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Noise, agitation and somatization: A case time series analysis of military-aircraft noise exposure and pro re nata medication in a psychiatric hospital in Switzerland

Benedikt Wicki[1,2], Danielle Vienneau[1,2], Beat Schäffer[3], Thomas J Müller[4,5], Charlotte Pervilhac[5,6], Martin Röösli[1,2]

[1] Swiss TPH (Swiss Tropical and Public Health Institute), Allschwil, Switzerland
[2] University of Basel, Basel, Switzerland
[3] Empa, Swiss Federal Laboratories for Materials Science and Technology, Dübendorf, Switzerland
[4] Translational Research Centre, University Hospital of Psychiatry and Psychotherapy University of Bern, Bern, Switzerland.
[5] Private Clinic Meiringen, Meiringen, Switzerland
[6] Institute of Psychology, Health Psychology and Behavioural Meidicne, University of Bern, Bern, Switzerland

Corresponding author's e-mail address: benedikt.wicki@swisstph.ch

ABSTRACT

Existing evidence suggests that noise exposure can increase the risk for adverse mental health outcomes, such as psychiatric hospitalizations and even suicide. To investigate acute effects of noise on patients suffering from mental health disorders, we assessed short-term associations between fighter jet noise and on-demand sedative and analgesic drug administrations in a psychiatric clinic located close to a military airfield in Switzerland. We applied a case-time-series analysis using distributed-lag models with an hourly time resolution, stratified by stays at the clinic. Noise exposure was modelled using detailed flight plans and noise footprints for different aircraft and route combinations. Hourly LAeq was used as main exposure metric. Outcome data was available from the clinic's records. During the study period (06/2016–12/2021), 23,486 flights with a mean estimated LAE of 80.49 dB (SD: 8.04) at the clinic's main building occurred. 5968 stays with a median length of 41 days (IQR: 28d, 50d) were included. Analysis was adjusted for long-term and seasonal trends, day of week, time of day, time-varying weather conditions (temperature, sunshine duration, foehn wind episodes) and the week of stay to account for a treatment effect. Time-constant, individual confounders such as diagnoses were accounted for by design. The odds ratio (OR) for sedative administration following hours with 64dB LAeq (=99th percentile) compared to hours with no flights (set to 20dB LAeq) was 1.062 (95%CI: 1.017, 1.108) over a lag of 3 hours. For analgesics, the effect was larger with an OR of 1.155 (95%CI 1.077, 1.239). These results suggest that loud noise events can lead to acute feelings of distress in psychiatric patients.

Keywords (3-6): Military Aircraft Noise, Loud Events, Acute, Mental Health, Case Time Series, Psychiatry

INTRODUCTION

Far beyond just being a nuisance, evidence suggests that noise can increase the risk for mental health disorder such as depression [1] and anxiety disorders [2], and even suicide [3]. Beyond chronic effects, there are also studies suggesting that exposure to transportation noise can lead to acute adverse mental health outcomes. For example, an ecological time series study from Madrid reported an increased risk for Emergency Hospital Mental Health Admissions [4]. The authors estimate that 5.5% of all psychiatric emergency admissions in their study sample might be attributable to environmental noise.
Already 30 years ago, studies reported that patients suffering from mental or behavioral disorders are suspected to be more sensitive to noise [5]. With an estimated prevalence of 13.4% or almost 1 Billion people worldwide in 2019 [6], this concerns a considerable share of the population. Surprisingly however, evidence on the effects noise can have on this population remains scarce.
The aim of this study was to investigate short-term effects of loud environmental noise on patients suffering from mental health and behavioral disorders. To study this, we assessed associations of fighter jet noise with pro re nata (PRN, ="as needed") administration of sedatives and analgesics in a psychiatric hospital in close vicinity to a military airfield in Switzerland. We hypothesize that loud noise events can trigger inner unrest, distress, agitation and somatization, which leads to an increased probability of PRN sedative and analgesic administration in the in-patient setting.

MATERIALS AND METHODS

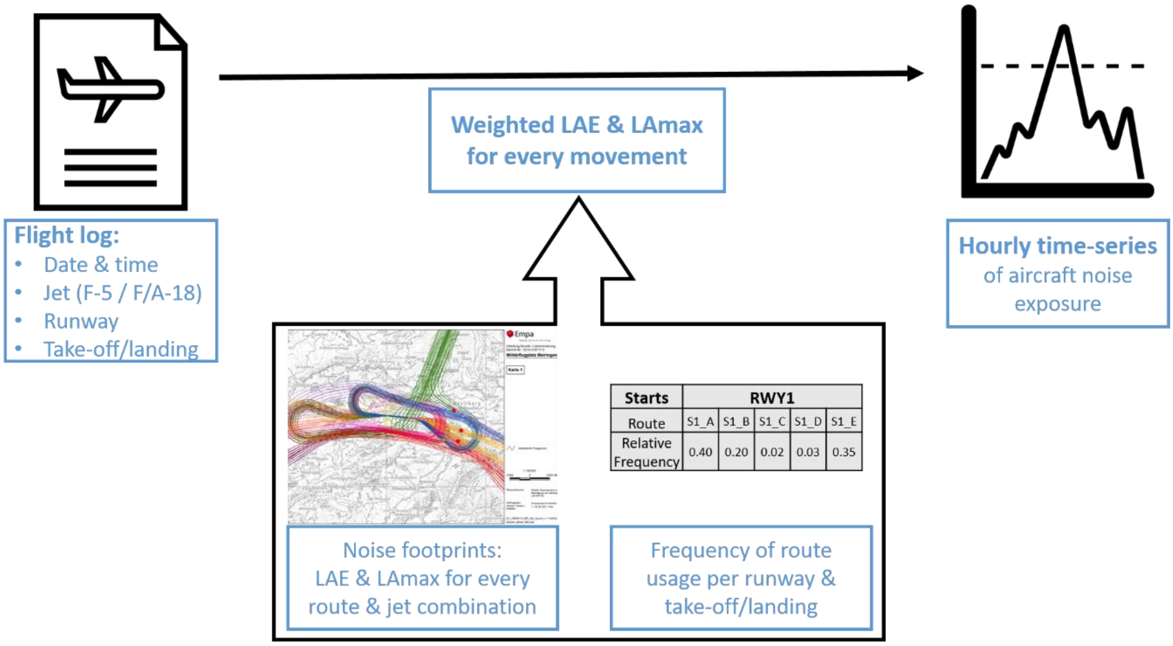
Study Setting

The Privatklinik Meiringen consists of two locations approximately three kilometers apart, one in the valley (Meiringen) and one further up on a mountainside (Hasliberg). Both sites are located roughly 6km from the military airfield, from where flights occur according to an irregular schedule. During the study period, there were two different fighter jet types in operation (F-5 and FA-18). The airfield has one runway, from which take-offs and landings are performed in both directions. In each direction, flights follow five different starting and six different landing routes. The study period lasted from June 2016 until December 2021.

Exposure assessment

For both clinic locations, we modelled the noise exposure resulting from the flying activity at the airfield as follows. Using Flula2 [7], we calculated noise footprints for every aircraft (F-5 or FA-18), runway, maneuver (take-off or landing) and route combination. From these footprints, LAE and LAmax values where assigned to the two clinic sites based on geocodes. The Swiss Air Force provided a detailed flight log including the date, time, aircraft type, maneuver and runway for each movement at the airfield during the study period, as well as relative frequencies of route usage per runway. Based on these probabilities, we calculated a weighted LAE and LAmax value for each of the eight aircraft, runway and maneuver combinations. Using the date, time and movement information from the flight log in combination with the modelled LAE values of every flight event, we then calculated the hourly equivalent continuous sound level (LAeq(h)) at the two clinic sites for the years 2016-2021. For hours without any flights, LAeq was censored at 20dB. See Figure 1 for a schematic overview of the exposure assessment process.

Figure 1: Schematic overview of the exposure assessment process



Flight log & Frequency of route usage: Provided by the Swiss Air Force.
Noise footprints: Calculated using FLULA2. LAE=sound exposure level [dB], total sound energy of a certain noise event; LAmax=Maximum sound level [dB] of a certain noise event

Outcome data collection

Outcome data was exported directly from the hospital's clinical information system. Discrimination between pro re nata and scheduled administrations was possible based on the time of administration, since scheduled administrations always take place at identical, fixed times. For the analysis concerning sedatives, pro re nata administered benzodiazepines, antipsychotics, non-benzodiazepines and antidepressants where used. Additionally, all pro re nata administered analgesics where exported. All administered doses where summed per hour for each stay at the clinic individually, and eventually dichotomized to a binary indicator for sedative and analgesic administration y/n for every hour of every stay. Stays which where 3 days or shorter were excluded.

Analysis

To assess the short-term association between aircraft noise generated from the nearby military airfield and pro re nata drug administrations, we applied a case-time series analysis of stay specific drug administrations and fighter jet noise exposure. The case-time series design combines properties of traditional time-series with self-matched study designs [8]. Its basic principle is that multiple time series with individual exposure and outcome information are combined in one model, while treating the individuals as matched risk sets. This accounts for time-constant, individual level confounders by design while retaining the longitudinal structure of time-series data.

In this study, we defined stays at the clinic as observational units of the case time series, hence constructing hourly time series of medication administrations and fighter jet noise for each stay at the clinic. The exposure-response relationship was modelled using distributed-lag linear models (DLM, [9]) with a lag duration of 0-3 hours for the main analysis. The main model included hourly LAeq as exposure, a spline to account for long-term trends and seasonality, the week of stay to account for treatment effects, and the day of the week and hour of the day as factors. Additionally, it adjusted for time-varying weather covariates temperature, daily sunshine duration and an index for foehn intensity (a warm fall wind linked with various symptoms including mental distress [10]).

RESULTS

A total of 23,486 flights occurred during the study period. Hourly LAeq values at the two locations ranged from 20dB (=censoring value) to 68.9 dB for Meiringen and to 77.5dB for Hasliberg. Median number of fighter jet flyovers with a value above 55dB (NAT55) per stay was 359 (IQR: 166, 607). A total 5968 stays with 107,640 PRN sedative and 30,826 analgesic administrations were included in the study. Median length of the included stays was 41 days (IQR: 28d, 50d), with a median number of 9 (IQR: 3, 21) sedative and 4 (IQR: 2, 10) analgesic administrations per stay.

We found that higher fighter jet noise levels increased the probability for PRN administration of analgesics and sedatives. The odds ratio (OR) for PRN sedative administration following hours with 64dB LAeq (=99th percentile) compared to hours with no flights (set to 20dB LAeq) was 1.062 (95%CI: 1.017, 1.108) over a lag of 3 hours. For analgesics, the effect was larger with an OR of 1.155 (95%CI 1.077, 1.239). Results were similar when extending the lag period to 12 hours.

DISCUSSION

In this study, we found that fighter jet noise increases the short-term probability for PRN administration of both sedatives and analgesics in a psychiatric clinic in Switzerland. The results were robust to adjustment for different meteorological covariates. These findings suggest that loud noise events can trigger acute agitation, anxiety and strong feelings of distress and inner unrest. Similarly, the increased probability of analgesic consumption following loud noise exposure is an indication that noise can cause somatization, which is a frequent, more subtle expression of psychological distress in patients suffering from mental and behavioral disorders [11].

The main strengths of our study are the availability of hourly resolution exposure and outcome data from almost 6,000 stays over more than five years. This enabled us to apply the case-time series design, which is very well suited to study short-term risk increases for acute outcomes due to environmental stressors. Additionally, by using this self-matched design, we could adjust for time-constant, individual level confounders by design without the need for a control group.

The main limitation of our study is that, since we did not have information on the exact route flights took, we had to use some approximations in the exposure assessment process. Our approach of using weighted values for flights based on runway direction, aircraft type and maneuver means that we have overestimated the exposure of the quietest flights, but also underestimated the loudest ones. However, any exposure misclassification resulting from this will be non-differential, hence having led rather to an underestimation of the true effect size.

As this is the first study exploring effects of fighter jet noise, or any transportation noise, specifically on patients with mental health disorders, direct comparison of our results to the existing literature is difficult. Two studies from Madrid, Spain have reported increased risk of mental-health related emergency admissions and suicide following days with more transportation noise [4, 12]. Our study supports these findings. We see that following hours with high fighter jet noise exposure, the probability for sedative administrations in the psychiatric clinic is increased. One of the most frequent causes for PRN sedative use in psychiatry is agitation [13]. Hence, it is very well possible that outside of psychiatric care, loud noise events can also trigger agitation and inner unrest in people with preexisting mental health disorders, which then leads to acute exacerbation of symptoms possibly resulting in emergency admissions or self-harm.

CONCLUSION

This is the first study of its kind, investigating acute effects of exposure to loud noise events in the form of fighter jet noise on patients affected by mental health disorders. We found that administration of sedatives and analgesics was more likely following exposure to fighter jet noise in a psychiatric clinic in Switzerland. This adds to the existing evidence that people with mental and behavioral disorders are a population vulnerable to noise exposure, in which noise can lead to symptom exacerbations and worsen the course of disease.

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