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Community Response to Noise and Noise Annoyance: Recent Studies and New Movements in Implementation from 2021-2023

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ABSTRACT

This review summarizes 27 studies reported by Team 6 on the community response to noise and noise annoyance between 2021 and 2023. The studies provide a more nuanced understanding of noise sources and their health impacts, which can inform public policy decisions. They also highlight the need for assessment methods to compare exposure-response functions for noise annoyance developed by different authors based on different data. Furthermore, the studies shed light on ongoing efforts to evaluate and improve noise guidelines and policies, including the establishment of an archive of survey response data to facilitate noise effects research worldwide. The studies challenge the recommended noise limits for transportation noise by the 2018 WHO Environmental Noise Guidelines for Europe, suggesting that new data should be considered to ensure that the guidelines effectively protect public health. Overall, the studies underscore the need for a multifaceted approach to noise assessment and policymaking that considers the complexities of noise exposure and its impact on human health and well-being and aims to develop effective policies to mitigate its effects.

Keywords: Community response, Environmental noise, Exposure-response relationship, Noise Annoyance

INTRODUCTION

Noise pollution from transportation sources is a growing public health concern as it affects many aspects of our daily lives. To address these issues, various studies to understand the effects of transportation noise on human health and to develop effective policies to mitigate the impacts have been conducted. Among these efforts, the community response to noise team (Team 6) has so far identified and engaged in various research topics related to the biological effects of noise. Team 6's most remarkable achievements between 2008 and 2011 include proposing individual community-based indexes, such as the Community Tolerance Level, and discussing differences in railway bonuses between Europe and Asia [1]. Additionally, they explored not only the negative aspects but also the positive aspects of sound by conducting soundscape studies. Team members addressed survey differences in annoyance response and their potential reasons to better predict the response in specific

situations. The need for more studies on cross-cultural comparisons and effect quantification of the most exposed facade in mitigation measures were emphasized. Further studies should be conducted on the effects of interventions and annoyance response to multiple noise sources.

Taking on the aforementioned tasks, between 2011 and 2014, Team 6 conducted an adaptation of the standardized annoyance questions and survey core information initially proposed by Fields [2]. They simplified the survey core information report format and uploaded it to the homepage of ICBEN. This initiative aimed to facilitate interstudy comparisons and data pooling for the development of exposure-response relationships. The prevalence of annoyance in populations exposed to transportation noise in many non-Western countries have been monitored. The methodology of monitoring community response to noise, including the influence of annoyance question wording or context, the usefulness of noise complaints in predicting the prevalence of annoyance, and the use of annoyance as a reaction measure indicative of adverse noise exposure or potential health effects have been studied. Team 6 has also derived exposure-response relationships for aircraft, road traffic, and railway noise, finding that at a given noise level, more annoyance by aircraft noise was found than by road traffic noise (aircraft penalty), and less annoyance by railway noise than by road traffic noise (railway bonus). However, there are indications that the annoyance response to aircraft noise has increased over the years, stressing the need for an update based on more recent studies with standardized methods. A new methodology to derive exposure-response relationships that better captures differences in annoyance response between communities was introduced. Several situational characteristics may ameliorate (or worsen) the effects of noise, such as good insulation or a quiet side to the dwelling, access to quietness or natural areas in the neighborhood, and views on greenery or on the sea, were revealed.

ICBEN team 6 has conducted research on combined exposure to noise in urban environments and the effects of wind turbine noise on communities. Various models have been proposed to evaluate the effects of combined exposures, with some studies suggesting that the annoyance due to the dominant source is the best predictor of total annoyance, while others have found higher annoyance with combined exposure than with individual sources. Exposure-response relationships have been derived for wind turbine noise. Sleep disturbance and psychological distress are particularly caused by the "swishing sound" or amplitude modulation of the aerodynamic noise from wind turbine blades. Overall, ICBEN team 6 studies have focuses on the community response to noise and noise annoyance in outdoor settings.

In the years 2014-2017, their activities involved reviewing peer-reviewed publications on the subject, which showed increased focus on case-specific exposure-response relationships and the influence of temporal and spectral characteristics on annoyance [3]. New research was also conducted on railway noise and vibration, wind turbine noise, interventions to reduce noise, and individual differences in noise sensitivity and annoyance. From 2017 to 2021, the team continued to take the previous defined challenges with studies focusing on transportation noise, environmental noise or soundscape, wind turbine noise, and other sources [4]. The main studied effects were noise annoyance and disturbances, soundscape perception, and health-related quality of life. Team 6 also investigated non-acoustic factors that could potentially affect noise responses. Additionally, they published a systematic review on environmental noise annoyance, which was reflected in the development of the Environmental Noise Guidelines of the World Health Organization.

In this review, we will summarize and discuss studies presented by ICBEN Team 6 in the period 2021-2023. In this summary, the studies cover a range of topics, including the ongoing development of a new ISO Technical Specification, the evaluation of the Quality of Life and health effects of noise insulation schemes, the perception of preschool children of environmental noise, the sound environment in various countries, and short-term noise annoyance due to motorcycle noise.

ROAD TRAFFIC

Annoyance is a major effect of transportation noise and a focus of Team 6's studies. The research project RESTORE conducted an extended cross-sectional field study in Zurich, Switzerland to assess the association between noise annoyance, self-reported and physiological stress, road traffic noise, and residential green areas [5]. Dopico et al. found that exposure to road traffic noise can lead to annoyance, which may trigger stress-related diseases and negatively impact quality of life. The results suggest that residential green spaces can potentially reduce negative health impacts, including noise annoyance.

Long-term and short-term investigations were conducted to assess residents' response to noise from motorcycles on busy routes in southern Germany [6, 7]. Schreckenberg et al. found that residents exposed to motorcycle noise experienced higher annoyance levels compared to other road traffic noise sources. Time-dependent differences in the impact of motorcycle noise on annoyance were assessed in more detail and closer to the event. A considerable number of complaints, especially from rural sightseeing attraction areas, specifically refer to motorcycle noise. Short-term study revealed that the percentage of highly annoyed (% HAv) due to motorcycle noise exceeded annoyance due to other road traffic sources such as passenger cars, lorries, or coaches.

Since 2020, the COVID-19 pandemic has spread globally and resulted in travel restrictions that significantly affect the sound environment in urban areas. This unprecedented situation has been the focus of Team 6's research. Argalasova et al. assessed noise annoyance trends over time in Bratislava at 10, 20, and 30-year intervals, including the situation during the pandemic [8]. They found that road traffic noise annoyance slightly declined but remains an important issue. The pandemic experience provides valuable data for developing healthy urban transportation and the necessity of implementing preventive measures to reduce traffic noise.

AIRCRAFT

More studies related to aircraft noise are reported than other sources, which suggests that aircraft noise remains the most significant concern in the field of environmental noise. Two studies assessing aircraft noise impact in the Netherlands were reported at this congress [9,10]. Longitudinal measurements of noise and annoyance caused by airplanes on citizens living near Schiphol airport showed the relevance of the perceived number of planes for annoyance. The association between aircraft noise exposure and the probability of being highly annoyed or sleep disturbed among residents living in the vicinity of 14 airports in the Netherlands was found to be airport-specific. The study recommended using recent non-linear exposure-response relationships for more accurate results for most airports.

Team 6 research also examines community responses to different changing scenarios of aircraft noise, particularly in developing nations such as Vietnam [11]. The patterns of exposure-response relationships found in this study suggest that the impact of noise change includes overreaction and underreaction depending on the airport, which deviates from what was observed in a steady state. Annoyance levels increased following the rise of operated flights compared to the pre-completion stage. However, in follow-up surveys, even though noise exposure rose, annoyance levels decreased and approached the pre-completion exposure-response relationship. As community response to noise depends on various factors other than physical sound, i.e., non-acoustic factors, the attitude towards the noise source is considered one of the important factors. The data collected around the Bangkok International Airport in Thailand [12] revealed the relationship between responses to environmental protection and the convenience of life for the population living around the airport. The result recommends that airport authorities should take these attitudinal factors into account when developing noise abatement strategies.

A longitudinal study of the Heathrow Noise Insulation Schemes involves collecting information on noise exposure within the home and individual-level information to quantify the effect of insulation on changes in health and quality of life [13]. The findings are important as they provide evidence-based insights into the effectiveness of noise insulation schemes and inform policy decisions related to aviation noise. Another significant research achievement of Team 6 is providing data to support regulatory efforts to allow supersonic flight over land at low noise levels [14]. Rathsam et al. provide an update on the community test campaign of community overflight tests to collect data on how people perceive the sounds from NASA's new aircraft design that allows for lower noise levels of supersonic flight.

RAILWAY

During this term, two studies were conducted in the Netherlands to investigate the response to vibrations caused by rail traffic [15-16]. Van Kempen el al. explored the annoyance and sleep disturbance caused by vibrations from trains on people living within 300 meters of a railway track in the Netherlands. It found that the Dutch population experienced significantly less severe annoyance due to vibrations from rail traffic in 2021 than in 2013. The study also discovered that exposure to both average and maximum rail traffic vibration levels was linked to severe annoyance and sleep disturbance, with the strongest relationships observed for freight trains. Although the different vibration exposure metrics had a high correlation, their ability to predict annoyance and sleep disturbance due to vibrations differed. Another study was conducted in the Netherlands to investigate the response of vibrations due to rail traffic using repeated measurements. Simon et al. found that the highest percentage of annoyance was reported in relation to freight trains and the percentage of severe annoyance due to vibrations from passenger trains doubled between 2013 and 2019 before decreasing again in 2021.

Another study was conducted in Germany to examine the effects of railway pass-by noise on pleasantness rankings [17]. Weidenfeld et al. found that freight trains equipped with a retrofitted brake system were preferred over those with a conventional system, regardless of their speed. The study pointed out that a ban on freight train wagons with conventional braking systems is necessary to prevent long-term exposure to unpleasant railway sounds.

Numerous efforts have been made to establish noise annoyance models based solely on energy-averaged index [18]. Marquis-Favre et al. proposed building relationships that allow for an estimation of different psychoacoustic indices from the sole knowledge of the L_{den} index given by noise maps for railway noise. The study found that these models can improve the accuracy of predicting annoyance due to railway noise and indicated their relevance for future use in environmental noise assessments. It revealed that railway noise annoyance models based on noise sensitivity and different noise indices estimated from railway noise L_{den} performed better than L_{den} based annoyance models.

OTHER NOISE SOURCES

The recent research conducted by Team 6 focuses on noise generated by industry and sports activities, such as machinery, equipment, and human physical exertion. Unlike transportation noise, which is spread out over a wide area, noise from industry and sports is often concentrated in specific locations such as factories or stadiums. Additionally, noise from industry and sports can be much louder and higher in frequency due to the use of heavy machinery and loudspeakers. These factors differentiate their impacts from transportation noise in terms of source, frequency and intensity, location and distance, and time of day. Therefore, it is crucial to gather data on industrial and sports noise for implementing effective noise control measures that can minimize their impacts on public health and the environment.

A study commissioned by the British government's Department for Business, Energy & Industrial Strategy identified evidence on the potential adverse effects of exposure to wind turbine sound [19]. The study aimed to answer whether the existing guidance should be updated considering the context of existing regulatory limits or controlling thresholds applied in the UK and in other national or regional territories. Another study by Yaman et al. examined the indoor acoustic performance of a textile industry facility in Turkey and its interpretation by employees [20]. The study found a significant and positive relationship between the noise sensitivity and noise annoyance of the employees. The study proposed measures to improve indoor acoustic performance and reduce noise in the textile industry. Another industrial noise source is mining in the Czech Republic [21]. This study focused on the impact of noise from mining activities on subjective health effects, such as annoyance and sleep disturbance, and proposed a methodology for assessing the impact of noise on subjective perceptions using a questionnaire survey. The preliminary results of the survey showed that the residents of the monitored area perceived mining noise as a significant problem. The assessment method proposed by the authors is potentially applicable to assess the impact of other industrial sources.

Finally, Kuhlmann et al. evaluated the impact of noise from sports facilities on nearby residents in six sports facilities across Germany with varying sport activities [22]. The study covered various topics, such as living conditions, noise annoyance due to different sources, sports facilities noise-related disturbances, personal and societal relevance of the local sports facility, coping strategies, and sociodemographic characteristics. The study found exposure-response curves for annoyance due to sports grounds for different days of the week. This is an important reference point for individuals and organizations seeking to prevent the harmful effects of exposure to sports noise.

EXPOSURE-RESPONSE RELATIONSHIPS

At this congress, three studies on exposure-annoyance relationships are reported. The first study compares results from annoyance surveys conducted in different noise situations [23]. Gjestland found that the results of these surveys are dependent not only on the noise situation but also on other factors, such as the wording of the annoyance questions, the presentation of questionnaires, response scales, and scoring methods for highly annoyed respondents. The paper suggests ways of comparing results from surveys conducted according to different protocols and modes of presentation. Gjestland and Evensen revisit the WHO Environmental Noise Guidelines for Europe published in 2018 [24]. Recent data from comprehensive studies in Switzerland and survey results from the UK and the US indicate that the recommended limits for transportation noise to avoid adverse health effects may be too stringent. The new data suggests that the limit values for noise exposure should be about 10 dB more lenient than those recommended by WHO. This finding has significant implications for noise policy and regulation.

The third study focuses on comparing exposure-response functions for annoyance [25]. The paper highlights some fundamental issues concerning statistical intervals used in these comparisons. Brown suggests that different intervals should be used depending on whether the functions being compared are from individual exposure-response studies or have been synthesized from multiple exposure-response functions. Brown argues that the Tolerance Interval, rather than the Confidence Interval, is required to assess how an exposure-response function from an additional study conforms to a function previously synthesized from multiple studies. The Tolerance Interval provides additional insight into the latest WHO annoyance synthesis. In summary, these studies provide important insights into the complexity of noise annoyance and exposure-response functions. The findings from these studies have implications for noise policy and regulation and suggest that more research is needed to refine exposure-response functions and improve noise management strategies.

NOISE ASSESSMENT METHODS

Noise assessment methods are crucial for identifying the sources of noise, measuring their intensity and frequency, assessing their potential harm to human health and the environment, and ensuring that individuals are not exposed to harmful noise levels. At this congress, four studies presented updates in noise assessment methods, along with two databases that enhance the determination of noise levels and impact in various settings.

Hongisto presents three psychoacoustic experiments on annoyance penalties due to tonal, impulsive, and amplitude-modulated characters in noise [26]. The results show disagreement with the constant penalty applied by many countries for noise carrying specific properties such as tonality or impulsiveness.

To better understand the influence of non-acoustic factors on community response to noise, a new working group by ICBEN is developing an ISO Technical Specification to standardize the characterization and use of non-acoustic factors for both noise and soundscapes assessments [27]. This new specification is expected to be a powerful tool for assessing noise impact in the future.

Concerning the impact of noise on young children, Schreckenberg et al. proposed a qualitative approach to assess preschool children's perception of their living environment [28]. The children were accompanied by a researcher and one parent on a walk around their neighborhood to gain a better understanding of their perception and experience of their living environment. The method of walking interviews was found to be effective for preschool children. Tokashiki focused on the noise worrisome during remote work and classes at home during the COVID-19 pandemic [29]. The findings provide insight into the current noise problem in Okinawa Prefecture and highlight the importance of considering sound environment in remote work and daily life.

Efforts have been made to establish a reasonable exposure-response relationship to set reasonable standard noise levels in environmental policies. Two independent projects have been implemented to build databases that contribute to updating that relationship curve. Lochmann developed an open database with primary data from noise annoyance studies to improve the accuracy of exposure-response functions [30]. The study shows limitations in the fitting method used for the "full-WHO" road noise annoyance function and suggests a different fitting approach. The other effort is the establishment of the ICBEN Socio-Acoustic Survey Archive (ISAR) to pool response data from socio-acoustic surveys for generalized exposure-response relationships [31]. Team 6 has publicized, promoted the archive, and encouraged the colleagues to share their survey data with the archive for new research on the biological effects of noise.

RECOMMENDATIONS FOR FUTURE TEAM ACTIVITIES

Based on the studies conducted by Team 6 in the 2021-2023 term, Team 6 identified the following issues for the next term:

(1) Conduct further research on noise assessment methods: Noise assessment methods are crucial to evaluate the potential harm that excessive noise exposure may cause to human health and the environment. Therefore, it would be beneficial for Team 6 to conduct further research on noise assessment methods and explore ways to improve these methods.

(2) Develop standardized protocols for non-acoustic factors in noise assessments: A new working group of ICBEN is developing a new ISO Technical Specification to standardize the characterization and use of non-acoustic factors for both noise and soundscapes assessments. Team 6 could contribute to this effort by developing standardized protocols for using non-acoustic factors in noise assessments.

(3) Conduct studies on noise impact on young children: Team 6 could conduct further studies on the impact of noise on young children and explore effective methods to assess their perception of their living environment.

(4) Contribute to the development of exposure-response functions: Two independent projects aimed at building databases that can contribute to updating exposure-response functions for noise. Team 6 could contribute to these efforts by sharing data from noise annoyance studies and conducting new research on the biological effects of noise, which could contribute to updating exposure-response functions for noise.

(5) Consider the impact of noise during remote work and classes: As remote work and classes continue to be a prevalent part of daily life, Team 6 could consider the impact of noise on individuals during these activities and explore ways to minimize excessive noise exposure.

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