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Pathways linking residential noise and air pollution to mental ill-health in young adults

Angel M. Dzhambov[a,*], Iana Markevych[b,c], Boris Tilov[d,e], Zlatoslav Arabadzhiev[f], Drozdstoj Stoyanov[f], Penka Gatseva[a], Donka D. Dimitrova[g]

[a] Department of Hygiene and Ecomedicine, Faculty of Public Health, Medical University of Plovdiv, 15A Vassil Aprilov Blvd., 4002 Plovdiv, Bulgaria
[b] Institute and Clinic for Occupational, Social and Environmental Medicine, University Hospital, LMU Munich, Munich, Germany
[c] Institute of Epidemiology, Helmholtz Zentrum München – German Research Center for Environmental Health, Neuherberg, Germany
[d] Medical College, Medical University of Plovdiv, Plovdiv, Bulgaria
[e] Department of Management, Faculty of Economics and Management, University of Agribusiness and Rural Development, Plovdiv, Bulgaria
[f] Department of Psychiatry and Medical Psychology, Faculty of Medicine, Medical University of Plovdiv, Plovdiv, Bulgaria
[g] Department of Health Management and Healthcare Economics, Faculty of Public Health, Medical University of Plovdiv, Plovdiv, Bulgaria

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ABSTRACT

Background: Recent years have seen growing, but still tentative, evidence of the potential associations of environmental noise and air pollution with mental disorders. In the present study, we aimed to examine the associations between residential noise and air pollution exposures and general mental health in young adults with a focus on underlying processes

Methods: We sampled 720 students (18–35 years) from one university in the city of Plovdiv, Bulgaria. Residential noise (L_{Aeq}; day equivalent noise level) and air pollution (NO_2) were assessed at participant's residential address by land use regression models. General mental health was measured with a short form of the General Health Questionnaire (GHQ). The following putative mediators were considered: annoyance from environmental pollution, sleep disturbance, restorative quality of the neighborhood, neighborhood social cohesion, and commuting/leisure time physical activity. Structural equation modeling was used to analyze the theoretically-indicated interplay between exposures, mediators, and GHQ.

Results: We observed an association between higher L_{Aeq} and GHQ, in which environmental annoyance and neighborhood restorative quality emerged as key mediators. First, L_{Aeq} was associated with higher annoyance, and through it with lower restorative quality, and then in turn with lower physical activity, and thus with higher GHQ. Simultaneously, higher annoyance was associated with higher sleep disturbance, and thereby with higher GHQ. NO_2 had no overall association with GHQ, but it was indirectly associated with it through higher annoyance, lower restorative quality, and lower physical activity working in serial.

Conclusion: We found evidence that increased residential noise was related to mental ill-health through several indirect pathways. Air pollution was associated with mental health only indirectly.

1. Introduction

The global burden of mental disorders is continuously rising and inflicts considerable social and economic losses to society. Some 4% of the population suffers from a common mental disorder – that is, 322 million people in the world live with depression, and 264 million, with anxiety (WHO, 2017). That translates into 50 million years lived with disability due to depression and 24.6 million due to anxiety (WHO, 2017).

In addition to genetic and psycho-social risk factors (WHO, 2016), recent years have seen growing, but still tentative and inconclusive, evidence of the potential detriment of environmental noise and air pollution (Stansfeld et al., 1996; Orban et al., 2016; Lim et al., 2012; Power et al., 2015; Tzivian et al., 2015). Several mechanistic hypotheses have been proposed to explain observed associations. For instance, individuals exposed to noise report annoyance (Guski et al., 1999), which has been proposed as a mediator linking noise to mental ill-health (van Kamp et al., 2013). Our previous study (Dzhambov et al., 2017) illustrated how road traffic noise may be associated with higher noise annoyance, which in turn may increase interpersonal distance and

* Corresponding author.
E-mail address: angelleloti@gmail.com (A.M. Dzhambov).

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social isolation in the neighborhood, and thus lead to mental ill-health. Increased annoyance may also constrain psychologically-restorative person-environment encounters in the neighborhood, and consequently limit outdoor physical activity and social interactions, and in turn lead to mental ill-health.

According to Frei et al. (2014), noise annoyance mediates the effect of nighttime noise on self-reported sleep quality, whereas objective sleep quality is independent of annoyance. Our previous model, however, did not consider sleep disturbance, which may be an important mediator between noise and mental health (Tiesler et al., 2013; Sygna et al., 2014) or lead to daytime sleepiness and decreased willingness to engage in physical activity (Roswall et al., 2017), which in turn may diminish mental health (Dzhambov et al., 2017). Another caveat that should have been considered is that there may be a reciprocal association between poor mental health and noise annoyance (van Kamp et al., 2013; Schreckenberg et al., 2017). Incorrect model specification and failure to account for the fact that mediators may be intertwined could be one of the reasons for the heterogeneous findings in the literature (Dzhambov et al., 2017).

Previous studies have focused on the biological pathways linking air pollution to mental health (Tzivian et al., 2015). Some air contaminants may influence neurobehavioral functions by entering the brain directly through the olfactory system (Doty, 2008) or by promoting pro-inflammatory cytokines that penetrate the blood-brain barrier (Genc et al., 2012). Thus, fine particles may induce neuroinflammation and neurodegeneration (Calderón-Garcidueñas et al., 2015). In addition to these biological pathways, perceived air pollution engenders cognitive stress, which leads to perceived symptoms of ill-health (Elliott et al., 1999; Stenlund et al., 2009; Claeson et al., 2013; Klaeboe et al., 2008). Furthermore, akin to noise, air pollution may reduce neighborhood restorative quality through higher annoyance (von Lindern et al., 2016), and thereby inhibit mental health-supporting behaviors outdoors (cf. Dzhambov et al., 2018a). However, epidemiological research is still in its infancy and the concurrent effects of noise and air pollution have received modest attention in the literature (Tzivian et al., 2015).

The present study examines associations between residential noise and air pollution exposures and general mental health in a sample of students. We specifically focus on different underlying processes. (Fig. 1) Understanding how these pathways may work together should enable practitioners to adequately tailor future preventive interventions for the improvement of mental health.

2. Methods

2.1. Study design and sampling

Data were collected between October and November 2017 from the Medical University in the city of Plovdiv, which is the second largest city of Bulgaria. To be included in our study, students had to be aged 18 – 35 years and to reside in Plovdiv or the near provinces in Southern Bulgaria for at least six months (See Supplementary Fig. S1 for location of the study area). We targeted potential participants with different ethnic and cultural background, age, and program enrollment (Faculties of Medicine, Dental Medicine, Pharmacy, Public Health, and the Medical College) to ensure sufficient variation in the data. During a class/lecture, members of the research group advertised the study as an omnibus survey on "neighborhood environment and quality of life", and asked the students to complete a questionnaire. Since a member of the research group was present, participants had the opportunity to give feedback and receive clarifications about each question. In addition to questions on sociodemographic factors, residential environment, mental and general health, participants were asked to report their residential address for subsequent assignment of air pollution, noise, and other geographic variables. The study design was approved by the Ethics Committee at the Medical University of Plovdiv (Dzhambov et al., 2018a). Participants signed informed consent forms. No incentives were offered.

Of the 1000 students invited, 823 agreed to participate (82% response rate). Residential addresses were converted to geocodes manually by inspecting each address with the help of Google maps. We were able to successfully geocode the residences of 720 students (89.2% residing in Plovdiv), which comprised our analytical sample. The rest had provided vague description of their address or no address at all.

2.2. Exposures to residential noise and air pollution

Residential noise exposure (L_{Aeq}; day equivalent noise level) was obtained by applying a land use regression (LUR) model. The LUR was developed specifically for this study and is based on noise measurements carried out by the Regional Health Inspection at 40 locations (traffic sites, industrial sites, sites in residential and recreational areas) in Plovdiv in 2016 (range: 62.4–73.5 dB(A)). Measurements were conducted over the 12-h period from 07.00 to 19.00 h, according to the ISO 1996–2:1987 (SPECTRI, 2017). Predictor variables were derived from the Geographical Information System. Regression equation followed a supervised forward stepwise selection procedure previously described by Aguilera et al. (2015). The final LUR has an adjusted R^2 of 0.72 and leave-one-out cross validation R^2 of 0.65. Further details are reported elsewhere (Dzhambov et al., 2018b).

Nitrogen dioxide (NO_2) was calculated as a proxy for residential traffic-related air pollution. We used a global LUR model for NO_2 with an adjusted R^2 of 0.52 and a root-mean-square error of 4.8 ppb (9.02 μg/m^3) (observed range 0 – 47 ppb (0 – 88.36 μg/m^3) in the European region) (Larkin et al., 2017). Briefly, the model was constructed by using data from air quality monitoring stations, satellite-based NO_2 and other commonly used geographic variables related to air pollution (Larkin et al., 2017). Predicted L_{Aeq} and NO_2 values ($n \approx 1\%$) outside the observed range of the measurements used to construct the respective LURs, were recoded to the closest observed value. Geographic data management and calculations were carried out using ArcGIS 10.3–10.4 (ESRI, Redlands, CA, USA).

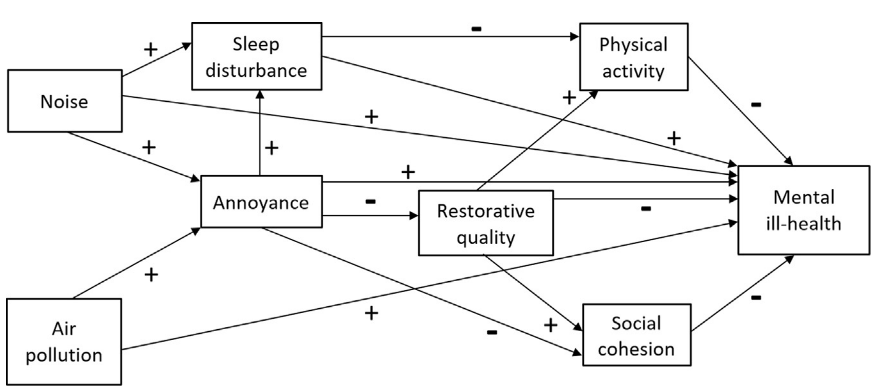

Fig. 1. Conceptual diagram showing theoretically-indicated pathways linking residential noise and air pollution to mental ill-health.