

## **The effects of aircraft noise exposure on subjective sleep quality: the results of the DEBATS study in France**

Ali Mohamed Nassur<sup>1</sup>, Marie Lefèvre<sup>1</sup>, Damien Léger<sup>2</sup>, Bernard Laumon<sup>3</sup>, Anne-Sophie Evrard<sup>1</sup>

<sup>1</sup> Univ Lyon, Université Claude Bernard Lyon1, IFSTTAR, UMRESTTE, UMR T\_9405, F-69675, Bron, France

<sup>2</sup> Université Paris Descartes, Sorbonne Paris Cité, APHP, Hôtel-Dieu de Paris, Centre du Sommeil et de la Vigilance et EA 7330 VIFASOM, Paris, France

<sup>3</sup> IFSTTAR, Transport, Health and Safety Department, F-69675, Bron, France

Corresponding author: ali-mohamed.nassur@ifsttar.fr

### **ABSTRACT**

*Objectives:* Exposure to aircraft noise has been shown to have adverse effects on health and particularly on sleep. This study aimed to investigate the relationship between aircraft noise exposure and subjective sleep quality in the population living near airports in France.

*Methods:* Sleep interview was made through a questionnaire administered to 1,244 residents of three major French airports: Paris-CDG, Lyon-Saint-Exupéry and Toulouse-Blagnac. For each participant, aircraft noise exposure was estimated at home using noise maps. Logistic regression models were used with adjustment for potential confounders.

*Results:* Aircraft noise exposure was associated with the risk of being a short sleeper (sleep duration  $\leq 6$ h), and with the feeling of tiredness while awakening in the morning. An increase of 10 dBA in aircraft noise level at night was respectively associated with an OR of 1.66 (95% CI: 1.16 to 2.35) and an OR of 1.24 (95% CI: 1.00 to 1.63).

*Conclusion:* These findings contribute to the overall evidence suggesting that aircraft noise exposure at nighttime may decrease subjective quality of sleep.

### **INTRODUCTION**

Noise is major cause of sleep disruption and global sleep dissatisfaction, with transportation noise at night at the first place. Aircraft noise is indeed perceived as a major environmental stressor in the vicinity of airports. It constitutes a major issue for public health, particularly in terms of sleep disturbance [1]. According to the World Health Organization (WHO), sleep disorders are the most serious consequence of environmental noise in Western Europe [2].

Both in laboratory and field studies, exposure to aircraft noise has been shown to disrupt sleep. Exposure to night time aircraft noise leads to an increased frequency of awakening,

increased motility, decreased slow wave sleep, changes in sleep structure, use of sleep drugs or sedatives, and a poor quality of sleep [3].

In France, the effects of aircraft noise exposure on sleep quality have insufficiently been evaluated. DEBATS (Discussion on the health effects of aircraft noise) is a French research program whose objective is to prospectively characterise the relationships between aircraft noise exposure and the health status, in particular sleep quality, of the population living in the vicinity of airports.

## **METHODS**

### **Study population**

1,244 individuals older than 18 and living in the vicinity of three French airports (Paris-Charles de Gaulle, Lyon-Saint-Exupéry and Toulouse-Blagnac) were randomly selected to participate in the longitudinal study of DEBATS. The study population was stratified on aircraft noise contours. These contours are based on the day–evening–night equivalent level ( $L_{den}$ ) defined in four categories, <50, 50–54, 55–59 and  $\geq 60$  dB(A). All participants responded to a questionnaire administered by an interviewer at their place of residence. The questionnaire collected in particular socio-demographic information, the subjective sleep quality of the participants, their personal medical history and lifestyle factors such as smoking and alcohol consumption.

### **Noise exposure assessment**

Exposure to aircraft noise was estimated with a 1-dB(A) resolution at the place of residence of the participants with noise maps produced by the French Civil Aviation Authority with the Integrated Noise Model. Four noise indicators were derived and used in the statistical analyses:  $L_{den}$ ,  $L_{Aeq24hr}$ ,  $L_{Aeq6hr-22hr}$ , and  $L_{night}$ .

### **Subjective sleep quality**

Subjective sleep quality was assessed using two variables: sleep duration and the feeling of tiredness while awakening in the morning. For sleep duration, each participant indicated usual time for bed time (lights off) and get-up time. Sleep duration was calculated as the difference between these two times. It was then categorized into two classes: “short sleep” (sleep duration  $\leq 6$  hours) versus “normal and long sleep” (sleep duration  $> 6$  hours). The participants also gave their feeling on awakening after a usual night sleep: well rested, rather rested, rather tired or very tired. This variable was categorized into two classes: well/rather rested versus rather/very tired.

### **Confounding factors**

Several factors which could affect subjective sleep quality were obtained from the questionnaire: age, gender, education (<French high-school certificate/=French high-school certificate/>French high-school certificate), marital status, smoking habits (non-smoker/ex-smoker/occasional smoker/daily smoker), alcohol consumption (no/light/moderate/heavy), physical activity (no/yes), self-reported health (fair or poor/good or excellent), body mass index (body weight divided by height squared: obesity / overweight / underweight or normal weight),

anxiety (extremely or a lot/moderately or slightly or not at all), depression (extremely or a lot/moderately or slightly or not at all), work schedule (always at night/always during the day/shift work/not concerned), physical tiredness (extremely or a lot/moderately or slightly or not at all), nervous tiredness (extremely or a lot/moderately or slightly or not at all), cardiovascular disease (no/yes) and hypertension (no/yes).

### **Statistical analysis**

Logistic regression models were estimated in order to study the relationship between aircraft noise exposure and the subjective sleep quality. They were adjusted for the confounding factors previously defined.

## **RESULTS**

Almost 56% of the participants in the longitudinal study of the DEBATS research program were women and half of the participants lived in the vicinity of the Paris Charles de Gaulle airport. Table 1 shows the description of the study population. About 63% of the participants were married, 50% were never smokers and 51% were small alcohol drinkers. About 21% were extremely or much anxious and 13% were depressed.

Nine percent of the participants were considered as short sleepers and 54% of these short sleepers were male. Whatever noise indicator, the prevalence of short sleepers increased with aircraft noise exposure (Figure 1).

Approximately 30% of the study population reported to be rather/very tired in the morning after a night sleep, 68% of them were women. The prevalence of individuals feeling tired while awakening in the morning also increased with the level of aircraft noise (Figure 1).

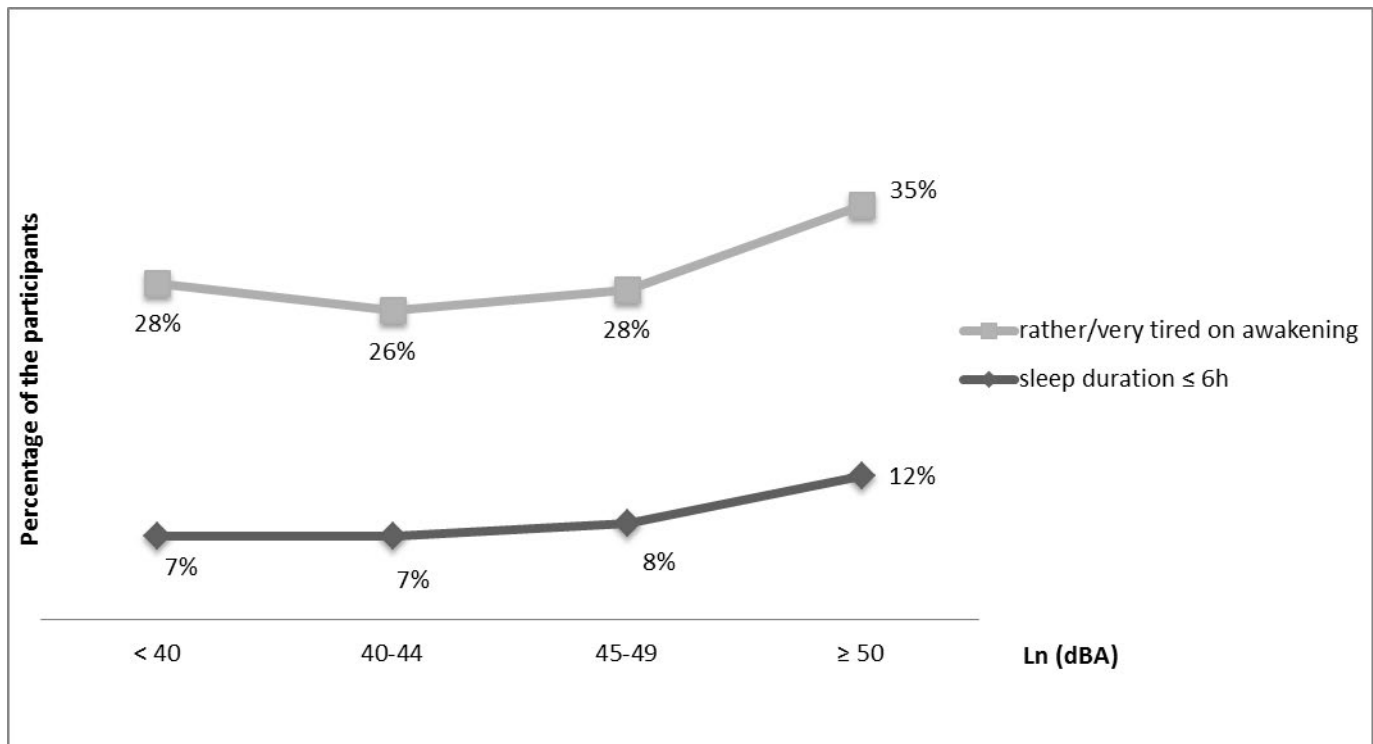
The association between aircraft noise exposure and sleep duration was significant before and after adjustment for confounding factors. After adjustment for confounding factors, an increase of 10 dBA in aircraft noise level at night was associated with an odds ratio (OR) of 1.66 (CI 95%: 1.16-2.35) for sleep duration.

In addition to aircraft noise exposure, gender, smoking, anxiety and work schedule were significantly associated with sleep duration. Men, daily smokers, anxious individuals and night or shift workers were more likely to be short sleepers than others.

A significant association was also found between exposure to aircraft noise and the feeling of tiredness while awakening. An increase of 10 dBA in aircraft noise level during the night was associated with an OR of 1.24 (CI 95%: 1.00-1.63). Other factors were also significantly associated with the feeling of tiredness on awakening: gender, age, education, self-reported health, physical tiredness, nervous tiredness and anxiety. Women, young people, having a certificate <French high-school certificate, people with a fair or poor health, extreme physical fatigue and nervous fatigue were more likely to be tired while awakening in the morning.

**Table 1:** Description of the study population

	N	(%)		N	(%)
<b>Sleep duration</b>			<b>Self-reported health</b>		
≤ 6h	112	(9)	Good or excellent	1052	(85)
> 6h	1132	(91)	Fair or poor	191	(15)
<b>Feeling of tiredness on awakening</b>			<b>Hypertension</b>		
Well/rather rested	876	(70)	No	804	(65)
Rather/very tired	368	(30)	Yes	426	(34)
<b>Airport</b>			<b>Cardiovascular disease</b>		
Lyon Saint Exupéry	213	(17)	Yes	156	(12)
Paris Charles de Gaulle	620	(50)	No	1088	(87)
Toulouse Blagnac	411	(33)			
<b>Gender</b>			<b>Anxiety</b>		
Women	695	(56)	Extremely or a lot	266	(21)
Men	549	(44)	Moderately or slightly or not at all	978	(79)
<b>Age</b>			<b>Depression</b>		
18-34	226	(18)	Extremely or a lot	164	(13)
35-44	236	(19)	moderately or slightly or not at all	1080	(87)
45-54	266	(21)			
55-64	260	(21)			
65-74	185	(15)			
≥75	71	(6)			
<b>Education</b>			<b>BMI</b>		
< French high-school certificate	452	(36)	Underweight or normal weight	562	(45)
= French high-school certificate	397	(32)	Overweight	424	(34)
> French high-school certificate	395	(32)	Obesity	249	(20)
<b>Marital status</b>			<b>Work schedule</b>		
Single	253	(20)	Always during the day	662	(53)
Married, living marital	782	(63)	Always at night	22	(2)
Widow, widower	76	(6)	Shift work	57	(5)
Divorced, separated	133	(13)	Not concerned	499	(40)
<b>Smoking</b>			<b>Nervous tiredness</b>		
Non-smoker	625	(50)	Extremely or a lot	203	(16)
Ex-smoker	330	(27)	Moderately or slightly or not at all	1041	(84)
Occasional smoker	19	(2)			
Daily smoker	269	(22)			
<b>Alcohol consumption</b>			<b>Physical tiredness</b>		
No	348	(28)	Extremely or a lot	235	(19)
Light	637	(51)	Moderately or slightly or not at all	1009	(81)
Moderate	193	(16)			
Heavy	54	(4)			
<b>Physical activity</b>					
Yes	657	(53)			
No	587	(47)			



**Figure 1** : Distribution of the prevalence of short sleep duration and of the feeling of tiredness while awakening by aircraft noise level

## DISCUSSION

The present study evaluated the effects of aircraft noise exposure on subjective sleep quality in the vicinity of three French airports (Paris-Charles de Gaulle, Lyon-Saint-Exupéry and Toulouse-Blagnac). Subjective sleep quality was characterized through two variables: sleep duration and the feeling of tiredness on awakening in the morning. Among the participants, 9% were short sleepers and 30% reported to be rather or very tired on awakening. In the French population, the prevalence of short sleepers is approximately 8% (<5 hours / day) [4] and 34% reported to be tired while awakening [5]. These two variables were found to be significantly associated with the level of aircraft noise exposure in the present study.

Some studies evaluating the effects of aircraft noise exposure on sleep duration showed evidence of a decreased sleep duration when aircraft noise exposure increased [6]. Kim et al for example found that sleep duration near a military airfield was more deteriorated in the highly exposed group, followed by the low-exposure group and finally the control group [6]. Other studies did not show any association between aircraft noise exposure and sleep duration [7]. Basner and Samel [8] found an unexpected increase in sleep duration with aircraft noise exposure, 2.5 minutes on average.

Concerning the feeling of tiredness while awakening, the results of the present study confirm those found in the literature, namely a significant association between noise exposure and the feeling of tiredness after sleep [9]–[11].

The findings of the present study contribute to the overall evidence suggesting that aircraft noise exposure at nighttime may decrease subjective quality of sleep.

## REFERENCES

- [1] WHO, *Burden of disease from environmental noise: quantification of healthy life years lost in Europe*. Copenhagen: World Health Organization, Regional Office for Europe, 2011.
- [2] WHO, *Night noise guidelines for Europe*. Copenhagen, Denmark: World Health Organization Europe, 2009.
- [3] S. Perron, L. F. Tetreault, N. King, C. Plante, and A. Smargiassi, 'Review of the effect of aircraft noise on sleep disturbance in adults', *Noise Health*, vol. 14, no. 57, pp. 58–67, Mar. 2012.
- [4] D. Leger, F. Beck, J. B. Richard, F. Sauvet, and B. Faraut, 'The risks of sleeping "too much". Survey of a National Representative Sample of 24671 adults (INPES health barometer)', *PLoS One*, vol. 9, no. 9, p. e106950, 2014.
- [5] C. Gourier-Fréry, C. Chan-Chee, and D. Léger, 'Insomnie, fatigue et somnolence: prévalence et état de santé associé, déclarés par les plus de 16 ans en France métropolitaine. Données ESPS 2008', *Bull Epidemiol Hebdom*, vol. 44, pp. 502–509, 2012.
- [6] S. J. Kim *et al.*, 'Exposure-Response Relationship Between Aircraft Noise and Sleep Quality: A Community-based Cross-sectional Study', *Osong Public Health Res Perspect*, vol. 5, no. 2, pp. 108–14, Apr. 2014.
- [7] B. Griefahn, A. Marks, and S. Robens, 'Noise emitted from road, rail and air traffic and their effects on sleep', *J. Sound Vib.*, vol. 295, no. 1–2, pp. 129–140, 2006.
- [8] M. Basner and A. Samel, 'Effects of Nocturnal Aircraft Noise on Sleep Structure', *Somnologie*, vol. 9, pp. 84–95, 2005.
- [9] B. Jakovljevic, G. Belojevic, K. Paunovic, and V. Stojanov, 'Road traffic noise and sleep disturbances in an urban population: cross-sectional study', *Croat Med J*, vol. 47, no. 1, pp. 125–33, Feb. 2006.
- [10] E. Öhrström, 'Longitudinal surveys on effects of changes in road traffic noise: effects on sleep assessed by general questionnaires and 3-day sleep logs', *J. Sound Vib.*, vol. 276, no. 3–5, pp. 713–727, 2004.
- [11] E. Öhrström and A. Skånberg, 'Longitudinal surveys on effects of road traffic noise: substudy on sleep assessed by wrist actigraphs and sleep logs', *J. Sound Vib.*, vol. 272, no. 3–5, pp. 1097–1109, 2004.