



Online Social Networking as a Social Zeitgeber

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Abstract

Purpose of Review Social relationships exert a robust influence on psychological wellbeing as well as to structure the rhythmicity – particularly patterns of sleep and wake – of adolescents. Online social messaging (OSM; e.g., texting, Instagram, Facebook, Snapchat, etc.) represents a key impact on adolescent behaviors. We review established and emerging literature to present a new framework for understanding social messaging as a critical Social Zeitgeber and discuss the uniquely powerful role that it presents in suicidality.

Recent Findings Unique qualities of OSM as a social zeitgeber – including social access/demands at all times – present a powerful influence on sleep and adolescent suicidality.

Summary Research, informed by our understanding of OSM as a social zeitgeber, is needed to guide intervention development.

Keywords Sleep · Adolescent · Online Social Messaging · Digital Media · Suicidality

Introduction

About 1 in 20 community youth report lifetime suicidal ideation [1]. Suicide rates have increased alarmingly – a 30% increase between 2000 and 2017– with further increases in youth suicide in recent years [2, 3]. In 2017, 7.4% of a national sample of adolescents reported a suicide attempt, with 13% reporting a suicide plan and 17% having seriously considered suicide [4, 5]. Although the child-to-adolescent

developmental shift marks a sharp increase in suicidal thoughts and behaviors (STB) as well as death by suicide [6–8], studies examining STB are less likely to be conducted with adolescent populations [9, 10]. With the alarming epidemic of adolescent STB, a major knowledge gap is the role of near-ubiquitous adolescent use of online social messaging (OSM; e.g., texting, Instagram, Facebook, Snapchat, etc.) in the on-going crisis of deteriorating adolescent mental health. Today’s adolescents, sometimes called “digital natives,” have grown up with digital media as an integral part of their lives [11–16]. Social rewards such as interactions on social media posts may be powerful drivers of affect, cognitions, and behaviors for teens [13, 17–19]. Higher levels of adolescent smartphone use [20] and negative OSM, such as cyberbullying, has been associated with STB [21–24]. In this manuscript, we introduce OSM as a powerful regulator of adolescents’ psychosocial and bioregulatory rhythms: a new and powerful social zeitgeber (i.e., time-giver). Shown in Fig. 1, as a social zeitgeber, OSM interactions can then be understood to shape overall rhythmicity, and specific features of these interactions may impact teens’ ability to slow down for sleep. For example, much like exercise, certain types of social interactions may spike alertness and arousal. Rapid pacing, emotional valence/tone, and juggling multiple message streams, for example,

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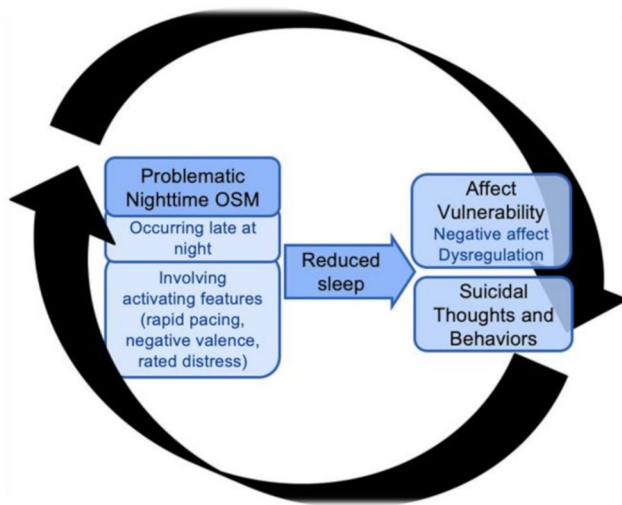


Fig. 1 Conceptual model

may reduce teens' parasympathetic activity and augment sympathetic activity [25], making it especially difficult to slow down. Thus, shown in Fig. 1 and consistent with the “Perfect Storm Model” [26, 27] of adolescent sleep, delays in sleep onset secondary to late night OSM use contributes to impairments in emotional capacity for managing daily stress, resulting in subsequent decreases in positive affect, increases in dysregulation, and increases in STB.

Sleep Disruption, Late Night OSM Use, and Suicidality Risk

Sleep disruption, a transdiagnostic feature in psychiatry [28], is closely linked to STB [29]. The link between sleep and suicide has been partially attributed to emotion dysregulation, with sleep disruptions conferring impaired management of daily stress, decreasing positive affect, and exacerbating affect dysregulation [30]. Sleep problems and subsequent emotion dysregulation have also been identified as key mechanisms of suicide risk conferred by long-term contextual factors, such as childhood abuse [31]. Circadian rhythm disruptions are implicated across adolescent mood and anxiety disorders [28, 32]. The deficits which emerge from reduced sleep duration (e.g., attention biases towards emotional information, stronger responses to provocation [33]) have been implicated in increased negative peer and relationship perceptions [33–35] and harmful relational behaviors [33, 36]. Associations of sleep disruption and lower positive affect have been observed across multiple study designs. For example, a sample of healthy adolescents completed an affective functioning battery following both sleep deprivation (6.5 h sleep 1st night, < 2 h sleep 2nd night) and adequate sleep (7–8 h. sleep 2 nights) [37]. Across early

through late adolescence, overall sleep deprivation was associated with less positive affect, increased anxiety during a catastrophizing task, and increased perceived likelihood of catastrophes. Self-report, longitudinal research points to the persistence of sleep disturbances and chronically low positive affect as moderators of the relationship between major life events and subsequent depressive symptoms [38]. This line of work was further reinforced by ecological research leveraging Fitbit with two weeks of daily surveys found that stress-related negative affect spillover effects (e.g., ability to “bounce back” from stressors) were exacerbated by decreased sleep [39]. Even when school -timing changed due to the COVID pandemic, research demonstrated sustained associations between sleep adequacy and a range of anxiety and depressive symptoms [40], providing naturalistic reinforcement regarding the intertwined nature of sleep and mental health [41].

In addition to overall sleep and circadian rhythm disruptions, *later timing of sleep onset* (in addition to irregularity) in particular is associated with greater suicidality in youth [42]. The incident risk ratio of suicide deaths is more than four times greater at nighttime compared to the 24-hour average risk [43], joining data from adolescents which indicate that death by suicide occurs most often in the late evening or overnight early morning hours [44–46]. Emerging research suggests that nocturnal wakefulness may increase the risk for psychopathology, including STB, via a combination of multiple factors, including negative affect that is at its highest at nighttime, blunted positive affect in the early morning hours, overfocus on negative thoughts and feelings, prefrontal disinhibition, and altered reward processing [47, 48]. Late-night OSM may contribute to increased risk for STBs by prolonging wakefulness rather than pursuing sleep. That is to say, late-night OSM may result in downstream alterations in maladaptive thoughts/behaviors, including decreases in positive affect, exacerbated affect dysregulation, and increases in STB [27]. We propose that late-night OSM and its modern dominance over teens' lives remains an underappreciated force which may tip the scales of sleep and its emotional and mental health consequences [40, 49].

OSM use surges during adolescence, and more time spent on OSM is related to greater STB in youth [50, 51]. In 2022, most teens (95%) reported having access to digital devices (e.g., smartphones), and 97% reported using the Internet daily [52]. The “pressure to stay connected” is a governing force for adolescents engaging in OSM use [53] conflicting with biological pressures for sleep, delaying sleep onset or even interrupting sleep due to alertness to possible messages received during sleep. Indeed, adolescents participating in a focus group described how OSM use has directly impacted their sleep, with teens reporting substantial social pressures from peers and close friends to be available for (and rapid

with) late-night OSM use even though they knew this was resulting in delayed bedtimes, insufficient sleep, and daytime fatigue [54]. These findings are also consistent with findings from a nationally representative sample: checking OSM in the 30 min before bed was associated with increased sleep disturbance, even after adjusting for overall use [55]. Importantly, there are multiple mechanisms through which delaying sleep (and in effect curtailing it as morning rise times remain fixed) as well as increasing sleep irregularity can result in an increased risk of STB.

The effects of OSM use on youth likely depend on who is using it and when and how they do it. For instance, although OSM use has been linked to a decline in life satisfaction and well-being of young adults [56], college students with lower self-esteem at the start of college may benefit from the ways that OSM may help them make the most of “bridging” (weak ties with informational benefits) social capital such that they report improvements in well-being outcomes over time [57, 58]. The impact of OSM on mental health may also be content-specific, with more negative or distressing emotional experiences on social media having a more severe impact on adolescent mental health symptoms [59]. Similarly, youth for whom aggressive OSM content gave rise to greater decreases in parasympathetic nervous system activity, showed greater subsequent internalizing symptoms and aggression. Thus, emerging evidence points to the need for more research describing how specific individual factors and circumstances, as well as the content of OSM, may alter OSM’s impact on adolescents’ mental health symptoms, including STB.

Social Zeitgebers and Adolescence: Making a Perfect Storm Worse

Endogenous circadian rhythms provide critical governing influences on our bioregulatory state and psychosocial well-being. These rhythms of diurnal wakefulness and nocturnal sleep are governed by external synchronizing forces such as light, deemed *zeitgebers* (literally, “time givers”). For example, light entrains the brain’s main pacemaker, the suprachiasmatic nucleus, and shifts circadian rhythms when we travel east or west [60]. Circadian rhythmicity and sleep-wake patterns, provide a critical lens for understanding adolescent emotional (and corresponding cognitive and behavioral) self-regulation, particularly given the profound changes to the circadian and sleep bioregulatory processes that unfold during adolescence. The “Perfect Storm Model” of sleep during adolescence [26, 27] highlights two such changes. First, adolescents experience a shift towards “eveningness,” a desire to go to sleep later in the day, and concomitantly wake later in the morning, that is driven by a biological delay in one’s intrinsic circadian timing system

(indexed by markers such as core-body-temperature and exogenous melatonin). Second, a progressively slower accrual of sleep pressure during the day alters the nature of sleep homeostasis such that teens can maintain more hours of waking vigilance and accommodate a desire to remain awake later in the day. In line with the model’s *perfect storm* metaphor, these two developmentally altered bioregulatory processes meet an encroaching front of societal pressures which either exaggerate the delay of evening sleep (e.g., heavy homework and social obligations) or constrain the ability to sleep in the next day (e.g., early school start times). Early school start times are particularly damaging to a teen’s social rhythm resulting in the adolescent waking to go to school at a time set for adult schedules, not for their developing brain. The end result is a *social jetlag*: an adolescent for whom biological pressures for sleep are out of alignment with the societal structures and peer pressures around them. Much like jetlag from travel, this resulting maelstrom gives way to insufficient and poorly timed sleep, sleep loss during a school-week can grow to upwards of 2-hours a night. On free nights and weekends, adolescents attempt to make-up for sleep loss, however inordinate sleeping in can further disrupt circadian rhythms, deteriorate the next-week’s sleep, and ensuring the perfect storm of adolescent sleep regulation remains a deleterious and persistent cycle.

It is against this background of developmental change in sleep and conflicting social pressures that adolescent OSM use at night may be especially problematic and deleterious to mental health. Teens are impacted by their perceptions of parent support and peer behavior, with sleep duration on both school and free days can be impacted by perceptions of peer behaviors [61]. In this way, we propose that OSM use becomes a “social zeitgeber,” which much like light, sends their biopsychosocial rhythms a message to be awake, rather than to sleep. An increasing body of research has shown that digital media use, particularly use of mobile phones, computer, internet, and social media is associated with shorter sleep duration and poorer sleep quality [62]. By using OSM late at night, adolescents may further exacerbate developmentally typical delays to sleep (i.e., if you are sending OSM, you are not sleeping) while also contributing to irregularity (i.e., OSM exchanges may alter bedtimes). Vigilance for OSM engagement may persist even after teens “go to sleep,” with teens’ sleep characterized by a level of monitoring / awareness of phone signals (i.e., vibration, light) that they may have received messages. Indeed research has shown that, relative to those who turned off their cell phones at bedtime, adolescents who left their phone activated overnight had more trouble falling and/or staying asleep [63]. Moreover, the activating features of any social interaction and particularly OSM (e.g., rapid pacing, negative valence, distress) that occur at bedtime may impact both sleep onset

and sleep quality. Below we will unpack how OSM, sleep disruption, and STB interact.

Theoretical Framing and Future Directions

Adolescence is a “stress-sensitive” period during which sensitivity to emotional cues and incentives is combined with underdeveloped systems for inhibition and regulation, resulting in greater physiological reactivity to stress [64–70]. The importance of momentary experienced affect is further supported by our ecological momentary assessment research, which linked increasing negative affect to the prediction of self-harm behavior [71]. Increased stress reactivity observed among adolescents is particularly concerning given the distress amplification model, which proposes that STB arises in part due to the intensification of distress through anxiety sensitive cognitive concerns [72, 73]. Cognitive behavioral and dialectical behavioral theories propose that affective distress narrows thinking or impedes regulation to increase the risk for STB [74–76]. Adolescents may be especially vulnerable to affect dysregulation and corresponding increased risk for STB under conditions of disrupted sleep. Positive and negative affect follow a circadian pattern, with positive affect being at its lowest and negative affect at its peak at nighttime, adding a layer of vulnerability to bedtime OSM [48, 77, 78]. Simultaneously, the coordination between the areas of the prefrontal cortex that promotes emotion regulation, cognitive flexibility, and behavioral inhibition is also reduced at nighttime [47], facilitating excessive rumination and potential difficulties disengaging from OSM. These processes likely compound the adverse effect of nighttime OSM on sleep and STB.

Theories of STB prominently feature interpersonal processes such as social buffering and thwarted belongingness [79–84]. OSM has been associated with some positive outcomes in subsets of participants and has also been associated with decreased loneliness [57, 58, 85]. When prompted by an ecological momentary assessment (EMA) device to indicate what adolescents were doing when they first thought of suicide, the largest proportion of youth reported they were “socializing,” [86] suggesting that social interactions may not always be protective. For example, there is concern that social media may increase access and exposure to others who have engaged in STB, amplifying the risk for social transmission far beyond local communities [87–89]. Also, peer-related distress (bullying, conflict with friends or romantic partners) is commonly described to precipitate STB [84, 90, 91] and while OSM may provide convenient opportunities for some teens (e.g., teens with disabilities) to connect with their community [92], it simultaneously introduces risk factors for greater STB, including cyberbullying

[93]. Social relationships are particularly powerful influences during adolescence, with bedtime OSM extending social pressures to later hours than ever before.

Interventions targeting adolescent social rhythms toward have shown promise for both sleep and mental health outcomes. For example, in bipolar disorder, sleep and mental health symptoms may be responsive to chronotherapies such as Interpersonal and Social Rhythm Therapy, an intervention that directly assesses the timing of social interactions (i.e., meals, work/school, exercise, homework) that are adaptive for both sleep and social needs [94–100]. Preliminary results from a small study ($N=13$) of youth with bipolar disorder of Social Rhythm Therapy reduced mood symptoms and suicide propensity independent of mood symptoms [101]. However, adaptations/ applications of this intervention do not explicitly incorporate OSM interactions as a social zeitgeber (meaning, a social interaction that impacts timing of wake/sleep activities). One study examined the impact of limiting social media use, with findings supporting improvements in well-being, which appeared to be related to improvements in sleep quality [102]. How much nighttime vs. overall OSM contributes to social jetlag and what specific aspects of OSM have the greatest impact on sleep irregularity in teens is also surprisingly understudied. Translational research aimed at leveraging wearable and EMA technologies, including just-in-time adaptive interventions, may be integrated in future treatment [103]. App and intervention developers may consider integrating OSM as a social zeitgeber into sleep-focused applications (e.g., Sleep-Coacher [104], SleepBandit [105]) that may serve either as stand alone interventions or, in the case of higher risk populations such as teens with mental health concerns, may be used as adjunctive interventions to enhance traditional care.

Conclusion

In sum, emerging lines of evidence illustrate a key link between sleep disruptions in general and possibly nocturnal awakeness in particular, and mental health processes underlying STB. We propose that OSM use serves as a key *social zeitgeber*— particularly for adolescents— and that the combined biological and social (OSM) developmental pressures during adolescence may disrupt sleep and increase a range of negative mental health outcomes. Given that OSM use is here to stay, more work is needed to understand the *specific conditions* under which OSM confers risk [106]. Recognition and characterization of OSM as a social zeitgeber are needed for both research theory and intervention. Furthermore, research exploring OSM needs to move beyond questions about exposure to light from screens (a biological “zeitgeber”) or simple engagement in activities incompatible

with sleep, to provide a more nuanced characterization of the processes that influence sleep, affect regulation, and suicidality. This is especially important for adolescent models of prevention and intervention, as adolescence is a stress-sensitive period during which patterns of behavior become established and the neurobiological impact is ingrained, the impact of disruptions is likely to be substantial and persistent. Findings from this proposed model of OSM as a critical social zeitgeber have the potential to inform treatment in four ways. First, if the *timing* of OSM use serves as a social zeitgeber, interventions such as Social Rhythm Therapy could be adapted for OSM. Second, if *late night* OSM use is uniquely problematic, app platforms could be informed that adjusting features (such as the “timer” that appears in Snapchat when a user is “at risk” for losing a “streak” of daily interactions) would reduce late night impact on sleep. Third, if daytime distress is observed to predict late-night OSM that may further entrench symptoms, interventions could be developed to assess daytime distress and then alert adolescents to their vulnerability for problematic late night OSM-related interactions. Adolescents could be guided through harm reduction strategies ranging from completely turning off the phone early in the evening to restricting phone interactions to “safer” applications or to interactions with only select others. Finally, much like biomarkers, OSM could be considered an easy-to-assess marker for risk and treatment matching.

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Author Contributions NRN conceptualized the framework, prepared figures, and wrote the initial draft. All authors contributed to manuscript content and all authors reviewed the manuscript. AK updated content and contributed to manuscript revisions. JS shared expertise, content, and heavily revised the manuscript.

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Data Availability No datasets were generated or analysed during the current study.

Declarations

Competing Interests The authors declare no competing interests.

Conflict of Interest Dr. Arney is a compensated member of Illumivu’s Scientific Advisory Board. Dr. Nugent is an unpaid member of Illumivu’s Scientific Advisory Board with stock options.

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