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Exploring the linkage of noise and mental health among adolescents – An Equal- Life study

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ABSTRACT

There is growing evidence that social and environmental factors contribute to adolescent's sleep. Sleep disturbance in adolescence affects cognitive functions, performance and is related to mental health problems such as anxiety and depression. It is however, less well known how mental health is linked to social and environmental factors and which the most important exposures, moderating and mediating factors are for this young population.

In the framework of a European project (Equal-Life) this study was performed among adolescents to evaluate the role of residential noise and mental health in a wider exposome perspective.

From a larger cohort (STARS), a study population of 109 adolescents (62.4% female), were recruited randomly within the age group 18-19 years, of which the analytical sample consisted of 106 participants. Participant's sleep and nighttime noise exposure were recorded in their home bedroom, with outdoor sound levels measured simultaneously. Physiological sleep was recorded with a headband (DREEM 3) using dry electrodes for four consecutive nights, Tuesday night to Saturday morning. Mental health, health, sleep and potential confounders and effect modifiers were measured using a questionnaire, completed by all participants before the study period (February-May 2022).

Outdoor noise measurements were obtained for 465 days and nights and ranged from 35.8 to 73.7 dBA Lnight (mean±SD 47.6±5.5 dB). The results of the associations of environmental exposures inclusive noise, mental health outcomes and sleep will be presented at the conference.

Keywords: Mental health, Sleep, Noise, Adolescents, Epidemiological, Green areas.

INTRODUCTION

In today's society adolescents may be exposed to a multitude of external stimuli, such as noise, artificial light and air pollution. In addition, other demands inherent to adolescent life, like peer relationships, individual development and societal and parental requests, may also affect perceived stress, and possibly mental health and well-being. The Swedish Public Health Authority [1] reported that the proportion of young people with recurring psychosomatic symptoms (including sleep difficulties, headache, stomachache, and irritability) had doubled since the 1980's. According to the Swedish National Board of Health and Welfare [2], increasing numbers of adolescents are diagnosed with depression and anxiety. Numbers are even larger among girls and adolescents from socioeconomically vulnerable areas.

While decreasing the number of total stressors could benefit resilience to mental health, the scientific evidence is insufficient to draw firm conclusions. Adequate sleep has been found to be associated with reduced risk of mental health, also in prospective studies [3], but less is known on how sleep mediates the linkage of environmental and social exposures and mental health [4].

Obtaining enough sleep and good quality sleep is essential to young people's health and wellbeing. Sleep is related to children and adolescents' biological development and undergoes significant changes during puberty [5]. In addition, change of lifestyle habits during this age period, such as increased energy drink intake and increased screen time and time spent on social media, may affect sleep quality and quantity.

Within an exposome perspective we aim to investigate how multiple factors relating to the living environment such as noise, artificial light and air pollution may negatively affect mental health while for example access to greenery may increase resilience and mental health. Sleep may be an important mediator or moderator in these relationships.

In this paper we present the method from a field study among adolescents, with the focus on how noise and some other social and environmental exposures may affect sleep quality and quantity and mental health.

MATERIALS AND METHODS

Study Design

We carried out an in-depth study investigating cross sectionally the association of external exposures on sleep and mental health among adolescents in spring 2022. Participants were recruited from an ongoing longitudinal larger cohort among children and adolescents: Study of Adolescence Resilience and Stress (STARS) [6]. The baseline of the cohort (n= 2283) was collected during 2015-2019, when 7th grade, 13 years old school children were recruited. In addition to baseline physiological measurements of weight, height, blood pressure and hair cortisol, the school children also completed a baseline questionnaire with items on self-perceived stress; coping strategy; psychological wellbeing; psychosomatic problems; familial factors (familial material affluence, physical custody and adolescent's relationships with parents); peer relationships (including bullying); school learning environment and schoolwork-related stress; school attendance; lifestyle habits such as diet, sleep habits, physical activity, tobacco and alcohol use; and subjective social status of their families and subjective social status of adolescents themselves in school. Follow-up data were collected, at ages 15, and 18 years. Register data were obtained for the student's final grade year 9 and upper secondary school; parental education, employment status, income, immigration, citizenship, disposable income; and area- and housing-specific socioeconomic conditions. Furthermore, aggregated register data were collected for school-level factors (e.g. distribution of credit points per school) and residential-level factors (e.g. distribution of educational level proportion with low / medium / high education).

For the in-depth study we recruited participants within the second follow-up study, among the 18year old students. Sampling was conducted to ensure that different sex and socio-economic positions were represented in the final sample. At the end we had to approach all eligible students to fulfill the intended sample size.

The study was approved by the Swedish Ethical Review Authority (Dnr 2021-05323-02). All subjects provided informed consent, were compensated with 800 SEK (around €70) for participating and were free to discontinue from the study at any time and without providing a reason.

Study protocol

Study subjects slept at their normal bedtimes for four consecutive nights (Tuesday night through to Saturday morning) with a headband that registered electrophysiological sleep. Nocturnal measurements of noise were made in the bedroom and outside the bedroom window. Questionnaires were completed every evening to record daytime activities and every morning to record self-reported sleep and restoration. All participants were visited by our research team in their homes, when they set up the noise measuring equipment and instructed participants on how to wear the sleep headband. The equipment was collected by the research team on the weekend after the final night.

Noise assessments

Outdoor noise levels were measured during the study period with custom-built sound level meters (equivalent to class 2). Sound level meters were mounted outdoors on or close to the bedroom window, and transmitted measurement data via a 3G modem to a central server. The connection status was monitored by the research team, and if connection was disrupted the study participants were contacted to determine and if possible, fix the problem.

Indoor noise levels were measured in the bedrooms with the microphone positioned next to the participants head while lying in bed, with Class 1 SLMs (Nor140, Norsonic, Tranby,Norway). All sound level meters were synchronized to atomic clock time and calibrated each week prior to deployment.

Perceived noise exposure was derived from reported noise annoyance. The question followed largely the recommendation by ICBEN 2001 [7] ("Thinking of the last 3 months when you are at home, how much does noise from road traffic noise, rail or tram, or neighbors disturb, bother or annoy you"). The answers were given on a five-grade verbal scale from not at all to extremely. Similar structure was used to assess disturbed sleep by noise or external artificial light.

Assessment of green areas

As a proxy for residential greenness we calculated from the Normalized Difference Vegetation Index (NDVI) using the 300meters distance from the residential address of each participant during the greenest period as the indicator.

Self-perceived accessibility to green area was measured as the participants estimation of time (minutes) it took to walt to nearest green area, nature, or park

Assessment of social exposures

Area-level socioeconomic conditions were calculated using a Socio-Economic index for the included Demographic statistical areas (Deso), provided by national statistics. This index is calculated based on the average of the proportion of individuals with low economic standard (i.e., disposable income lower than 60 percent of the median income), low education level (i.e., compulsory education – 9 years education) and unemployment greater than 6 months or under financial welfare support for at least 10 months. This index was then used to classify areas into 4 groups with 1 denoting socioeconomic challenge and 4 very good conditions.

Perceived social position was calculated based on self-report on the Cantril ladder [8], where 1 denotes worst imaginable life, and 10 denotes best imaginable life.

Questionnaire on outcomes

At the time of the recruitment the participants were asked to fill in a comprehensive questionnaire of sleep habits, media use, perceived stress, and mental health and well-being. The questionnaire included some questions previously used in STARS assessing perceived stress, coping, sleep duration, physical activity, psychosomatic symptoms, and cognitive life satisfaction. For the in-depth study we added additional questions on external exposures, sleep and mental health.

Mental health was assessed using the Multidimensional Peer Nomination Inventory (MPNI) [9], the rumination and brooding scales from the Ruminative responses scale (RRS-BR) [10] and the 12-item version of the General Health Questionnaire (GHQ-12), [11]. Mental well-being was measured by the Warwick-Edinburgh mental well-being scale (WEM) [12]. Psycho-somatic problems (PSP) were measured using the psycho-somatic scale [13].
Questions were also posed on screen time and social media use, with questions inspired by Serena Bauducco's research [14].

Physiological and self-reported measures of sleep

Sleep was measured objectively through a headband (www.dreem.com) that participants wore for four nights in a row (Figure 1). The headband measures signals by frontal and occipital dry electrodes of brain activity (electroencephalography EEG). The signals are analysed through validated algorithms and will give information about sleep duration, awakenings, and sleep stages [15]

Participants were provided extenders so that they could change the sizing of the headband to ensure a comfortable fit. We provided lightweight nylon headbands that could be worn on top of the Dreem 3, to further secure it in place if necessary. Sleep data were automatically uploaded to secure servers at the end of each sleep period. Daily checks were performed to ensure subject compliance and high data quality.

Figure 1. Dreem headband worn during four nights by the participants in the field study. The headband measures frontal and occipital brain activity (EEG).

Participants answered every evening a brief questionnaire that assessed how they felt at the time of answering the questionnaire (rested, tensed, happy), their sleepiness during the day based on [16] and if they had taken naps during the day, and if they during the last 8 hours had been engaged in physical exercise, consumed caffeine or drugs. Every morning the participants answered questions on their previous night sleep quality, and quantity, how tired, rested, happy they feel at the time of answering the questionnaire, how much noise from various sources disturbed their sleep, if they slept with window open or not and how cold or warm it had been during the night. Questions were developed based on the research group previous field and experimental studies and largely in accordance with [17]

Study population

Of the total 109 participants, three dropped out due to illness, and the remaining 106 were used for analyses. Table 1 presents the basic characteristics of the study population.

Table 1. Characteristics of the study population

		n, (%)
Sex n, (%)	Male	41 (38.7)
	Female	65 (61.3)
Chronotype n,(%)	Definite morning type	7, (6.6)
	Somewhat morning type	27, (25.5)
	Somewhat evening type	42, (39.6)
	Definite evening type	30 (28.3)
Insomnia n, (%) yes		33, (31)
Deso (1-4) n (%)	1 or 2	27 (25.5)
	3	59 (55.7)
	4	20 (18.9)
Noise annoyance n, (%) "high"		26 (24.5)
Light disturb sleep, n (%) "high)		48 (45.2)
		Median(IQR)
Lnight (average Tue-Fri),		46.9 (44.9-50.2)
NDVI		0.56 (0.52- 0.60)
Distance in min to nature		5 (2-10)
Perceived social position (1-10)		7 (6-8)
Self-reported sleep duration weekdays		7.5 (7.0 - 8.5)
WEM (high value low mental health)		26.5 (24 - 29.75)
PSP (high value more symptoms)		12 (9 -16)
Rumination (RRS-BR) higher value more rumination		10 (8-12)
MNPI	Externalising	1.69 (1.5-1.94)
	Internalizing	1.67 (1.5-2-13)
	Prosocial	2.92 (2.69-3.0)

NDVI= Normalized Difference Vegetation Index; WEM= Warwick-Edinburgh mental well-being scale; PSP= Psycho-somatic problems; MNPI = Multidimensional Peer Nomination Inventory (

Statistical analyses

In the analyses we will investigate the associations between objectively measured noise exposure, perceived noise exposure and mental health and objectively measured noise exposure, perceived noise exposure and sleep quantity and quality. As objective noise levels we will use a mean of outdoor noise level measured during three or four nights. As perceived noise exposure we will use annoyance to the three noise sources (road traffic, rail or tram, and neighbors) categorized into low if the participant reported “not at all” for at least two out of three sources, otherwise high. Similar approach will be used for green areas, where NDVI is used as objective measure and estimated time to nearest green area, nature or park used as perceived accessibility. For artificial light only perceived sleep disturbance is available. For social exposures, we will use area level socioeconomic coding by Deso, as objective and self-perceived social position using the Cantril ladder (1-10). Statistical analyses will include regression-based path analysis to examine the associations between exposures and sleep and mental health, as well as the potential role of sleep as a mediator in these associations.

RESULTS

The results will be presented at the conference.

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