008; Blunden, Kira, Hull, & Maddison, 2012; Moseley & Gradisar, 2009), consistent with evidence on health promotion more generally (Spencer, 2018). In our pilot, we informed parents that pupils would be taking these lessons and outlined their purpose. Pupils were also encouraged to discuss lessons with their parents and to involve family in take-home activities. This approach acknowledged that, whilst in-class peer discussions were valuable to challenge perceived social expectations and consequences of disconnecting, effectively *implementing* changes to bedtime habits in the home sleep environment would require support from family. Previous school-based sleep promotion programmes have similarly attempted to engage parents, for example by distributing information booklets and hosting information events

(Azevedo et al., 2008; Blunden, Chapman, & Rigney, 2012), although studies to date have not directly assessed whether parental involvement was instrumental in influencing outcomes (Blunden & Rigney, 2015). Therefore, promising avenues for future research include establishing effective strategies for engaging parents in school-based sleep promotion and assessing whether this enhances adolescents' sleep knowledge, attitudes, motivations and behaviour change.

Together, these recommendations support a holistic approach to addressing adolescents' sleep-relevant social media behaviours and concerns, aiming to involve families alongside a whole-school strategy that integrates appropriate teacher training for class lessons and additional peer mentoring. This type of linked-up approach has been supported in other areas of school-based health promotion (Basch 1984; Dzewaltowski 2004). Furthermore, the insight gained here has implications beyond the current focus on targeting one motivational barrier in order to optimise school-based sleep promotion outcomes. It can inform wider discussions within and beyond schools around adolescent wellbeing. Indeed, our pilot school and previous research partner schools (who contributed data to Chapter 5) anecdotally reported that their tailored school data summaries on typical social media and sleep habits had supported evidence-based discussions on pupil wellbeing with senior management teams and parents. This is especially valuable in supporting a broader shift in attitudes towards adolescent social media use, as local data can add the adolescent voice to these discussions on how best to support young people with the key issues they identify as affecting their sleep and wellbeing. Therefore, taking an evidence-based approach to supporting meaningful dialogue between teachers, pupils and parents around adolescents' experiences of and concerns about social media interactions can inform practice and policy more widely beyond this targeted curriculum input on sleep health specifically.

6.4.2 Limitations

Our conclusions from this stakeholder consultation and lesson pilot should be considered within the limitations of the current process, including our small convenience samples of teachers and recent school leavers. Our consultation findings therefore do not claim to provide a comprehensive view of the issues or to provide generalisability in a statistical sense. Instead, they intended to

maximise available opportunities to gain a range of stakeholder perspectives where feasible within available time and resources (Levac, Colquhoun, & O'Brien, 2010). This process raised important new insights which we implemented to refine our pilot approach, alongside consideration of relevant literature. This was an initial evidence-based step that lays the foundations for ongoing work with stakeholder onboard.

Survey responses collected in a classroom environment are particularly susceptible to inaccurate responses due to low motivation, carelessness or deliberate "mischievous responding" (Fan et al., 2006). The pilot feedback comments we received do not claim to be representative of all participating pupils, since many individuals chose not to provide comments. However, we were able to use available meaningful responses to inform our overall discussion and reflection on findings from the stakeholder consultation, pilot and previous literature.

6.4.3 Conclusions

This chapter has outlined our approach to maximising available opportunities for stakeholder engagement, to explore facilitators and barriers to transferring the new knowledge gained in this PhD into evidence-based practice in a school setting. Our pilot has highlighted the potential to incorporate pupil-led activities into a classroom-based curriculum to target concerns about perceived negative social consequences of disengaging from social media at bedtime to sleep. Promising approaches to incorporate and evaluate in future programmes include facilitating peer discussion, modelling cognitive reframing techniques, and supporting pupils to develop personalised strategies in collaboration with peers. The lessons learned from this consultation and pilot programme can support efforts to update sleep education and interventions, to specifically target the most relevant issues that adolescents currently identify as affecting their sleep. This process has taken evidence-based steps towards developing initial materials and recommendations for realistically addressing social media use and sleep within the context and needs of the Scottish school system. With stakeholders onboard, we are now in a position to move forward with these evidence-based discussions, to ensure that the findings from this PhD support real-world impact.

Chapter 7   General discussion

This thesis aimed to target gaps in current understanding of adolescent social media use and sleep, enriching the evidence and tools available to support meaningful, informed decision-making. The studies in this PhD were driven by identified gaps in existing research literature, including its prevalent techno-centric "screentime" approach, and lack of adolescent voice. These new findings complement and build on existing evidence by providing novel understanding of social media as an inherently social and interactive experience with unique implications for sleep within the context of adolescent development. This insight can help to keep sleep research, education and treatments fit for purpose in a rapidly evolving social media landscape, with the potential for 24/7 online interactions adding to the existing 'perfect storm' of pressures working against sufficient good quality sleep during adolescence (Carskadon, 2011b).

7.1 Summary of findings

Chapters 1 and 2 outlined the context and rationale for examining adolescent social media use and sleep, highlighting the gaps in existing research that the current studies aimed to target. These include: a limited focus on generic "screentime", which is often pathologised; a limited focus on simply the duration and frequency of social media use, rather than its unique social and interactive experiences; a lack of appropriate validated measurement tools to move beyond this; and the need to update sleep interventions to meaningfully address current adolescents' experiences of social media. The studies presented in subsequent chapters have enhanced available evidence, tools and recommendations in each of these areas. Table 21 presents a summary of the key findings of each study.

Table 21 – Summary of key findings in this thesis

Chapter	Key findings
Chapter 3 Adolescent social media use and sleep patterns: cross-sectional findings from the UK Millennium Cohort Study	• Examined social media use and sleep patterns in a large representative sample of UK adolescents, with extensive range of covariates. • Found significant associations between social media use duration and sleep patterns, particularly late sleep onset.
Chapter 4 Identifying drivers for bedtime social media use despite sleep costs: the adolescent perspective	• Used focus groups to add adolescent voice on motivations for bedtime social media use and perceived sleep impact. • Identified concerns around missing out and perceived social norms and expectations that create difficulties disengaging.
Chapter 5 Nodding off but can't disconnect: development and validation of the iNOD index of Nighttime Offline Distress	• Developed and validated a new self-report measure to capture difficulty disengaging from social media at night. • Found significant associations between concerns about disengaging, extended bedtime social media use, shorter sleep duration and poorer sleep quality.
Chapter 6 Informing evidence-based school practice through stakeholder consultation and a pilot lesson programme	• Engaged with stakeholders to develop recommendations for addressing social media within school-based sleep education programmes. • Identified key features to support effective implementation, such as parent engagement and pupil-led dialogue.

Chapter 3 made use of data from a large representative UK sample, to quantify links between social media use and a range of sleep parameters, controlling for an extensive range of covariates. Its approach enhanced existing literature by: (1) providing evidence specific to social media, rather than "screentime" or technology use generally; (2) examining a range of sleep parameters and controlling for an extensive range of covariates; (3) framing effects within the context of current norms to provide meaningful comparisons for higher versus typical users. The study's results indicated statistically and practically significant associations between daily duration of social media use, sleep timing and difficulty falling asleep after nighttime awakenings, with the strongest effects for later sleep onset. It also provided a normative profile for current adolescent social media use and sleep in the UK, which can be used as a baseline

to support evidence-based decision-making. These findings address a number of gaps in available evidence and provide robust evidence to support links between social media use and adolescent sleep patterns, particularly late sleep onset. However, they are limited by the available measure of simply social media use *duration*, which does not capture the rich variety of how adolescents *experience* this time spent using social media. These results therefore laid the foundation for further work to move beyond 'hours per day' to explore how the content, context and experience of this time on social media may have unique implications for adolescent sleep.

In Chapter 4, we therefore aimed to build on evidence of associations between social media use and sleep, to explore the underlying motivations for bedtime social media habits. This study used focus group data to address the lack of adolescent perspective in available literature, to gain a richer understanding of the emotional, social and cognitive drivers that make it difficult for some adolescents to disengage from social media at night. The resulting themes highlighted that adolescents could struggle to disengage from social media at bedtime due to concerns about: (1) *Missing Out* on online interactions and feeling excluded in later offline peer settings; and (2) *Norms and Expectations* around online availability and prompt response times, with fear of social disapproval if these were violated by disconnecting to sleep. Adolescents faced a trade-off in balancing the opportunity for social connection via social media platforms at night and the need for bedtime schedules that allowed sufficient sleep, especially on school nights. This adolescent perspective therefore offered novel insight into social media as a highly rewarding source of peer interaction that directly competes with – and is often prioritised over – sleep. These findings suggest a need for sleep research to reframe bedtime social media use not simply as a technology-based activity – measured in hours per day – but as an inherently social and interactive experience, underpinned by the same concerns around peer acceptance and belonging as offline interactions.

We then identified that – in order to move the research forward – there was a clear need for a measurement tool that would go beyond simply *duration* of social media use to capture these core aspects of adolescents' *experiences* of balancing online interactions with sleep. Chapter 5 therefore built on this insight

gained from focus groups to rigorously develop and validate a new self-report measure that captures difficulty disengaging from social media at night. It produced a valid and reliable measure – the iNOD index of Nighttime Offline Distress – with two subscales that capture the extent to which individuals experience concerns about (1) staying connected and (2) following etiquette. This measure can support future research efforts to build a more nuanced understanding of the sleep-specific implications of adolescents' social media interactions. The study findings also highlighted that, whilst many adolescents scored low on these concerns, those who did experience these concerns more strongly tended to use social media for longer than intended in bed and reported shorter sleep duration and poorer sleep quality. These results suggest that sleep education and interventions would benefit from targeting these underlying concerns about staying connected and following etiquette, rather than focusing only on restricting social media or device access.

In Chapter 6, we therefore moved on to explore how school-based sleep education could go beyond simply advising pupils to limit their bedtime social media use, to more meaningfully support young people to overcome the challenges of implementing such changes. Our results to date had highlighted the need for sleep education to specifically target the powerful role that social influence can play in adolescents' sleep patterns, with concerns about staying connected and following etiquette presenting an important motivational barrier between recognising the importance of sleep and actually implementing healthier sleep behaviours. Consultations with a range of stakeholders identified important considerations for effectively delivering this in a school setting, such as bridging the generational gap between teachers and pupils, and supporting pupil-led discussions and parent engagement. These insights helped refine our pilot lesson programme, which: equipped teachers with a tailored school profile of typical social media and sleep habits; facilitated peer discussions to challenge perceived expectations and consequences of disconnecting; and helped pupils to develop their own strategy that was personalised but had peer support. This stakeholder consultation and pilot testing were important evidence-based steps towards ensuring that the findings from this PhD can inform real-world practice and policy.

Each of these studies moved our understanding forward. Together, they led to a clear take home message of this PhD as a whole: in order to move forward, sleep research and practice needs to reframe adolescent social media use as a social interaction, not a technology.

7.2 Implications

This message has implications for research, practice and policy. Approaching adolescent social media use as an inherently social and interactive experience – rather than simply another hour of "screentime" – can (1) update our current models of adolescent sleep; (2) support more efficient future research; (3) inform meaningful and effective sleep interventions and education; and (4) guide a more constructive narrative in public and policy spheres. We now discuss implications for each of these four areas in turn.

7.2.1 Updating models of adolescent sleep

The current findings indicate that we cannot fully understand adolescent sleep without understanding the experience of social media interactions. There is an important opportunity for these results to update and extend existing models of adolescent sleep (Carskadon, 2011b; Crowley et al., 2018) and its links to technology use (Bartel & Gradisar, 2017; Cain & Gradisar, 2010).

For example, the original Perfect Storm model outlined developmental changes to bioregulatory and psychosocial factors that contribute to typically delayed bedtimes during adolescence (Carskadon, 2011b). This was recently updated to incorporate new evidence on the specific developmental changes that occur to bioregulatory systems governing sleep-wake regulation during adolescence (Crowley et al., 2018). The current findings present a further opportunity to now update the psychosocial element of this model. Whilst the model already notes that typical adolescent sleep patterns are influenced by the increased *autonomy* associated with this developmental period, the current results additionally indicate the role of its characteristic heightened *sensitivity to social cues* (Blakemore, 2018a; Blakemore & Mills, 2014). With increased vigilance to possible social evaluation and heightened stress responses to social scrutiny (Gunnar et al., 2009; Westenberg et al., 2004), it is unsurprising that

adolescents may choose to prioritise social media interactions over sleep in order to avoid the risk of missing out and social disapproval from violating perceived norms and etiquette.

With ubiquitous smartphone access amongst this age group (Pew Research Center, May 2018) and increasingly blurred boundaries between online and offline worlds (Redden & Way, 2017), social media has become a key part of adolescent daily life, facilitating the opportunity for peer interaction 24/7, including in bed. Adolescents themselves identify this as the major barrier to healthy sleep habits that they face (Godsell & White, 2019; Quante et al., 2018). It is therefore impossible to have a comprehensive model of adolescent sleep without addressing the experience of social media interactions, including underlying concerns that drive social media behaviours and increase cognitive arousal once offline (Scott & Woods, 2018). Therefore, to support meaningful research and practice, we must ensure that up-to-date models of adolescent sleep do not address social media simply as another hour of daily "screentime" but instead as an inherently social and interactive experience.

Even models that already specifically attend to the role of technology use in adolescent sleep (Bartel & Gradisar, 2017; Cain & Gradisar, 2010) can benefit from this new insight. These have provided a useful framework to date for examining mechanisms linking different technology use to adolescent sleep patterns. However, when this techno-centric approach is applied to *social media* specifically, it limits the potential insight we can gain, by maintaining a focus on the frequency and duration of social media activity and failing to capture its unique social, emotional and cognitive user experiences (Scott & Woods, 2019). Extending models to address social media as an inherently social and interactive experience – underpinned by the same concerns as offline interactions – can therefore move beyond a focus on time spent using social media simply *displacing* time spent asleep, to better understand its additional unique implications for bedtime behaviours, arousal and sleep, separate from other technology-based activities.

Figure 8 illustrates how the current findings can inform and extend Bartel and Gradisar's (2017) model – which attends to technology use in general – with additional considerations specific to social media interactions in the context of

adolescent sleep. It highlights social influence as an additional important factor in determining social media habits, which can be driven by concerns about staying connected and following etiquette influences. It further elaborates on existing possible mechanisms linking this to sleep, noting that displaced bedtimes can arise from difficulty disengaging from social media interactions and reinforcing the important social, cognitive and emotional dimensions of associated arousal. Finally, it adds longer shut eye latency (SEL) to the already identified associated later bedtimes and longer sleep onset latency (SOL), as an extended period of wakefulness in bed before attempting to sleep appears to be typical for today's adolescent social media users.
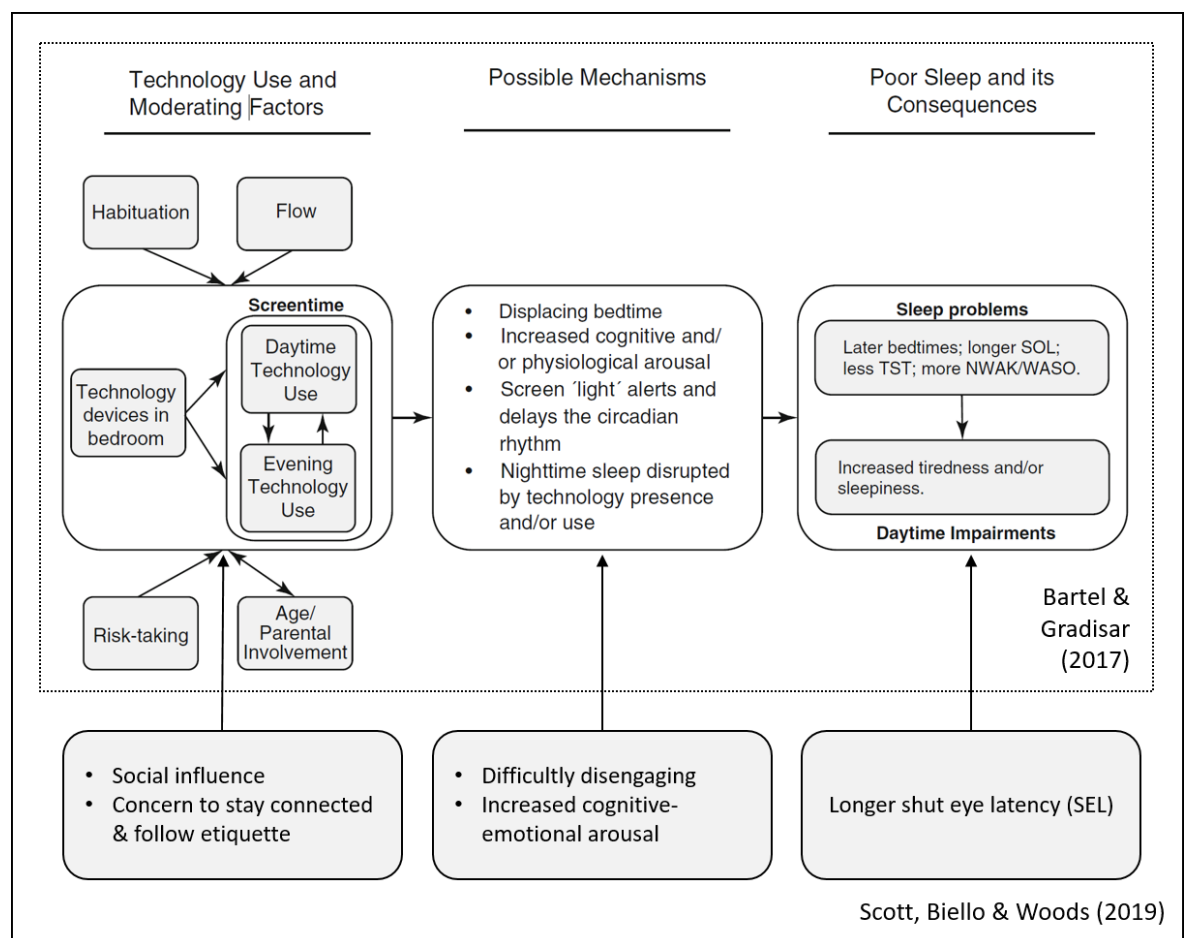
Figure 8 – Updated model of social media use and adolescent sleep
The original model within the dashed box illustrates mechanisms linking generic technology use or "screentime" to sleep in children and adolescents. This original figure is taken from Bartel & Gradisar (2017). The additional three boxes below highlight the novel insight gained in this PhD regarding additional considerations for *social media* specifically (unlike other technologies) in the context of adolescent sleep.

7.2.2 Supporting more efficient future research

This thesis also provides a valuable tool to support researchers in these efforts to move the field forward. The iNOD self-report measure fills an important gap for a rigorously developed and validated self-report measure that captures the sleep-specific implications of adolescents' social media experiences. This enables researchers to move beyond prevalent current use of unvalidated single-item measures of frequency and duration of social media use, to use a validated multi-item measure that does not pathologise adolescent social media interactions, but instead captures related concerns about staying connected that young people themselves identify as highly relevant to their sleep behaviours. This can support efficient research by tackling a key challenge facing researchers in this field: ensuring that research measurement maintains pace with a rapidly evolving social media landscape. By tapping into underlying social processes – around peer approval and belonging – that drive sleep-relevant social media habits, the iNOD offers better longevity than existing platform- or feature- specific measures, which can quickly become outdated (The Lancet, 2019). This is especially relevant given calls for longitudinal work on adolescent sleep and social media use (Bhat et al., 2018; Li et al., 2019), where including a high-quality measure that will remain relevant across the course of the study is crucial to maximise meaningful and useful conclusions from the considerable investment of resources required.

7.2.3 Informing approaches to interventions & education

As well as shaping the models and tools available to researchers, the conclusions of this thesis can also inform evidence-based efforts to update and evaluate adolescent sleep interventions and education. Importantly, the current findings together suggest that interventions which only address the technology aspect of social media use – by restricting device access at bedtime, for example – are unlikely to be the most effective approach. Efforts to reduce smartphone use at bedtime have proved unpopular with adolescents (Bartel et al., 2019), likely in part due to the concerns highlighted here around staying connected and following etiquette, which can contribute to difficulties disengaging for some (but not all) adolescents. This is an important motivational barrier that a successful intervention must address in order to meaningfully support

adolescents to implement and maintain changes to their bedtime social media habits that facilitate sufficient, good quality sleep.

Our pilot lesson programme highlighted the potential for classroom-based approaches to target this by incorporating peer discussions led by young people, to challenge perceived expectations, pressures and negative consequences of ending social media interactions to sleep. A promising direction for future interventions and education is to further develop and evaluate this type of peer-led approach, aiming to tackle the role of social influence in promoting a culture that prioritises social media over sufficient sleep. Peer mentoring approaches can instead seek to use this adolescent sensitivity to social influence to their advantage, for example with older pupils modelling healthy sleep choices for optimal functioning, and promoting new norms around the acceptability of taking control and prioritising one's sleep over social media interactions. Beyond the school setting, interventions at the individual level can focus on supporting the young person to identify and overcome concerns about disconnecting, promoting autonomy within a motivational interviewing approach (Cassoff et al., 2014). These can also explore the extent to which individuals perceive social concerns as a barrier to healthy bedtime social media habits, and teach cognitive behavioural- or mindfulness- based techniques to those who do experience distress and increased arousal when disconnected (Cincotta et al., 2011; Peterman et al., 2016).

Whilst further research is required to continue developing and rigorously evaluating the most effective strategies, the current findings strongly suggest that sleep education and interventions should address underlying concerns about staying connected, rather than simply restricting social media or device access. This presents an important opportunity to move the focus on from simply setting time limits on daily or nightly use, towards facilitating a healthier overall relationship with social media platforms, which optimises wellbeing by maximising benefits like connectedness (Davis, 2012, 2013) whilst minimising disruption to sufficient, good quality sleep.

7.2.4 Guiding a more constructive narrative around adolescent social media use

Reframing adolescent social media use as a social interaction – rather than technology use – can also help guide a more constructive narrative in public and policy spheres around its role in adolescent sleep and wider wellbeing. As a topic of current interest to a wide audience, research in this field is being widely discussed in a public forum and amongst policymakers, with these discussions often driven by concerns about social media's potential negative impact on young people (The Guardian, 25 December 2016; UK House of Commons Science and Technology Committee, 2019). This predominantly negative focus is maintained by available research literature often framing adolescent social media use as a potential threat or harmful activity, using language around social media "addiction" and "problematic use" (Andreassen et al., 2017; Bányai et al., 2017; Bhat et al., 2018; Rozgonjuk et al., 2018; Satici & Uysal, 2015; Vernon et al., 2017), which can pathologise social media use despite insufficient evidence for considering it an addiction (Billieux et al., 2015). This narrative does not align with the adolescent perspective gained in this thesis, with young people focusing on the peer interactions that platforms facilitate, viewing social media as a valuable opportunity for rewarding social connection that can understandably compete with sufficient sleep when available 24/7.

In addition to providing the qualitative adolescent perspective on balancing social connection with sufficient sleep, the quantitative data presented in this thesis also reinforce the importance of acknowledging the wide range of different social media habits and experiences. For example, our normative profile for UK adolescents in Chapter 3 indicated that although one in five spent 5+ hours using social media on a typical school day, two thirds used social media for less than 3 hours. This data-driven profile can provide a baseline to support evidence-based policymaking discussions, rather than relying on assumptions around prevalence of high use. Furthermore, the distribution of iNOD scores in Chapter 5 suggested that a considerable proportion of adolescents *do not* struggle to disengage from social media at night, which challenges the prevalent narrative of universally highly engaged or "addicted" teenage social media users. Instead, this provides a new measure that is useful to distinguish the smaller proportion of adolescents who *do* experience moderate to high levels of

concerns about disengaging, to quantify the extent of their difficulty and start a dialogue around these concerns.

Moving forward, discussions in research, practice and policy should therefore consider the *positive* aspects of online social interactions alongside their potential pitfalls, and acknowledge the variation in adolescents' habits and experiences. This can support more constructive discussion to ensure that we are best placed to support those young people who *do* perceive their experiences on social media as problematic, whilst avoiding applying unhelpful labels to those young people who may devote considerable time to online social interactions, but who have positive experiences (Tzavela et al., 2015; Tzavela et al., 2017).

7.3 Limitations

The contribution of this thesis should be considered within the limitations of what these studies can and cannot yet tell us.

7.3.1 Causality

The cross-sectional nature of the quantitative data presented in this thesis precludes conclusions of causality. This is a common limitation of the wider available literature, with continued calls for longitudinal and experimental work to enrich current understanding of links between technology use and sleep (Bartel & Gradisar, 2017; Bhat et al., 2018; Li et al., 2019). Recent experimental work has supported a causal link from bedtime smartphone habits to adolescent sleep patterns, with restricted phone use resulting in earlier bedtimes and extended sleep opportunity (Bartel et al., 2019). Longitudinal work has further indicated that the association between adolescent technology use and short sleep is likely to be bidirectional (Mazzer et al., 2018), with researchers arguing that existing poor sleepers or those with a later circadian preference may turn to technology as a sleep aid or to pass time until they fall asleep (Exelmans & Van den Bulck, 2016; Tavernier & Willoughby, 2014). Furthermore, it is important to note that an alternative causal model could be that broader self-regulation difficulties in some adolescents may be expressed in both poor sleep

and more social media engagement (Exelmans, 2019; Owens, Dearth-Wesley, Lewin, Gioia, & Whitaker, 2016).

Nonetheless, the insight gained in this thesis does enhance existing understanding of the mechanisms linking social media use and adolescent sleep. The current findings add the adolescent perspective through focus groups and self-report on the subjective experience of balancing online social interactions and sleep. These have confirmed that at least some young people *do* feel that their social media experiences impact on their sleep behaviours. Furthermore, this thesis has provided a new self-report tool that offers improved longevity compared to existing platform- or feature- specific measures, and that can support more meaningful conclusions from future longitudinal work by capturing underlying concerns rather than simply tracking "screentime" habits over time.

7.3.2 Subjective self-report

The studies in this thesis have combined self-report quantitative and qualitative data to capture adolescents' subjective experience of sleep and social media interactions. This was the best measurement approach to gain novel insight into the nature and extent of adolescents' *concerns* about disconnecting from social media at night, and their *perceptions* and *experiences* of how this can impact on sleep behaviours. However, there are limitations where subjective self-report measures were used to quantify social media and sleep *behaviours* (e.g. time spent using social media, sleep onset latency, sleep duration). This type of retrospective self-reporting is common in this literature, but estimates can diverge from diary self-reporting and more objective measures (Orben & Przybylski, 2019; Tubbs et al., 2019). For example, sleep state misperception in both good and poor sleepers can result in poor self-report estimates of sleep onset latency (Fernandez-Mendoza et al., 2011), although the differences in estimates from self-report and polysomnography tend to be relatively small (Silva et al., 2007).

Whilst the current approach has not provided a verifiable objective measure of sleep behaviour or physiology, it has instead offered valuable insight into adolescents' own experience of sleep as they navigate this period of intense psychosocial development with access to 24/7 online social interactions. The

current findings therefore contribute one important part of the overall picture, with the opportunity for future work to complement this with different information from other methodologies, that can together build a fuller understanding of adolescent sleep and social media use (Scott & Woods, 2019). Furthermore, since self-report data is commonly used in this field (Scott & Woods, 2019), this thesis makes a valuable contribution to supporting ongoing research by providing a rigorously developed and validated self-report measure that moves beyond frequency and duration of use to capture underlying concerns.

7.3.3 Generalisability

Our analysis of data from the UK Millennium Cohort Study in Chapter 3 combined a nationally representative sample with statistical techniques (survey weighting and multiple imputation for missing data) that maximised the generalisability of our findings to the UK adolescent population. However, despite making use of the most recent available cohort data, these analyses still provide a snapshot of adolescent social media use in 2015. Maintaining pace with a rapidly evolving social media landscape is a common challenge for studies in this field (The Lancet, 2019), especially this type of large national cohort study.

In contrast, it is important to note that our qualitative analyses from focus groups and stakeholder consultations did not aim to provide this type of generalisability in a statistical sense. We instead sought to develop in-depth, rich understanding of the experiences and perspectives of our participants (Braun & Clarke, 2013). These findings aligned with wider literature on online interactions, social dynamics, and health education, indicating that the issues highlighted by our analyses have broader relevance beyond our specific samples.

Furthermore, all of the studies in this thesis have drawn from the same WEIRD (Western, Educated, Industrialised, Rich, Democratic) population (Henrich, Heine, & Norenzayan, 2010). WEIRD societies are overrepresented across psychological research, and this has been highlighted as an important but often overlooked issue in current understanding of sleep, given its strong cultural determinants (Beebe, 2016). Even between two WEIRD populations – Australia and the United States – Short and colleagues (2013) noted marked differences in

cultural expectations around adolescent sleep. Therefore, whilst the current findings are particularly suited to informing policy and practice considerations within the UK, it is important to avoid assuming that these results can be applied universally without further examination of their cross-cultural generalisability (Beebe, 2016). This is especially relevant when considering recommendations for educational approaches outlined in Chapter 6, since school-based health programmes can be less effective when implemented outside the culture they were developed in, with work required to align materials to the "cultural needs, values and expectations" of that country's school system (Humphrey et al., 2016, pp. 85-86).

7.3.4 Definition of social media

The studies in this thesis have tended to define social media to participants by providing examples of popular current platforms (e.g. Facebook, Instagram). This approach is common in this research field, which often assumes an inherent understanding of social media based on current technologies, with a lack of consensus on a precise definition (Carr & Hayes, 2015; Parks & Howard, 2012). This may have influenced how participants responded, depending on exactly which platforms and activities different individuals considered to be included under 'social media' (e.g. online multiplayer gaming, private messaging, video streaming). As the boundaries continue to blur – for example with gaming becoming an increasingly social and interactive online experience – we suggest that research examining platform-specific experiences should consider these alongside more universal social processes that underpin interactions across different platforms.

7.4 Future research directions

Having already noted how the contribution and limitations of the current work can inform how sleep research and practice approach social media moving forward, we now highlight and further discuss some specific areas that future studies can examine. These include studying social media's role in sleep, mental health and interpersonal functioning within more holistic models of adolescent wellbeing; gaining the parent perspective; and exploring how these issues are expressed in other age groups beyond adolescence.

7.4.1 A more holistic view of social media use and functioning

This thesis has focused on addressing gaps in current understanding of the role of social media in one important aspect of adolescent health and wellbeing: sleep. A promising next step will be to integrate the new insight gained in this PhD into a more holistic model of social media's role within adolescent health and development overall, including sleep, mental health and interpersonal functioning. Despite increasing recognition of sleep and mental health as two inextricably linked aspects of wellbeing (Reynolds & O'Hara, 2013), research on adolescent social media use has predominantly examined these two domains separately (Scott & Woods, 2019). Recent work has started to consider these simultaneously, often positioning sleep as a mediator linking social media use to mental health outcomes (Kelly, Zilanawala, Booker, & Sacker, 2018; Li et al., 2019). However, there is important potential for future work to develop a more complete understanding by incorporating validated measures of sleep, mental health and social media experiences (e.g. our new iNOD measure) into longitudinal data collection, to examine more complex models that allow for likely bidirectional and interactive effects. This can help to move the field on from focusing on associations between duration of social media use and various positive and negative health markers in isolation, to build a more balanced and holistic view of social media use within adolescent functioning.

7.4.2 Testing mechanisms in experimental work

One particularly promising avenue for future work is to examine the issues identified in this thesis with experimental work that can directly test different mechanisms, building much-needed causal evidence. This thesis has found that a subset of adolescents experience difficulties disengaging from social media at night due to concerns about staying connected and following etiquette. An important outstanding question is how this vulnerable group's experiences and behaviours would or would not differ in the absence of social media. For example, if a school- or peer- cohort all stopped using social media, would this subset of highly engaged users simply invest in an alternative rewarding activity? Future experimental work can examine how restricted social media use alters not only sleep outcomes (Bartel et al., 2019), but also other media and non-media behaviours. This can test to what extent the social processes identified

here (e.g. concern about belonging and etiquette) are truly *driving* unique consequences for sleep, or whether this subgroup shares a broader underlying vulnerability that would be expressed through difficulty disengaging from other bedtime activities, regardless of social media.

7.4.3 The parent perspective

This thesis has added the adolescent voice to available literature and engaged with a range of school and Local Education Authority stakeholders to develop recommendations for school-based approaches. A remaining gap in current understanding is the *parent* perspective on supporting adolescents to balance online social interactions with sufficient sleep. This was a strong message from stakeholders in our consultations, who consistently voiced the importance of engaging parents to provide a consistent message across school and home environments. This was further complicated by perceived generational gaps between adolescents' and adults' experiences and opinions of social media. Therefore, a promising avenue for future research would be to more fully explore the parent perspective. This could incorporate in-depth qualitative analysis to add new insight into the experiences, concerns and challenges of today's parents as they aim to support their adolescents' health, wellbeing and interpersonal functioning through this period of rapid development. This could help establish effective strategies to engage parents in enhancing school-based input with consistent messages and support at home.

7.4.4 Beyond adolescence

Throughout this thesis, we have argued for the importance of understanding social media use and sleep during *adolescence* specifically. The prevalent focus on adolescents and young people in this research area to date has partly been driven by concerns voiced by policymakers, health professionals, educators and parents around the possible negative impact of social media on young people's wellbeing (UK House of Commons Science and Technology Committee, 2019). These concerns are understandable, since adolescents and emerging adults must navigate an intense period of development that is typically characterised by insufficient sleep, high academic demands and increased risk for developing lifelong poor mental health (Carskadon, 2011b; Crowley et al., 2018; F. S. Lee et

al., 2014). However, future research should ensure that available evidence does not neglect other age groups, as social media use is increasingly prevalent across all age groups (Greenwood, Perrin, & Duggan, 2016), and its potentially changing implications for sleep across the lifespan remain a gap in current understanding (Scott & Woods, 2019). Although the social processes that lead some individuals to prioritise social media over sleep are especially heightened during adolescence – with particular value placed on peer approval and belonging (Blakemore, 2018a) – these still remain highly relevant throughout life, and could be expressed differently in the social media and sleep habits of different age groups (e.g. working adults, retired older adults). Furthermore, tracking the habits and experiences of this current cohort of adolescents as they move into young adulthood and beyond will remain an important issue to follow.

7.4.5 Open science practices

As future research explores these areas, it can benefit from embracing Open Science practices, such as pre-registration and open access, to maximise transparency and accessibility throughout the research cycle (Munafò et al., 2017; Przybylski, 2018). This thesis has started to engage with an Open Science approach, by conducting secondary analysis on openly available cohort data and posting preprints to promote wider peer review and facilitate more immediate impact for its studies' findings. Positing preprints is an accessible first step into Open Science practices for researchers, which involves depositing a freely available manuscript in a dedicated online server (e.g. PsyArXiv; https://psyarxiv.com) before peer-review and publication in an academic journal. This offers a simple way to accelerate communication of new findings, with benefits for authors and the field as a whole (Sarabipour et al., 2019), which can be especially valuable when studying rapidly evolving phenomena like social media use. Moving forward, using preprints can help tackle the challenge of maintaining pace with rapid developments technological and social trends, by minimising the delay between data collection and sharing findings in a field where even the very latest published research findings can quickly become outdated (The Lancet, 2019).

7.5 Conclusions

This thesis has targeted gaps in existing research literature on adolescent social media use and sleep, helping to enrich the evidence and tools available for researchers, practitioners, educators and policymakers in this area. These studies have triangulated novel insight from different methodologies, combining the breadth of a national profile of UK adolescent social media use and sleep patterns with the richness of an in-depth adolescent perspective on the challenges of balancing online interactions with sufficient sleep. This thesis has produced a rigorously developed and validated new self-report measure that allows researchers and practitioners to move beyond time spent on social media to instead capture core underlying concerns about staying connected at night that lead some – but not all – adolescents to prioritise social media over sleep. Furthermore, we have taken evidence-based steps towards translating this PhD's findings into educational practice by engaging with a range of relevant stakeholders and piloting initial curriculum materials that address this important current issue in adolescent sleep. Together, the current findings indicate that sleep research and practice must reframe adolescent social media use as an inherently social and interactive experience, rather than simply another hour of generic "screentime". This can enhance existing models of adolescent sleep, support more efficient future research, inform more effective intervention and education strategies, and help shape a more constructive narrative around adolescent social media use in public and policy spheres moving forward.

Appendix A – Supplementary materials for Millennium Cohort Study analyses

Appendix A presents the supplementary materials that accompany the accepted manuscript from Chapter 3.

Full breakdown of sleep patterns

Supplementary Table 1. Typical sleep onset (school days) for males & females

Typical sleep onset on school days	Male		Female		Total	
	%	n	%	n	%	n
Before 9 pm	5.8	288	4.7	248	5.2	536
9 - 9:59 pm	28.5	1619	30.0	1681	29.2	3300
10 - 10:59 pm	40.2	2352	38.8	2284	39.5	4636
11 pm - midnight	18.7	1076	20.3	1220	19.5	2296
After midnight	6.9	366	6.1	335	6.5	701

Notes: percentages account for survey design and weights.

Supplementary Table 2. Typical sleep onset (free days) for males & females

Typical sleep onset on free days	Male		Female		Total	
	%	n	%	n	%	n
Before 9 pm	0.9	53	0.9	45	0.9	98
9 - 9:59 pm	6.0	328	5.4	299	5.7	627
10 - 10:59 pm	22.8	1311	24.4	1407	23.6	2718
11 pm - midnight	35.1	2044	37.2	2208	36.1	4252
After midnight	35.2	1969	32.1	1808	33.7	3777

Notes: percentages account for survey design and weights. Gender difference in sleep onset (free days) $p < .05$.

Supplementary Table 3. Typical wake time (school days) for males & females

Typical wake time on school days	Male		Female		Total	
	%	n	%	n	%	n
Before 6 am	4.4	220	4.5	230	4.5	450
6 - 6:59 am	37.0	1995	47.9	2609	42.2	4604
7 - 7:59 am	53.3	3205	44.9	2771	49.3	5976
8 - 8:59 am	4.0	247	2.1	130	3.1	377
After 9 am	1.3	42	0.6	32	1.0	74

Notes: percentages account for survey design and weights. Gender difference in wake time (school days) $p < .001$.

Supplementary Table 4. Typical wake time (free days) for males & females

Typical wake time on free days	Male		Female		Total	
	%	n	%	n	%	n
Before 8 am	9.9	545	6.4	342	8.2	887
8 - 8:59 am	17.1	940	15.6	846	16.3	1786
9 - 9:59 am	22.9	1348	26.5	1537	24.6	2885
10 - 10:59 am	27.6	1628	30.2	1763	28.8	3391
11 - 11:59 am	14.8	836	15.3	934	15.0	1770
After midday	7.8	401	6.2	348	7.0	749

Notes: percentages account for survey design and weights. Gender difference in wake time (free days) $p < .001$.

Supplementary Table 5. Typical sleep onset latency for males & females

Typical sleep onset latency	Male		Female		Total	
	%	n	%	n	%	n
0 - 15 minutes	37.1	2104	29.3	1709	33.3	3813
16 - 30 minutes	31.4	1838	33.7	1963	32.6	3801
31 - 45 minutes	14.8	819	17.3	973	16.0	1792
46 - 60 minutes	6.4	383	8.7	495	7.5	878
More than 60 minutes	10.3	516	11.0	610	10.6	1126

Notes: percentages account for survey design and weights. Gender difference in sleep onset latency $p < .001$.

Supplementary Table 6. Frequency of nighttime awakenings for males & females

Frequency of nighttime awakenings	Male		Female		Total	
	%	n	%	n	%	n
None of the time	35.8	2050	24.1	1435	30.1	3485
A little of the time	32.8	1951	32.7	1966	32.8	3917
Some of the time	14.5	831	17.6	991	16.0	1822
A good bit of the time	7.0	380	10.7	583	8.8	963
Most of the time	6.7	337	10.7	554	8.6	891
All of the time	3.1	143	4.3	226	3.7	369

Notes: percentages account for survey design and weights. Gender difference in nighttime awakenings $p < .001$.

Social media use by demographics

Table 1 in the main text (Table 3 in this thesis) provides a breakdown of social media use by gender. Supplementary tables 7 and 8 provide a breakdown of social media use by additional demographics: household income and ethnic minority status.

Supplementary Table 7. Social media use by household equivalised income

		Social media use				
		Low <1 h	Average 1 to <3 h	High 3 to <5 h	Very high 5+ h	Total n
	Quintile 1 (lowest)	33.9	28.7	11.3	26.1	2038
Household equivalized income	Quintile 2	30.6	29.2	16.3	23.9	2008
	Quintile 3	31.6	30.3	15.2	22.9	2414
	Quintile 4	32.4	35.8	14.0	17.9	2727
	Quintile 5 (highest)	40.0	33.8	12.7	13.6	2685

Notes: Numbers represent row percentages (e.g. 33.9% of cohort members in lowest income quintile were low social media users). Percentages account for survey design and weights. Income difference in social media use $p < .001$.

Supplementary Table 8. Social media use by ethnicity

		Social media use				
		Low <1 h	Average 1 to <3 h	High 3 to <5 h	Very high 5+ h	Total n
Ethnicity	White	32.9	31.7	14.4	21.1	9086
	Non-white	37.3	31.4	11.9	19.4	2326

Notes: Numbers represent row percentages (e.g. 32.9% of White cohort members were low social media users). Percentages account for survey design and weights. Ethnicity difference in social media use $p < .05$.

Survey questions

About what time do you usually **go to sleep** on a **school night**?
1 Before 9 pm
2 9 - 9:59 pm
3 10 – 10:59 pm
4 11 - midnight
5 After midnight

About what time do you usually **wake up** in the morning on a **school day**?
1 Before 6 am
2 6 - 6:59 am
3 7 – 7:59 am
4 8 - 8:59 am
5 After 9 am

About what time do you usually **go to sleep** on the nights when you **do not have school** the
next day?
1 Before 9 pm
2 9 - 9:59 pm
3 10 - 10:59 pm
4 11 - midnight
5 After midnight

About what time do you **wake up** in the morning on the days when you **do not have school**?
1 Before 8 am
2 8 - 8:59 am
3 9 – 9:59 am
4 10 - 10:59 am
5 11 - 11:59 am
6 After Midday

During the last four weeks, how long did it usually take for you to fall asleep?
1 0-15 minutes
2 16-30 minutes
3 31-45 minutes
4 46-60 minutes
5 More than 60 minutes

During the last four weeks, how often did you awaken during your sleep time and have
trouble falling back to sleep again?
1 All of the time
2 Most of the time
3 A good bit of the time
4 Some of the time
5 A little of the time
6 None of the time

On a normal week day during term time, how many hours do you spend on social networking
or messaging sites or Apps on the internet such as Facebook, Twitter and WhatsApp?
1 None
2 Less than half an hour
3 Half an hour to less than 1 hour
4 1 hour to less than 2 hours

5 2 hours to less than 3 hours
6 3 hours to less than 5 hours
7 5 hours to less than 7 hours
8 7 hours or more

Supplementary Table 9: Illustrative items for covariate questionnaire measures

Covariate	Measure	Items	Response options
Psychosocial adjustment	Parent-report Strengths and Difficulties Questionnaire (Goodman, 2001)	25 items, e.g. "Helpful if someone is hurt, upset or feeling ill" "Thinks things out before acting"	Not true (0) Somewhat true (1) Certainly true (2)
Depressive symptoms	Self-report Short Mood and Feelings Questionnaire (Angold, Costello, Messer, & Pickles, 1995)	13 items, e.g. "I felt miserable or unhappy" "I cried a lot"	Not true (0) Sometimes (1) True (2)
Self-esteem	Self-report shortened version of Rosenberg Self-Esteem Scale (Rosenberg, 1965)	5 items, e.g. "On the whole, I am satisfied with myself" "I feel good about myself"	Strongly agree (4) Agree (3) Disagree (2) Strongly disagree (1)

Appendix B – Final 10-item version of the index of Nighttime Offline Distress (iNOD)

Thinking about how you use social media at night, please rate each of the following statements from 'not at all true of me' to 'extremely true of me'.

Not at all true of me	Slightly true of me	Moderately true of me	Very true of me	Extremely true of me
0	1	2	3	4

1. I feel like I am missing out on something if I am not on social media around bedtime
2. I would feel left out from my friends if I could not use social media at night
3. I feel like my friends expect me to be on social media around my bedtime
4. I feel like my friends expect me to be on social media throughout the night
5. I need to be up to date with things on social media before I can relax at bedtime
6. If I am not on social media around bedtime, I wonder if my friends are
7. I feel like a bad friend if I do not answer a message quickly
8. I worry that I will offend someone if I leave a conversation
9. If I end a conversation, I feel like a bad friend
10. I feel rude if I end a conversation

Scoring instructions:
Sum scores for items 1-6 for *Staying Connected* subscale total (0-24).
Sum scores for items 7-10 for *Following Etiquette* subscale total (0-16).

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