Environ Health Perspect

DOI: 10.1289/EHP14156

Supplemental Material

Associations between Aircraft Noise, Sleep, and Sleep–Wake Cycle: Actimetric Data from the UK Biobank Cohort near Four Major Airports

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Additional File- Excel Document

Supplemental Word File

Supplemental Tables

Table S1 sleep disturbance outcomes – name, definition, data range, and interpretation – as included in the UK Biobank questionnaire or actimetrically measured.

Outcome name	Question or definition	Response options or data description	Interpretation
Self-reported sleeplessness/insomnia	Do you have trouble falling asleep at night or do you wake up in the middle of the night?	Response options: 'never/rarely', 'sometimes', 'usually', and 'prefer not to say'.	N/A
Self-reported daytime dozing	How likely are you to doze off or fall asleep during the daytime when you don't mean to? (e.g. when working, reading or driving)?	Response options: 'never/rarely', 'sometimes', 'often', 'all of the time', 'do not know', and 'prefer not to say'.	N/A
Self-reported sleep duration	About how many hours sleep do you get in every 24 hours? (please include naps)	Response options: whole number between 0 and 24, 'do not know', and 'prefer not to say'.	N/A
Average acceleration during the least active 8 hours	Average acceleration, measured in milli-gravitational units (m*g*), quantifies the overall activity during the least active periods.	Positive value ranging from 1.6 to 39.2 (in our data).	The average acceleration during the least active periods proxy the movements during the rest period. A lower value suggests a more restful and recuperative window[18].
Actimetric measured overall average proportion of time spent on sleep or in bed	This outcome measures the length of non-waking period.	Positive value ranging from 0.02 to 0.73 (in our data).	This outcome indicates non-waking period that may include actual time sleeping as well as time in bed[20].
Relative amplitude (RA)	RA measures the contrast in activity levels between the most active 10 hours and the least active 5 hours within a 24-hour period.	Positive value ranging from 0.3 to 1.0 (in our data).	A higher RA value indicating greater activity during the day and reduced activity during sleep.
Intra-daily variability (IV)	IV measures the fragmentation of the 24-hour rest-activity rhythm.	Positive value ranging from 0.0 to 2.0 (in our data).	A high IV suggests a more fragmented rhythm indicative of circadian dysfunction.

Inter-daily stability (IS)	IS measures the stability of the rest-activity rhythm.	Positive value ranging from 0.4 to 1.1 (in our data).	A higher IS score indicating a stronger alignment with light and other environmental cues that regulate the biological clock[21].

Note: This table presents the questions and response options for self-reported outcomes, as well as definitions and data descriptions for actimetric outcomes.

Table S2 Field IDs or return ID of the variables used in the study and their descriptions.

Variable name	Field ID/return ID in UK biobank	Description/definition	Answers used in analysis
Sleeplessness/insomnia	1200	Question 'Do you have trouble falling asleep at night or do you wake up in the middle of the night?' Answers in the questionnaire: 1 Never/rarely 2 Sometimes 3 Usually -3 Prefer not to answer	1 Never/rarely 2 Sometimes 3 Usually
Daytime dozing/sleeping	1220	Question 'How likely are you to doze off or fall asleep during the daytime when you don't mean to? (e.g. when working, reading or driving)' Answers in the questionnaire: 0 Never/rarely 1 Sometimes 2 Often 3 All of the time -1 Do not know -3 Prefer not to answer	0 Never/rarely 1 Sometimes 2 Often 3 All of the time
Sleep duration	1160	Question 'About how many hours sleep do you get in every 24 hours? (please include naps)' Answers in numbers within a range between 1 and 23. There are two special values: -1 represents 'Do not know' -3 represents 'Prefer not to answer'	We categorised sleep duration into less than 6 hours, between 6 and 8 hours, and more than 8 hours.
Relative amplitude	2101	RA measures the contrast in activity levels between the most active 10 hours and the least active 5 hours within a 24-hour period. A higher RA value indicates	All values were used

		greater activity during the day and reduced activity during sleep.	
Intra-daily variability	2101	IV measures the fragmentation of the 24-hour rest-activity rhythm, and a high IV suggests a more fragmented rhythm indicative of circadian dysfunction.	All values were used
Inter-daily stability	2101	IS measures the stability of the rest-activity rhythm, and a higher IS score indicates a strong alignment with light and other environmental cues that regulate the biological clock [19].	All values were used
Average acceleration during the least active 8-hour	2101	This measures participants' movement or arousals during the least active continuous 8-hour, and a low level of movement suggest a more peaceful rest during those periods.	All values were used
Average acceleration during the least active 6-hour	2101	This measures participants' movement or arousals during the least active continuous 6-hour, and a low level of movement suggest a more peaceful rest during those periods.	All values were used
Average acceleration during the least active 5-hour	2101	This measures participants' movement or arousals during the least active continuous 5-hour, and a low level of movement suggest a more peaceful rest during those periods.	All values were used
Start time of the least active 8-hour	2101	This measures the start time of the least active continuous 8-hour.	All values were used
Proportion of time spent on sleep within 7 days	40046	The overall average proportion of time spent sleeping across the monitoring period.	All values were used
Sex	31	Answers in the questionnaire: 0 Female 1 Male	0 Female 1 Male
Age	34	Field 34 contains participants' year of birth. Age in 2006 is calculated by subtracting the value of Field 34 from the year 2006, while the age in 2011 is calculated by subtracting the value of Field 34 from the year 2011.	All values were used
Time at current address	699	Answers within the range between 1 and 85. There are three special values:	We used anyone with positive values.

		-10 Less than a year -1 Do not know -3 Prefer not to answer	
Ethnic background	21000	Answers in the questionnaire: 1 White 1001 British 2001 White and Black Caribbean 3001 Indian 4001 Caribbean 2 Mixed 1002 Irish 2002 White and Black African 3002 Pakistani 4002 African 3 Asian or Asian British 1003 Any other white background 2003 White and Asian 3003 Bangladesh 4003 Any other Black background 4 Black or Black British 2004 Any other mixed background 3004 Any other Asian background 5 Chinese 6 Other ethnic group -1 Do not know -3 Prefer not to answer	1 White 2 Mixed 3 Asian or Asian British 4 Black or Black British 5 Chinese 6 Other ethnic group
Townsend deprivation index at recruitment	22189	Townsend deprivation index calculated immediately prior to participant joining UK Biobank. Based on the preceding national census output areas. Each participant is assigned a score corresponding to the output area in which their postcode is located. The values here are rounded to 2 decimal places, replacing an earlier unrounded version.	All values were used
BMI	21001		All values were used
Ever seen a psychiatrist or doctor (GP) for nerves,	2090 (Seen doctor (GP)	Each field has four answers:	Yes and no.

anxiety, tension or depression	for nerves, anxiety, tension or depression) and 2100 (Seen a psychiatrist for nerves, anxiety, tension or depression)	1 Yes 0 No -1 Do not know -3 Prefer not to answer	Yes if the participant answered yes to any of the fields.
Smoking status	20116	-3 Prefer not to answer 0 Never 1 Previous 2 Current	0 Never 1 Previous 2 Current
Alcohol consumption	1558	1 Daily or almost daily 2 Three or four times a week 3 Once or twice a week 4 One to three times a month 5 Special occasions only 6 Never -3 Prefer not to answer	1 Daily or almost daily 2 Three or four times a week 3 Once or twice a week 4 One to three times a month 5 Special occasions only 6 Never
Total number of vigorous or moderate physical activities (in days)	884 (Number of days/week of moderate physical activity) and 904 (Number of days/week of vigorous physical activity 10+ minutes)	Numbers between 0 and 7. In addition, there are two special values: -1 Do not know -3 Prefer not to answer	We used the largest number of days between 884 and 904.
Average annual household income before tax	738	1 Less than 18,000 2 18,000 to 30,999 3 31,000 to 51,999 4 52,000 to 100,000 5 Greater than 100,000	1 Less than 18,000 2 18,000 to 30,999 3 31,000 to 51,999 4 52,000 to 100,000

		-1 Do not know -3 Prefer not to answer	5 Greater than 100,000
$PM_{2.5}$ concentration	24006	PM10 (particulate matter with diameter less than or equal to 2.5 micrometres); Land Use Regression (LUR) estimate for annual average 2010.	All values were used
Greenspace percentage, buffer 1000m	24500	The percentage of the home location buffer classed as 'Greenspace', as a proportion of all land-use types, and with home location data buffered at 1000m. Land use data were obtained from the Generalized land use database for England (GLUD) 2005 data at the 2001 Census Output Area level. Each home location polygon was then allocated an area weighted mean of the land use percentage coverage for the 2001 Census Output Areas intersecting the home location buffer. Data are only available for participants whose home location was in England.	
Diabetes diagnosed by a doctor	2443	ACE touchscreen question 'Has a doctor ever told you that you have diabetes?' Answers include 1 Yes 0 No -1 Do not know -3 Prefer not to answer	We used 1 Yes
Presence of hypertension	4080, 4079, 6153, 6177, and 6150	Field 6150 Description: Vascular/heart problems diagnosed by doctor Answers include 1 Heart attack 2 Angina 3 Stroke 4 High blood pressure -7 None of the above -3 Prefer not to answer Fields 4079 Description: Diastolic blood pressure, automated reading Fields 4080	The presence of hypertension was defined as meeting any one of the following criteria: a) Field 6150 indicates an answer of 4 (high blood pressure). b) Field 4080 shows a systolic blood pressure measurement equal to or greater than 140 mmHg, or Field 4079 shows a diastolic blood pressure measurement equal to or greater than 90 mmHg.

		Description: Systolic blood pressure, automated reading Field 6153 Description: Medication for cholesterol, blood pressure, diabetes, or take exogenous hormones Answers include 1 Cholesterol lowering medication 2 Blood pressure medication 3 Insulin 4 Hormone replacement therapy 5 Oral contraceptive pill or minipill -7 None of the above -1 Do not know -3 Prefer not to answer Field 6177 Description: Medication for cholesterol, blood pressure or diabetes Answers include 1 Cholesterol lowering medication 2 Blood pressure medication 3 Insulin -7 None of the above -1 Do not know -3 Prefer not to answer	c) Field 6153 indicates an answer of 2 (blood pressure medication). d) Field 6177 indicates an answer of 2 (blood pressure medication).
Night-shift worker	3426	1 Never/rarely 2 Sometimes 3 Usually 4 Always -1 Do not know -3 Prefer not to answer	In sensitivity analysis, we excluded any participants who reported either Sometimes, Usually or Always.
Hearing difficulties	2247	1 Yes 0 No 99 I am completely deaf -1 Do not know -3 Prefer not to answer	In sensitivity analysis, we excluded any participants who reported either yes or I am completely deaf.

Sleep disorder	131061	20 Death register only 21 Death register and other source(s) 30 Primary care only 31 Primary care and other source(s) 40 Hospital admissions data only 41 Hospital admission data and other source(s) 50 Self-report only 51 Self-report and other source(s)	We used all sources of dementia report
Dementia report	42019	0 Self-reported only 1 Hospital admission 2 Death only 11 Hospital primary 12 Death primary 21 Hospital secondary 22 Death contributory	We used all sources of dementia report
People who look after home/family	6142	1 In paid employment or self-employed 2 Retired 3 Looking after home and/or family 4 Unable to work because of sickness or disability 5 Unemployed 6 Doing unpaid or voluntary work 7 Full or part-time student -7 None of the above -3 Prefer not to answer	We used 3 Looking after home and/or family

Supplemental Word File Source Code

Main models – STATA code

Average movement during the continuous least active 8 hours

glm L8h_cont_ i.air_lnight_4cat2011 i.mentalhealth sex age time_at_address i.ethnic_background_cat daysofphyact n_189 i.smoking i.alcohol n_21001 i.household_income i.road_lnight_4cat i.rail_lnight_4cat greenspace n_24006_all total_no2_09_all, vce(cluster airportid) family(gamma) link(identity)

Relative amplitude

glm RA_ad i.air_lnight_4cat2011 i.mentalhealth sex age time_at_address i.ethnic_background_cat daysofphyact n_189 i.smoking i.alcohol n_21001 i.household_income i.road_lnight_4cat i.rail_lnight_4cat greenspace n_24006_all total_no2_09_all, vce(cluster airportid) family(gamma) link(identity)

Intra-daily variability

glm IV_intra i.air_lnight_4cat2011 i.mentalhealth sex age time_at_address i.ethnic_background_cat daysofphyact n_189 i.smoking i.alcohol n_21001 i.household_income i.road_lnight_4cat i.rail_lnight_4cat greenspace n_24006_all total_no2_09_all, vce(cluster airportid) family(gamma) link(identity)

Inter-daily stability

glm IS_inter i.air_lnight_4cat2011 i.mentalhealth sex age time_at_address i.ethnic_background_cat daysofphyact n_189 i.smoking i.alcohol n_21001 i.household_income i.road_lnight_4cat i.rail_lnight_4cat greenspace n_24006_all total_no2_09_all, vce(cluster airportid) family(gamma) link(identity)

Proportion of time spent on sleep or in bed

glm n_40046 i.air_lnight_4cat2011 i.mentalhealth sex age time_at_address i.ethnic_background_cat daysofphyact n_189 i.smoking i.alcohol n_21001 i.household_income i.road_lnight_4cat i.rail_lnight_4cat greenspace n_24006_all total_no2_09_all if RA_ad!=., vce(cluster airportid) family(gamma) link(identity)

Self-reported sleeplessness

xtlogit sleepless i.air_lnight_4cat i.mentalhealth sex age time_at_address i.ethnic_background_cat daysofphyact n_189 i.smoking i.alcohol n_21001 i.household_income i.road_lnight_4cat i.rail_lnight_4cat greenspace n_24006_all total_no2_09_all, vce(cluster airportid)

Self-reported daytime dozing

xtlogit doze i.air_lnight_4cat i.mentalhealth sex age time_at_address i.ethnic_background_cat daysofphyact n_189 i.smoking i.alcohol n_21001 i.household_income i.road_lnight_4cat i.rail_lnight_4cat greenspace n_24006_all total_no2_09_all, vce(cluster airportid)

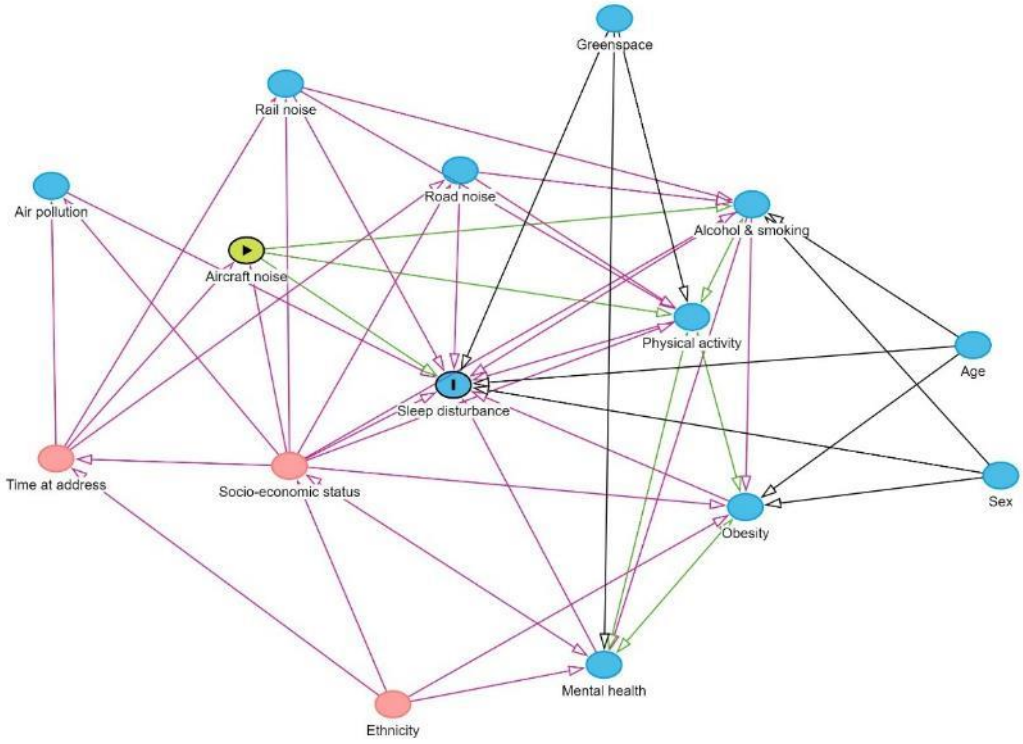
Self-reported sleep duration

xtgee sleepd i.air_lnight_4cat i.mentalhealth sex age time_at_address i.ethnic_background_cat daysofphyact n_189 i.smoking i.alcohol n_21001 i.household_income i.road_lnight_4cat i.rail_lnight_4cat greenspace n_24006_all total_no2_09_all, family(gamma) link(identity) robust

Supplemental Figures

Directed Acyclic Graph (DAG)

Figure S1 Directed Acyclic Graph (DAG) identifying potential confounders for the relationship between night-time aircraft noise exposure and sleep disturbance.



Note: The DAG depicted a graphical model where each factor was represented as a node and the arrows between them suggested possible associations. In the graph, red circles were used to indicate ancestor of exposure and outcome while blue circles denote ancestor of outcome.

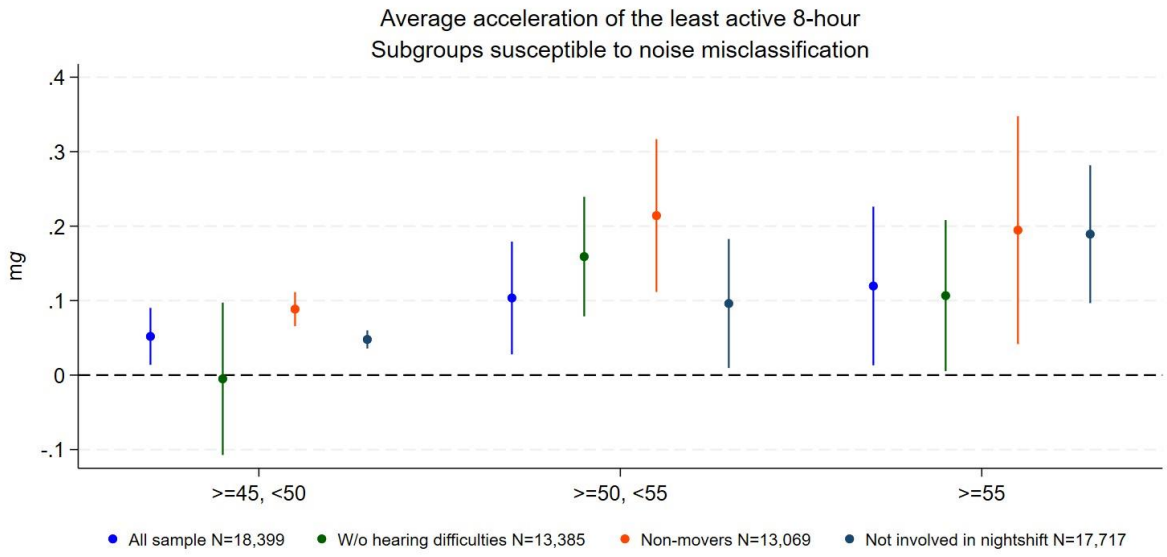
Sensitivity Analysis

We performed analyses on subsets of the sample that excluded individuals less prone to noise misclassification, considering individuals not engaged in night shifts (N=100,375 out of 105,773; average age=61.4 years in 2006), those who hadn't changed residences since recruitment (N=76,883; average age=54.2 years), and individuals without hearing impairments (N=73,468; average age=52.9 years). The results are presented in Figure S2 – 9.

In subset analyses considering demographic and sociodemographic factors that might influence susceptibility to sleep disturbances, we considered individuals aged above 65 years (N=8,971; average age=66.1 years); White (N=91,251; average age=54.2 years) and non-White (N=13,488; average age=50.1 years) ethnicity; females (N=57,381; average age=53.5 years) and males (N=48,387; average age=53.9 years); households with incomes below the national median (annual income < £31,000; N=36,296; average age=55.6 years), and those involved in home/family caregiving (N=6,025; average age=50.7 years). The results are presented in Figure S10 – 17.

In the third set of sensitivity analyses (Figure S18 to 40), we examined participants reporting diabetes (N=6,278; average age=56.7 years), hypertension (N= 53,690; average age=56.1 years), high BMI (N=51,824; average age=54.1 years), dementia (N=1,605; average age=61.9 years), those with anxiety or depression (N=32,223; average age=53.5 years) and those with sleep disorder (N=4,028; average age=54.1).

Figure S2 Cross-sectional association between night-time aircraft noise and average acceleration during the least active 8 hours while excluding subgroups susceptible to noise misclassification using UK Biobank cohort.

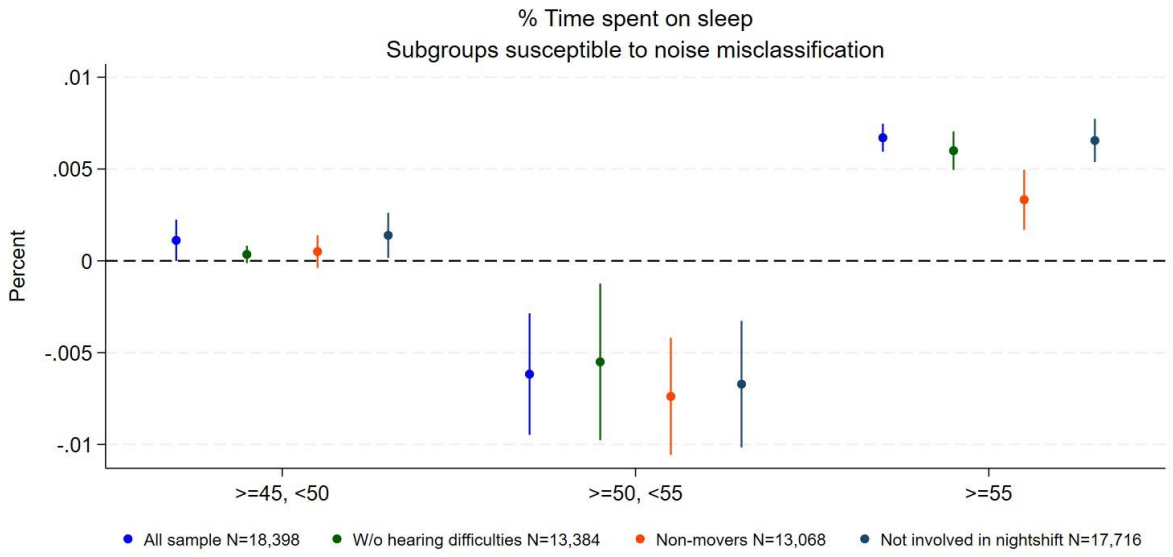


Note: The figure illustrates the point estimate (β) and 95% CIs. β represents the increment in the absolute value of the outcome when exposed to higher aircraft noise categories, compared to those exposed to less than 45 dB. The subgroups of individuals excluded include are those not engaged in night shifts, those who hadn't changed residences since recruitment, and individuals without hearing impairments.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S1.

Figure S3 Cross-sectional association between night-time aircraft noise and proportion of time spent on sleep or in bed (7-day average) while excluding subgroups susceptible to noise misclassification using UK Biobank cohort.

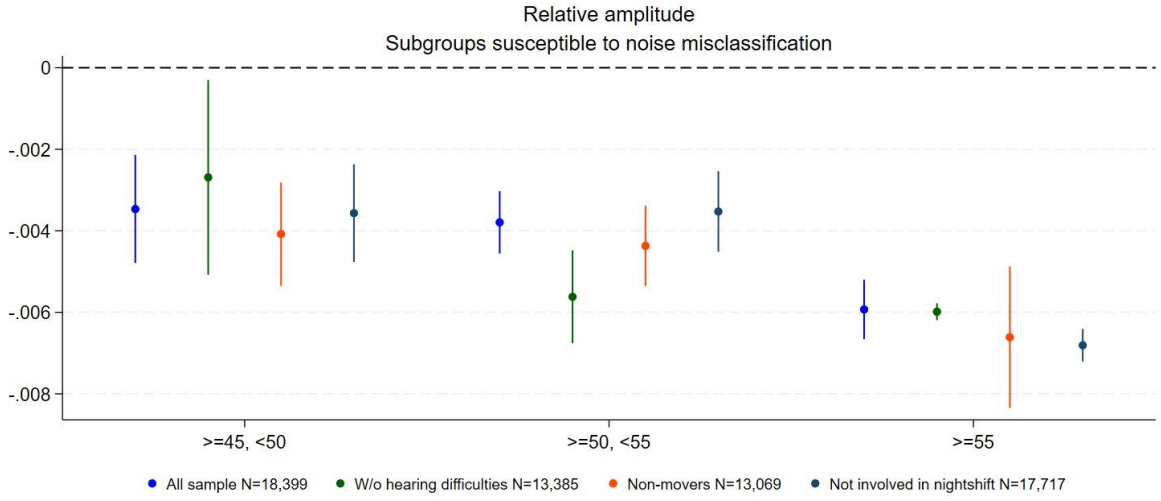


Note: The figure illustrates the point estimate (β) and 95% CIs. β represents the increment in the absolute value of the outcome when exposed to higher aircraft noise categories, compared to those exposed to less than 45 dB. The subgroups of individuals excluded include are those not engaged in night shifts, those who hadn't changed residences since recruitment, and individuals without hearing impairments.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S2.

Figure S4 Cross-sectional association between night-time aircraft noise and relative amplitude while excluding subgroups susceptible to noise misclassification using UK Biobank cohort.

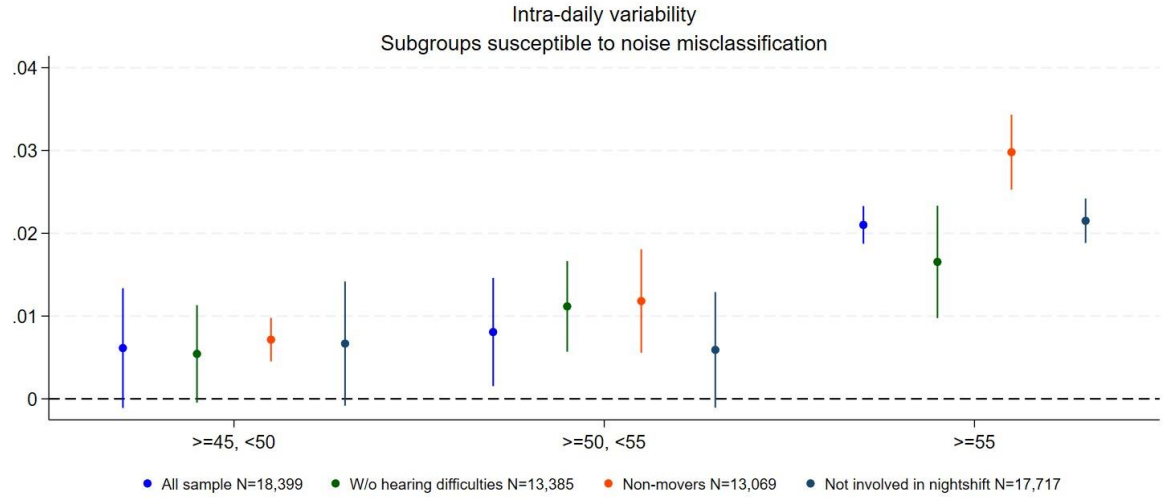


Note: The figure illustrates the point estimate (β) and 95% CIs. β represents the increment in the absolute value of the outcome when exposed to higher aircraft noise categories, compared to those exposed to less than 45 dB. The subgroups of individuals excluded include are those not engaged in night shifts, those who hadn't changed residences since recruitment, and individuals without hearing impairments.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S3.

Figure S5 Cross-sectional association between night-time aircraft noise and intra-daily variability while excluding subgroups susceptible to noise misclassification using UK Biobank cohort.

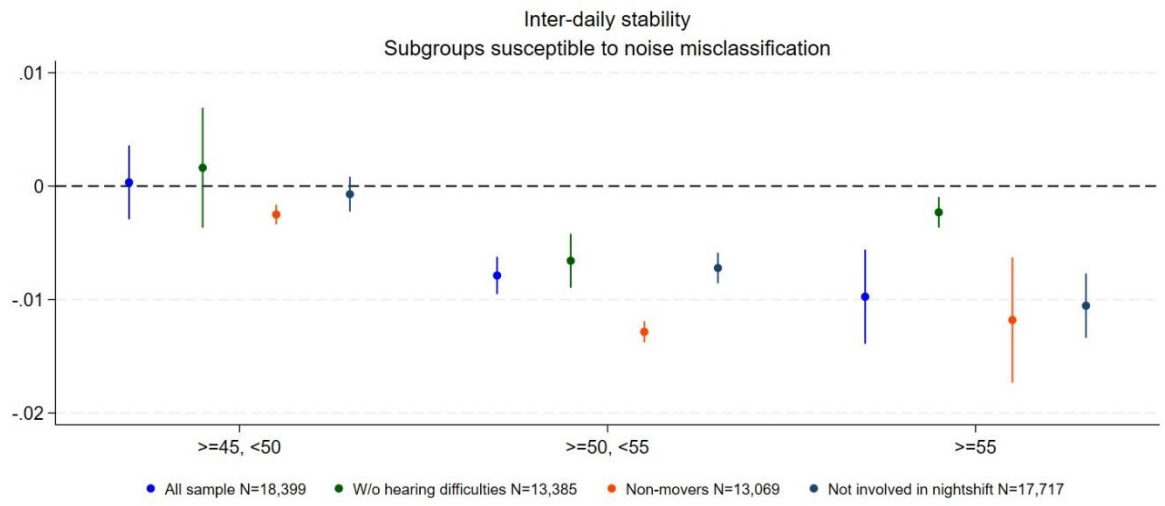


Note: The figure illustrates the point estimate (β) and 95% CIs. β represents the increment in the absolute value of the outcome when exposed to higher aircraft noise categories, compared to those exposed to less than 45 dB. The subgroups of individuals excluded include are those not engaged in night shifts, those who hadn't changed residences since recruitment, and individuals without hearing impairments.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S4.

Figure S6 Cross-sectional association between night-time aircraft noise and inter-daily stability while excluding subgroups susceptible to noise misclassification using UK Biobank cohort.

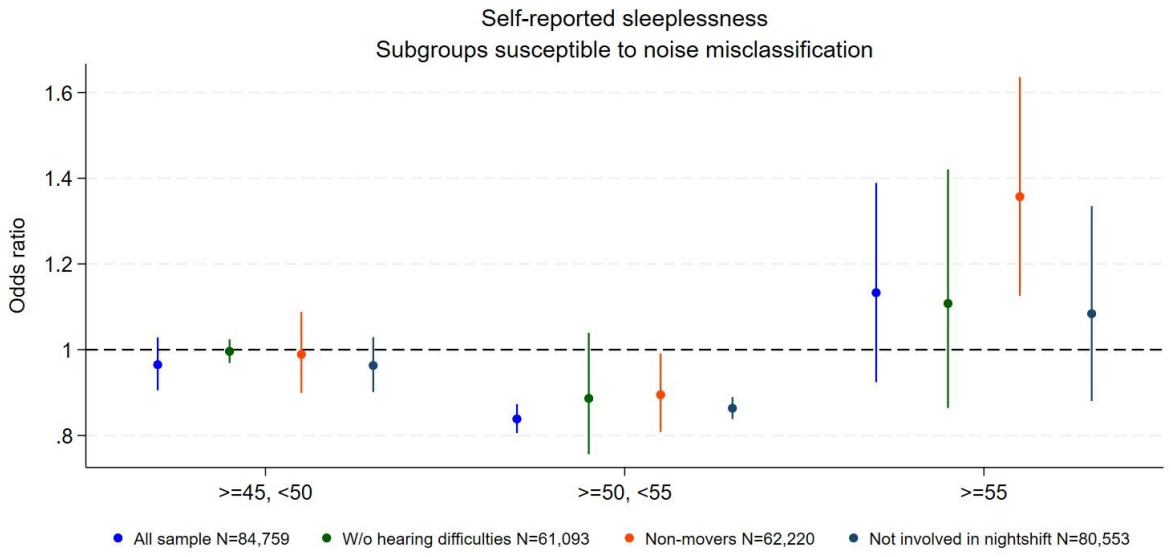


Note: The figure illustrates the point estimate (β) and 95% CIs. β represents the increment in the absolute value of the outcome when exposed to higher aircraft noise categories, compared to those exposed to less than 45 dB. The subgroups of individuals excluded include are those not engaged in night shifts, those who hadn't changed residences since recruitment, and individuals without hearing impairments.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S5.

Figure S7 Repeated cross-sectional association between night-time aircraft noise and self-reported sleeplessness while excluding subgroups susceptible to noise misclassification using UK Biobank cohort.

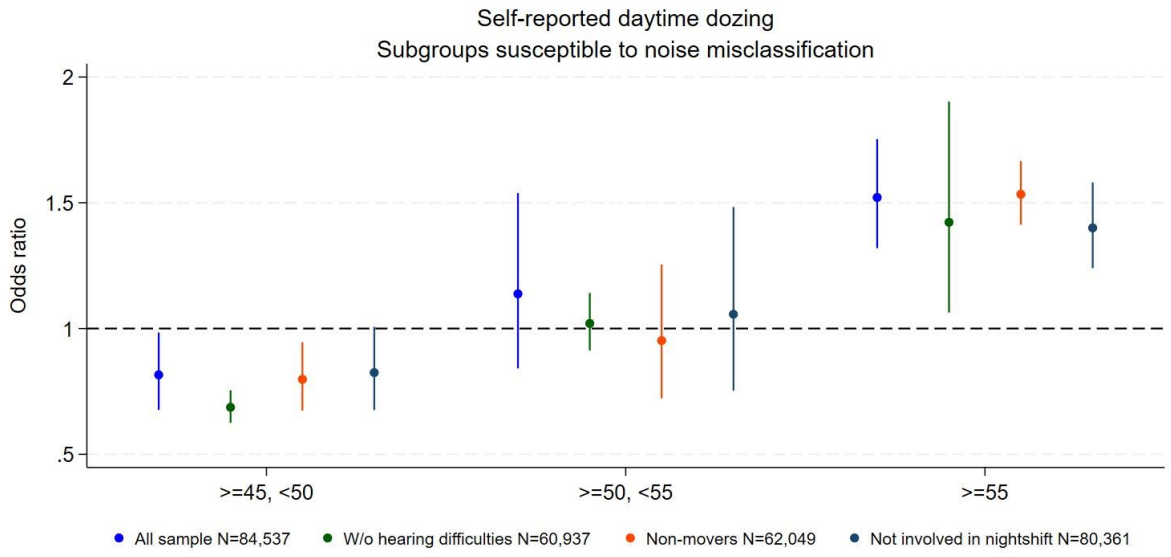


Note: The figure illustrates the odds ratios (ORs) and 95% confidence intervals (CIs). The odds ratio represents the likelihood of someone experiencing more severe sleep disturbance outcomes when exposed to noise levels ≥55dB compared with those exposed to <45 dB. The subgroups of individuals excluded include are those not engaged in night shifts, those who hadn't changed residences since recruitment, and individuals without hearing impairments.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S6.

Figure S8 Repeated cross-sectional association between night-time aircraft noise and self-reported daytime dozing while excluding subgroups susceptible to noise misclassification using UK Biobank cohort.

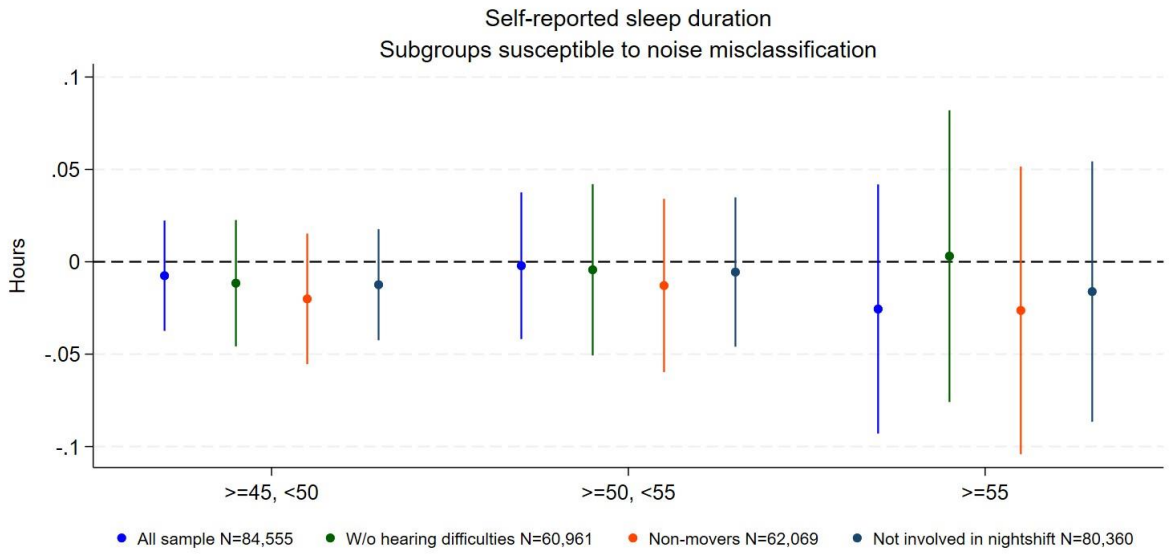


Note: The figure illustrates the odds ratios (ORs) and 95% confidence intervals (CIs). The odds ratio represents the likelihood of someone experiencing more severe sleep disturbance outcomes when exposed to noise levels ≥55dB compared with those exposed to <45 dB. The subgroups of individuals excluded include are those not engaged in night shifts, those who hadn't changed residences since recruitment, and individuals without hearing impairments.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S7.

Figure S9 Repeated cross-sectional association between night-time aircraft noise and self-reported sleep duration while excluding subgroups susceptible to noise misclassification using UK Biobank cohort.

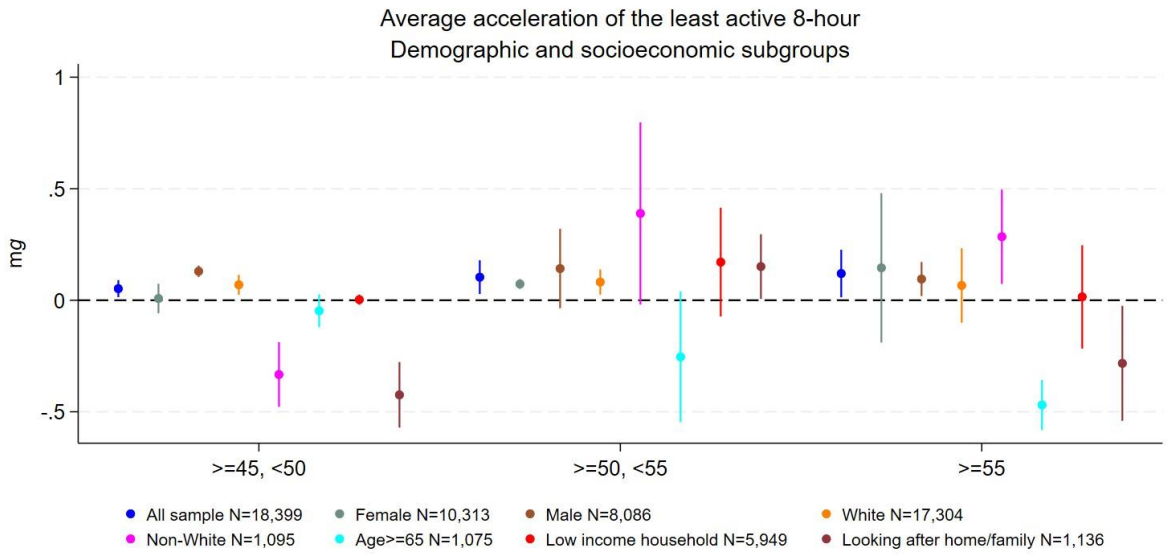


Note: The figure illustrates the point estimate (β) and 95% CIs. β represents the increment in the absolute value of the outcome when exposed to higher aircraft noise categories, compared to those exposed to less than 45 dB. The subgroups of individuals excluded include are those not engaged in night shifts, those who hadn't changed residences since recruitment, and individuals without hearing impairments.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S8.

Figure S10 Cross-sectional association between night-time aircraft noise and average acceleration during the least active 8 hours among some demographic or socioeconomic groups using UK Biobank cohort.

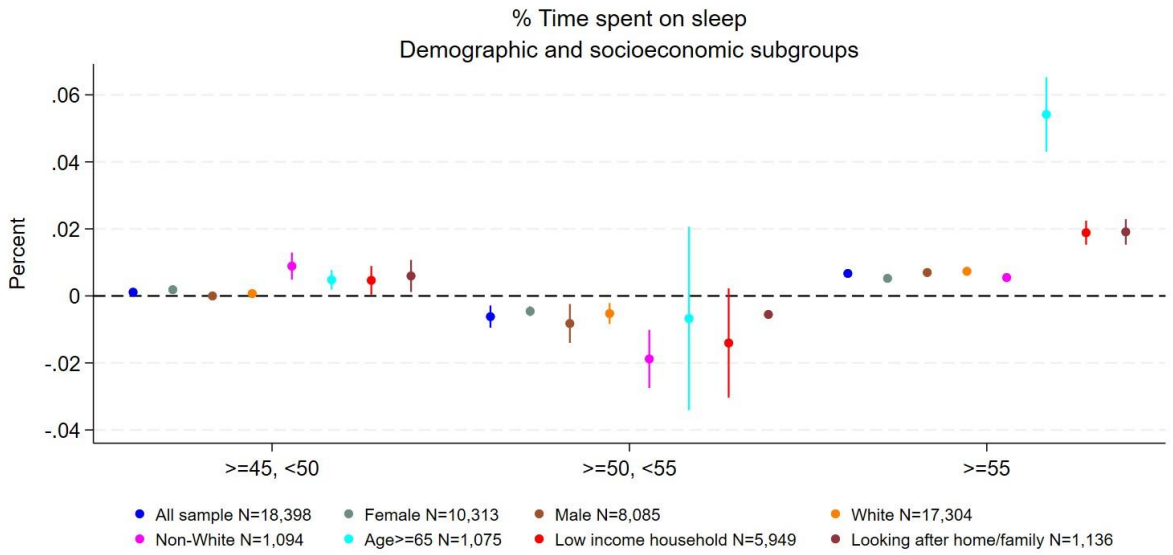


Note: The figure illustrates the point estimate (β) and 95% CIs. β represents the increment in the absolute value of the outcome when exposed to higher aircraft noise categories, compared to those exposed to less than 45 dB. The demographic or socioeconomic groups include individuals aged above 65 years; White and non-White ethnicity; females and males; households with incomes below the national median, and those involved in home/family caregiving.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S1.

Figure S11 Cross-sectional association between night-time aircraft noise and proportion of time spent on sleep or in bed (7-day average) among some demographic or socioeconomic groups using UK Biobank cohort.

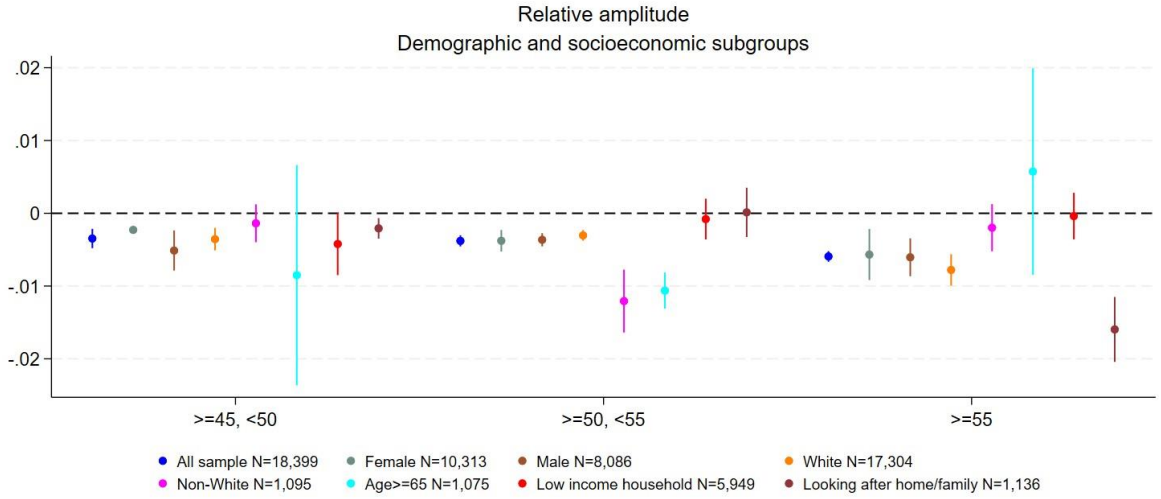


Note: The figure illustrates the point estimate (β) and 95% CIs. β represents the increment in the absolute value of the outcome when exposed to higher aircraft noise categories, compared to those exposed to less than 45 dB. The demographic or socioeconomic groups include individuals aged above 65 years; White and non-White ethnicity; females and males; households with incomes below the national median, and those involved in home/family caregiving.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S2.

Figure S12 Cross-sectional association between night-time aircraft noise and relative amplitude among some demographic or socioeconomic groups using UK Biobank cohort.

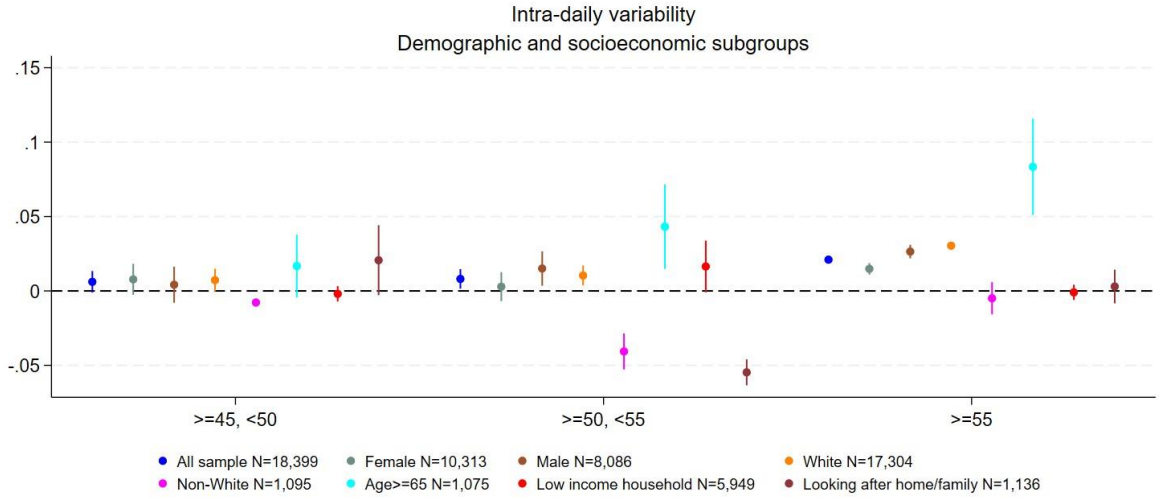


Note: The figure illustrates the point estimate (β) and 95% CIs. β represents the increment in the absolute value of the outcome when exposed to higher aircraft noise categories, compared to those exposed to less than 45 dB. The demographic or socioeconomic groups include individuals aged above 65 years; White and non-White ethnicity; females and males; households with incomes below the national median, and those involved in home/family caregiving.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S3.

Figure S13 Cross-sectional association between night-time aircraft noise and intra-daily variability among some demographic or socioeconomic groups using UK Biobank cohort.

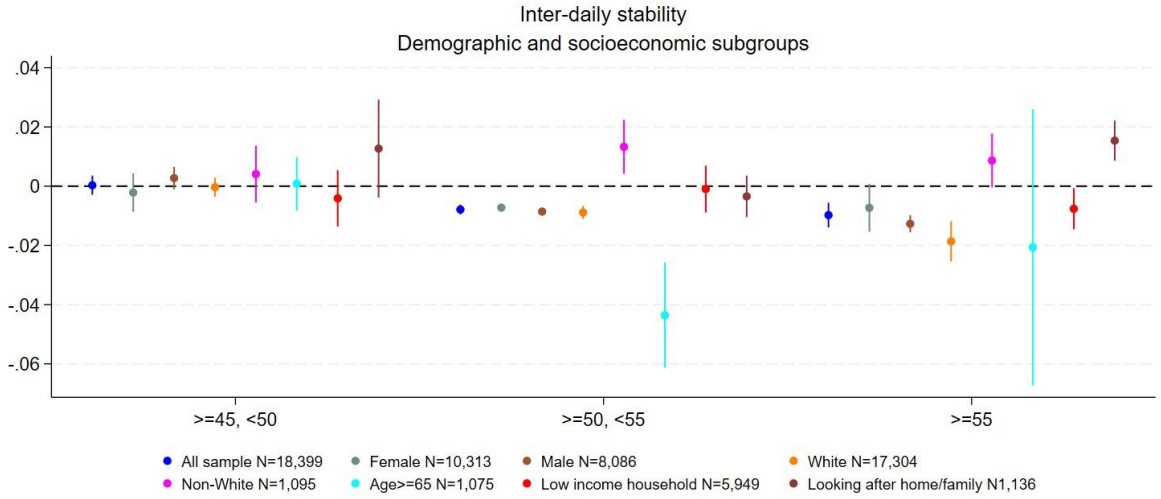


Note: The figure illustrates the point estimate (β) and 95% CIs. β represents the increment in the absolute value of the outcome when exposed to higher aircraft noise categories, compared to those exposed to less than 45 dB. The demographic or socioeconomic groups include individuals aged above 65 years; White and non-White ethnicity; females and males; households with incomes below the national median, and those involved in home/family caregiving.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S4.

Figure S14 Cross-sectional association between night-time aircraft noise and inter-daily stability among some demographic or socioeconomic groups using UK Biobank cohort.

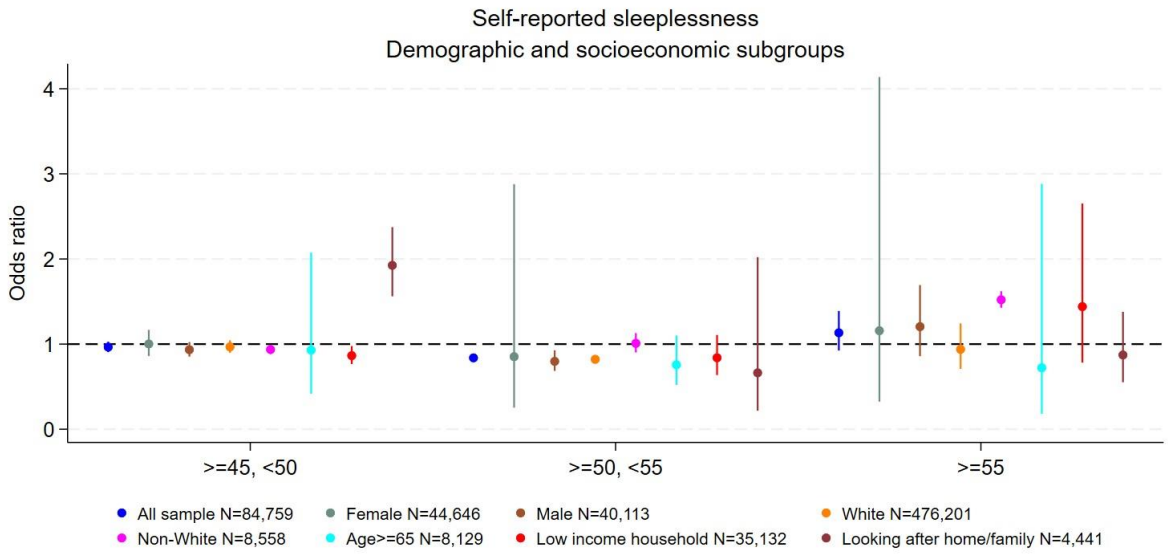


Note: The figure illustrates the point estimate (β) and 95% CIs. β represents the increment in the absolute value of the outcome when exposed to higher aircraft noise categories, compared to those exposed to less than 45 dB. The demographic or socioeconomic groups include individuals aged above 65 years; White and non-White ethnicity; females and males; households with incomes below the national median, and those involved in home/family caregiving.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S5.

Figure S15 Repeated cross-sectional association between night-time aircraft noise and self-reported sleeplessness among some demographic or socioeconomic groups using UK Biobank cohort.

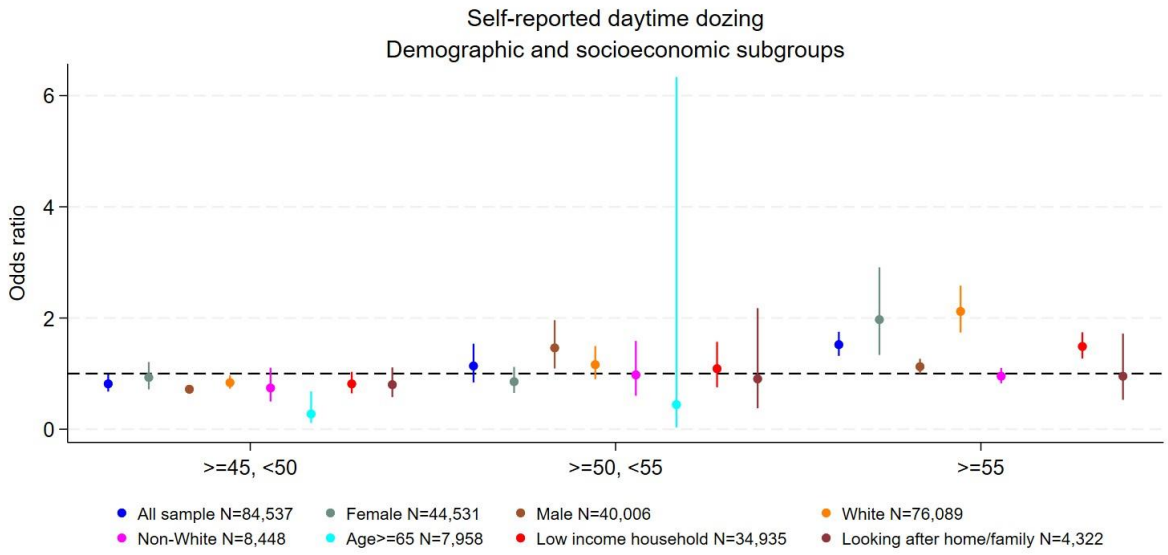


Note: The figure illustrates the odds ratios (ORs) and 95% confidence intervals (CIs). The odds ratio represents the likelihood of someone experiencing more severe sleep disturbance outcomes when exposed to noise levels ≥55dB compared with those exposed to <45 dB. The demographic or socioeconomic groups include individuals aged above 65 years; White and non-White ethnicity; females and males; households with incomes below the national median, and those involved in home/family caregiving.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S6.

Figure S16 Repeated cross-sectional association between night-time aircraft noise and self-reported daytime dozing among some demographic or socioeconomic groups using UK Biobank cohort.

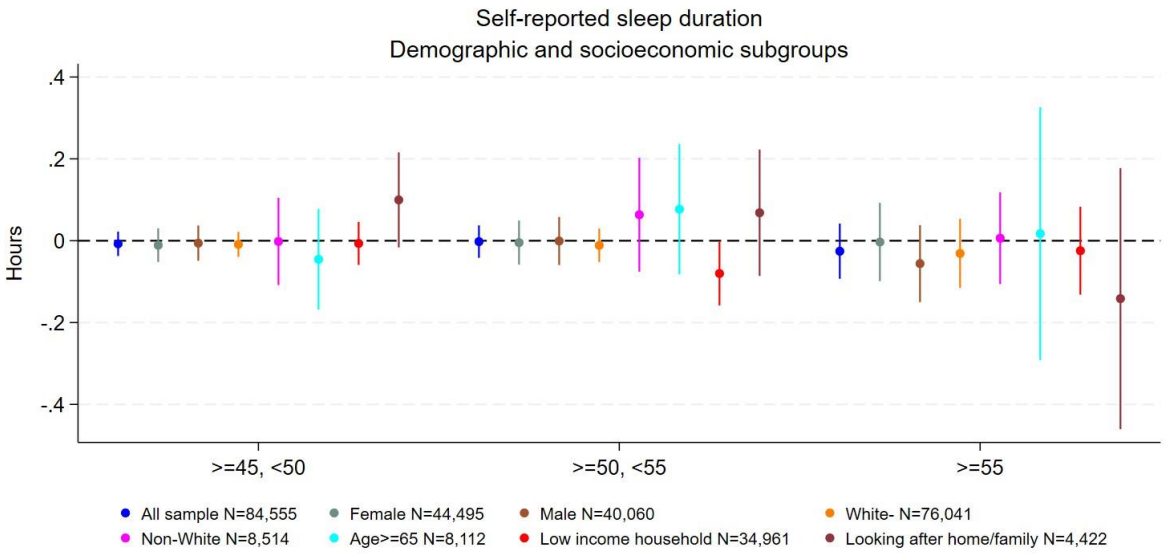


Note: The figure illustrates the odds ratios (ORs) and 95% confidence intervals (CIs). The odds ratio represents the likelihood of someone experiencing more severe sleep disturbance outcomes when exposed to noise levels ≥55dB compared with those exposed to <45 dB. The demographic or socioeconomic groups include individuals aged above 65 years; White and non-White ethnicity; females and males; households with incomes below the national median, and those involved in home/family caregiving.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S7.

Figure S17 Repeated cross-sectional association between night-time aircraft noise and self-reported sleep duration among some demographic or socioeconomic groups using UK Biobank cohort.

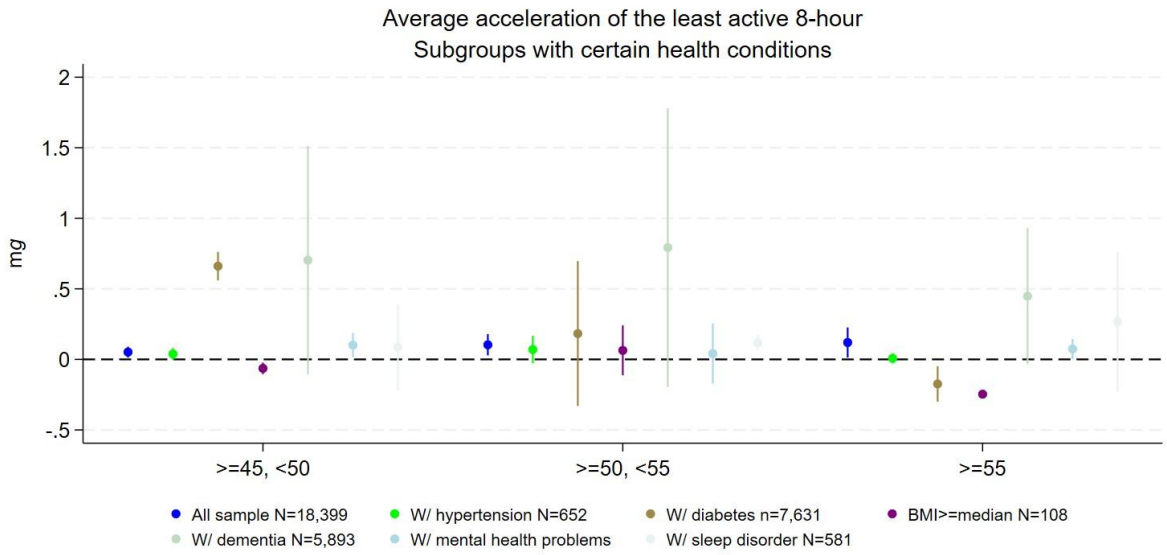


Note: The figure illustrates the point estimate (β) and 95% CIs. β represents the increment in the absolute value of the outcome when exposed to higher aircraft noise categories, compared to those exposed to less than 45 dB. The demographic or socioeconomic groups include individuals aged above 65 years; White and non-White ethnicity; females and males; households with incomes below the national median, and those involved in home/family caregiving.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S8.

Figure S18 Cross-sectional association between night-time aircraft noise and average acceleration during the least active 8 hours among people with health conditions linked to sleep disturbance using UK Biobank cohort.

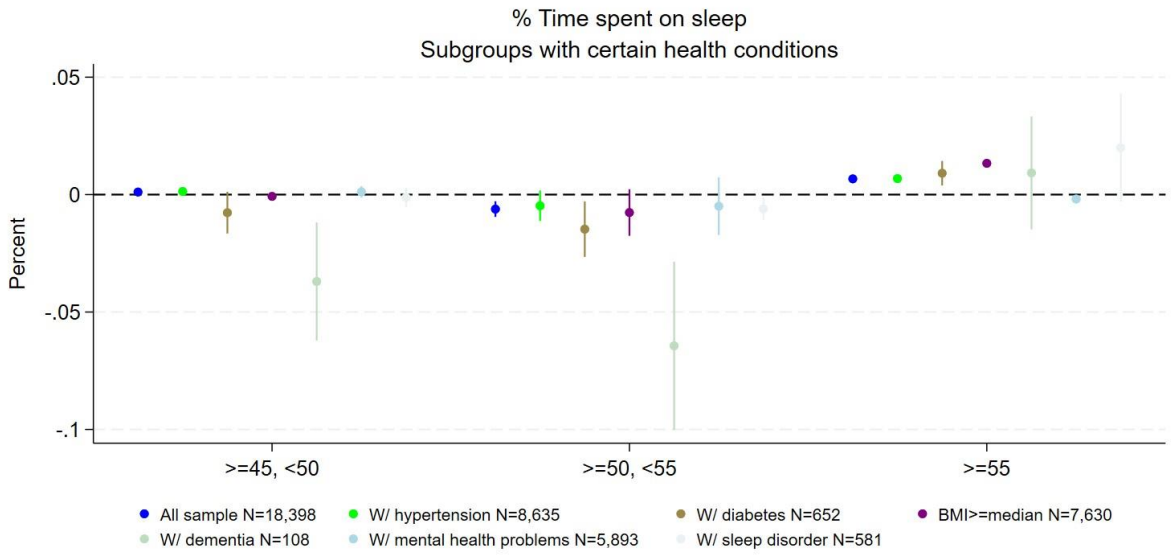


Note: The figure illustrates the point estimate (β) and 95% CIs. β represents the increment in the absolute value of the outcome when exposed to higher aircraft noise categories, compared to those exposed to less than 45 dB. The subgroups of individuals with health conditions linked to sleep disturbance include participants reporting diabetes, hypertension, high BMI, dementia, those with anxiety or depression and those with sleep disorder.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S1.

Figure S19 Cross-sectional association between night-time aircraft noise and proportion of time spent on sleep or in bed (7-day average) among people with health conditions linked to sleep disturbance using UK Biobank cohort.

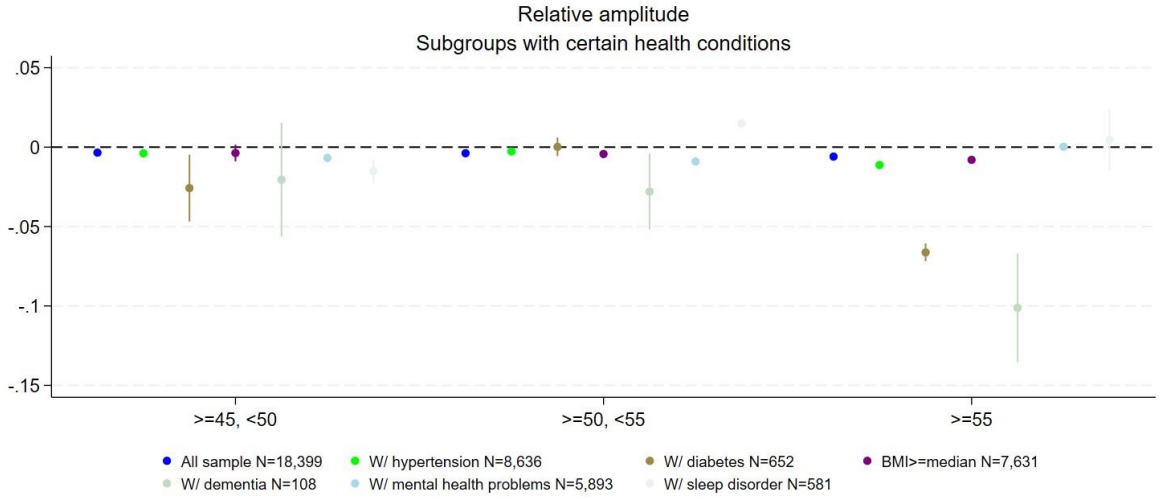


Note: The figure illustrates the point estimate (β) and 95% CIs. β represents the increment in the absolute value of the outcome when exposed to higher aircraft noise categories, compared to those exposed to less than 45 dB. The subgroups of individuals with health conditions linked to sleep disturbance include participants reporting diabetes, hypertension, high BMI, dementia, those with anxiety or depression and those with sleep disorder.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S2.

Figure S20 Cross-sectional association between night-time aircraft noise and relative amplitude among people with health conditions linked to sleep disturbance using UK Biobank cohort.

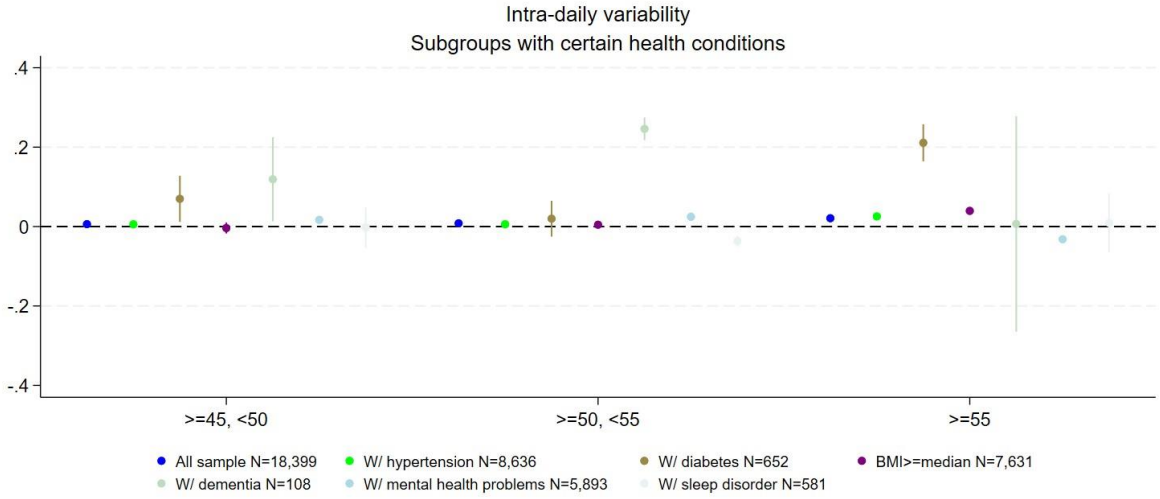


Note: The figure illustrates the point estimate (β) and 95% CIs. β represents the increment in the absolute value of the outcome when exposed to higher aircraft noise categories, compared to those exposed to less than 45 dB. The subgroups of individuals with health conditions linked to sleep disturbance include participants reporting diabetes, hypertension, high BMI, dementia, those with anxiety or depression and those with sleep disorder.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S3.

Figure S21 Cross-sectional association between night-time aircraft noise and intra-daily variability among people with health conditions linked to sleep disturbance using UK Biobank cohort.

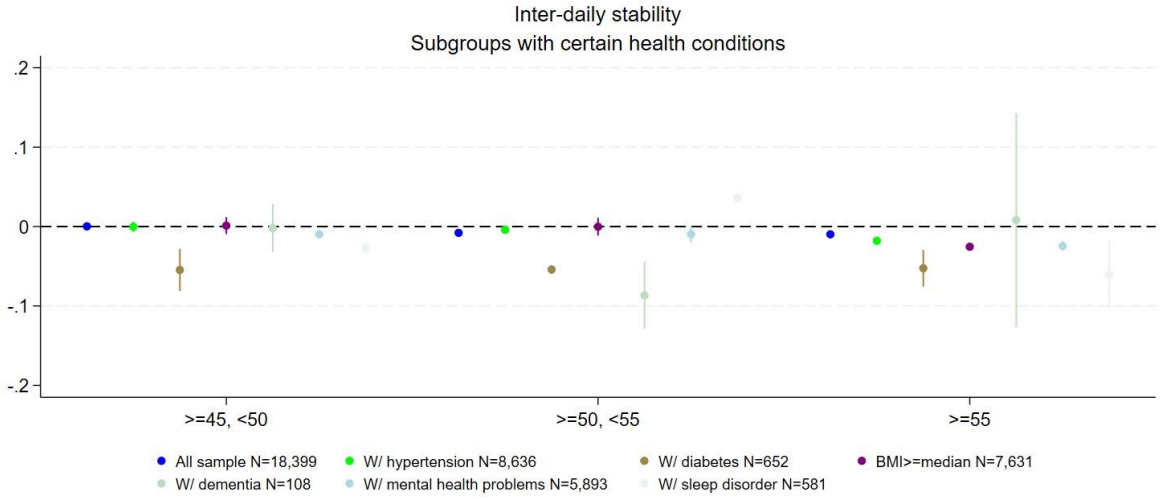


Note: The figure illustrates the point estimate (β) and 95% CIs. β represents the increment in the absolute value of the outcome when exposed to higher aircraft noise categories, compared to those exposed to less than 45 dB. The subgroups of individuals with health conditions linked to sleep disturbance include participants reporting diabetes, hypertension, high BMI, dementia, those with anxiety or depression and those with sleep disorder.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S4.

Figure S22 Cross-sectional association between night-time aircraft noise and inter-daily stability among people with health conditions linked to sleep disturbance using UK Biobank cohort.

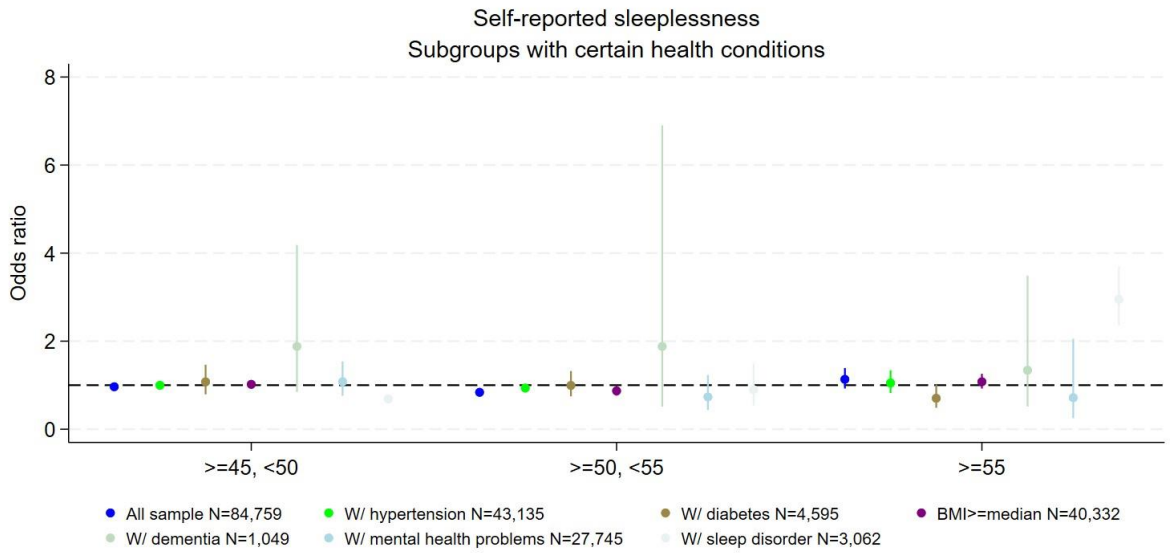


Note: The figure illustrates the point estimate (β) and 95% CIs. β represents the increment in the absolute value of the outcome when exposed to higher aircraft noise categories, compared to those exposed to less than 45 dB. The subgroups of individuals with health conditions linked to sleep disturbance include participants reporting diabetes, hypertension, high BMI, dementia, those with anxiety or depression and those with sleep disorder.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S5.

Figure S23 Repeated cross-sectional association between night-time aircraft noise and self-reported sleeplessness among people with health conditions linked to sleep disturbance using UK Biobank cohort.

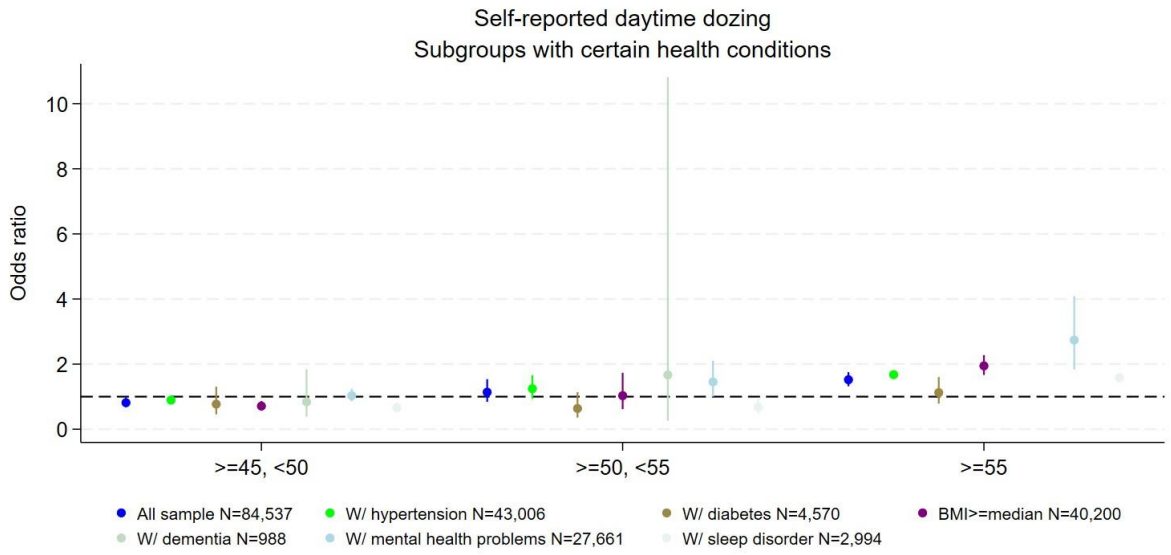


Note: The figure illustrates the odds ratios (ORs) and 95% confidence intervals (CIs). The odds ratio represents the likelihood of someone experiencing more severe sleep disturbance outcomes when exposed to noise levels ≥55dB compared with those exposed to <45 dB. The subgroups of individuals with health conditions linked to sleep disturbance include participants reporting diabetes, hypertension, high BMI, dementia, those with anxiety or depression and those with sleep disorder.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S6.

Figure S24 Repeated cross-sectional association between night-time aircraft noise and self-reported daytime dozing among people with health conditions linked to sleep disturbance using UK Biobank cohort.

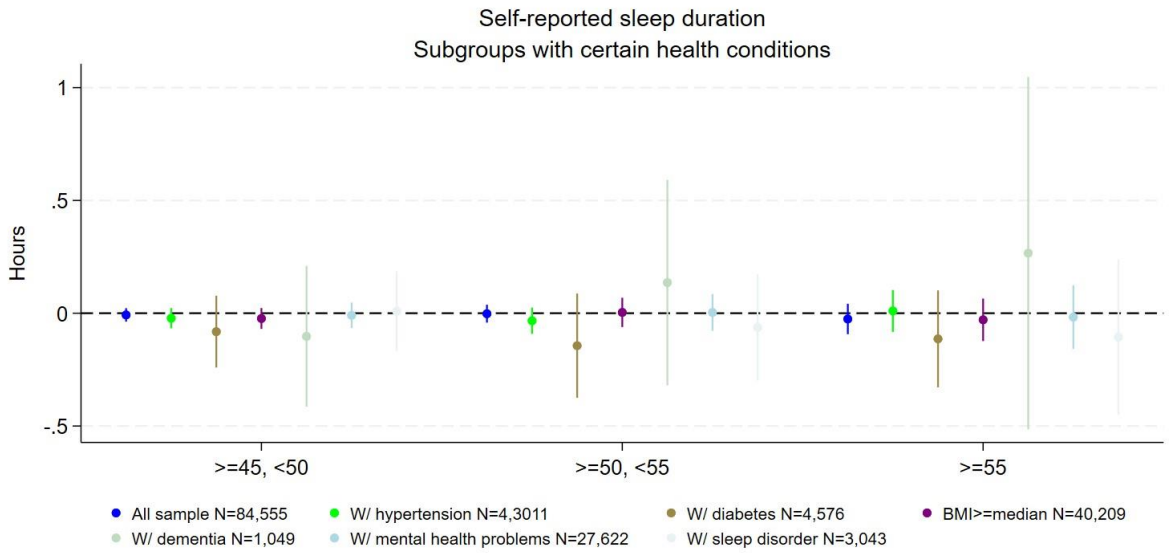


Note: The figure illustrates the odds ratios (ORs) and 95% confidence intervals (CIs). The odds ratio represents the likelihood of someone experiencing more severe sleep disturbance outcomes when exposed to noise levels ≥55dB compared with those exposed to <45 dB. The subgroups of individuals with health conditions linked to sleep disturbance include participants reporting diabetes, hypertension, high BMI, dementia, those with anxiety or depression and those with sleep disorder.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S7.

Figure S25 Repeated cross-sectional association between night-time aircraft noise and self-reported sleep duration among people with health conditions linked to sleep disturbance using UK Biobank cohort.



Note: The figure illustrates the point estimate (β) and 95% CIs. β represents the increment in the absolute value of the outcome when exposed to higher aircraft noise categories, compared to those exposed to less than 45 dB. The subgroups of individuals with health conditions linked to sleep disturbance include participants reporting diabetes, hypertension, high BMI, dementia, those with anxiety or depression and those with sleep disorder.

All models have been adjusted for sex, ethnicity, age in 2006 and 2011, BMI, ever seen a psychiatrist or doctor (GP) for nerves, anxiety, tension, or depression, smoking status, alcohol consumption, total number of vigorous or moderate physical activities (in days) a participant typically reported doing in a week, average yearly household income before tax, Townsend deprivation index at the time of recruitment from the national census output areas associated with the participant's place of residence, night-time road traffic noise, night-time rail traffic noise, NO_2 concentration, $PM_{2.5}$ concentration, and greenspace percentage within a buffer of 1000m.

The numeric results can be found in Excel Tables S8.