MADRID
inter.noise 2019
June 16 - 19
NOISE CONTROL FOR A BETTER ENVIRONMENT

Urban built environment, environmental exposures and mental health in a dense Mediterranean city

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ABSTRACT

The urban built environment and environmental exposures such as road traffic noise and ambient air pollution could affect mental health, but it's unclear how these factors interact. We aimed to study these factors simultaneously to holistically evaluate the impact on mental health. This cross-sectional study was based on a population-based sample of 3216 individuals aged 15-97 years residing in Barcelona, Spain that participated in the Barcelona Health Survey 2016. A face-to-face interview was carried out by trained interviewers at the respondent's residence. We characterized the built environment (e.g. facility richness), road traffic noise, and ambient air pollution at the residential level using a geographical information system (GIS). Mental health was assessed with the 12-item General Health Questionnaire. Built environment, road traffic noise and air pollution indicators were low-to-moderately correlated with each other. Higher facility richness was associated with a higher likelihood of poor mental health, while living in higher altitude areas appeared to benefit mental health. Noise and air pollution

indicators were associated with poor mental health, but this was only statistically significant for coarse particulate matter. This cross-sectional study shows that characteristics of the built environment and air pollution were associated with mental health. Further analysis is needed to shed light on interrelations between these factors and pathways to poor mental health.

Keywords: Urban Built Environment, Road Traffic Noise, Mental Health
I-INCE Classification of Subject Number: 63

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1. INTRODUCTION

Cities play a crucial part in public health. On the one hand because more than half of the world's population lives in cities. On the other hand, because our living environment affects our health in many ways. At the same time, cities can make a difference to public health because they are able to make local planning and policy for health. This has been shown by the *Healthy Cities* movement that is empowering local governments to put health and equity high on their agenda (1).

Urban living has been associated with higher risk of mental health problems (2,3). Some studies suggest that urban exposures including noise and air pollution are associated with deterred mental health (4–6), although not consistently (7). Others have shown mental health benefits associated with urban green space (8) and neighborhood walkability (9). Urban-related exposures such as traffic noise, ambient air pollution, lack of natural space and features of the built environment (e.g. walkability and building density) may affect mental health, but are often studied separately (10). We aimed to study these factors simultaneously to holistically evaluate the impact of the urban environment on mental health.

2. METHODS

2.1 Sample

This cross-sectional study was based on a population-based sample of 3216 individuals aged 15-97 years residing in Barcelona, Spain that participated in the Barcelona Health Survey 2016. Respondents were randomly selected from the municipal register of residents, while taking into account the age and sex structure of districts for representativeness purposes. A face-to-face interview was carried out by trained interviewers at the respondent's residence.

2.2 Exposure assessment

Residential addresses at the time of the study were geocoded and used for exposure assessment of the urban built environment and environmental exposures around the residences. We followed the HELIX methodology for exposure assessment of the urban built environment and environmental exposures in Barcelona (11) by using a geographical information system (GIS). Building density in 100m buffers was calculated using a topographic map (ICC). Population density in 100 and 300m was calculated as inhabitants/km^2 using data from Catalunya population grid 2016 and EUROSTAT. Facility richness in 300m buffers was calculated as the number of different facilities divided by the maximum number of potential facilities. The following facility types were included: business, community services, educational institutions, entertainment, financial institutions, hospitals, parks and recreation, restaurants, shopping, transportation hubs and travel destinations. Land use mix in 300m buffers was based on Shannon's Evenness Index (SEI), and was calculated by multiplying each proportion of land use type by its logarithm and dividing the sum of all land use type products by the logarithm of the total possible land use types. Included land use types were residential, commercial, entertainment, and office development. The average slope within 50m buffers was calculated based on altitude data from the ICC topographic map. Intersect density was calculated as the number of intersects within 300m, with data inputs from the Barcelona traffic map (2014). A walkability index was created as an average of the deciles of following variables: population density, facility richness, land use mix, and intersect density (all in 300m buffers). Green space was assessed with a number of indicators. The total green space area within 50, 100, and 300m buffers, and the linear and network distance to the nearest green space was calculated with data inputs from the MCSC version 4 and Urban Atlas land use maps. Surrounding greenness was calculated as the average Normalized Difference Vegetation Index (NDVI) in 100, 300, and 500m buffers. NDVI data was based on satellite images from Landsat 8 (2016).

Road traffic noise levels (*Lden*, the average 24-hr sound pressure with a 5dB added penalty for evening values and a 10 dB added penalty for night values), averaged for year 2012 and obtained from the Barcelona Strategic Noise Map, were calculated in accordance with the Environmental Noise Directive 2002/49/EC. Noise levels were estimated at the street-level and were linked to participants' residences. Air pollutants (NO_2, NO_x, $PM_{2.5}$, PM_{10}, PM_{coarse}, and $PM_{2.5absorbance}$) were estimated with Land Use Regression (LUR) models for Barcelona developed within the ESCAPE project (12,13).

2.3 Mental health status

Mental health status was assessed with the 12-item General Health Questionnaire (GHQ-12). The GHQ-12 is a valid and reliable screening tool for non-psychotic psychiatric problems (i.e. mental health status) in the Spanish population (14).

The mental health score was dichotomized with those having a general score ≥3 being classified as being at risk of psychiatric problems following guidelines (15).

2.4 Covariates

The covariates were chosen a priori based on previous studies (16,17). Age, sex, marital status, place of birth, education level, household income, perceived income situation, social class, and length of residence were collected within the Barcelona Health Survey during the interview. Unemployment rate (% persons aged >16 years unemployed at census level), % illiteracy (census level), and % of immigrants (census level) were used as indicators for area-level socioeconomic status and were obtained from the Vulnerability Atlas Spain 2001-2011.

2.4 Statistical analysis

Descriptive statistics were used to characterize the study population, and were calculated by mental health status (at risk of poor mental health; good mental health). Pearson's correlations between the exposures were calculated and plotted on a heatmap [corrplot Rpackage (version 0.84; R Development Core Team)] to show the relations between continuous exposures. Associations between each of the environmental exposures and mental health were estimated using mixed effects logistic regression with random intercepts defined at the district level. Analyses were adjusted for age, sex, marital status, place of birth, education level, household income, perceived income situation, social class, length of residence and area-level unemployment rate. Finally, we used factor analysis to capture patterns of the environmental exposures and to reduce the number of exposures. We retained three factors: *dense, walkable, polluted; less dense, mixed land use, hilly, green; and less dense, low altitude, lower area SES.* Associations between the three factors and mental health were estimated using a mixed effects logistic regression as described above.

3. RESULTS

In total, 3216 respondents had complete exposure, outcome and covariate data. Respondents had a mean age of 49 years, 52% was female, and 18% was at risk of having mental health problems.

3.1 Characteristics of the urban built environment and environmental exposures

Correlations between all urban built environment and environmental exposure variables are shown in Figure 1. Built environment indicators showed moderate to strong correlations with green space indicators. For example, building density and facility richness correlated most strongly with green space indicators. Facility richness and slope also showed correlations with air pollution indicators, but less so with road traffic noise. Most, but not all, green space indicators were moderately correlated with air pollution and noise. Noise showed moderate correlations with all air pollutants, except with PMcoarse. Indicators of area socioeconomic status showed weak to moderate correlations with the other urban exposome variables.

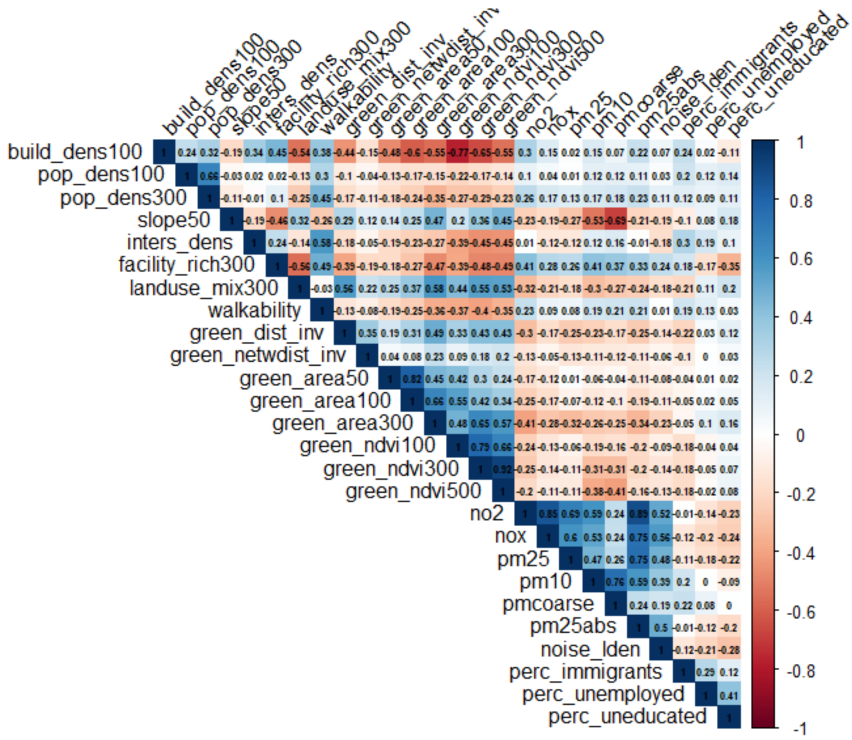

Figure 1. Correlations between urban built environment and environmental exposures

3.2 Associations with mental health

Higher facility richness within a 300m buffer around the residence was associated with a higher likelihood of poor mental health (per IQR: 1.01, 95% CI 1.00, 1.01). A higher average slope within a 50m buffer around the residence was associated with a lower likelihood of poor mental health (per IQR: OR 0.88, 95% CI 0.81, 0.95). Associations between green space indicators and mental health were generally OR<1, but not statistically significant. Associations between noise and air pollution indicators and poor mental health were OR>1, but only statistically significant for PMcoarse (per IQR: OR 1.27, 95% CI 1.07, 1.51). A mixed model including scores of the three factors revealed that living in a dense, walkable and polluted environment was associated with a higher likelihood of poor mental health (OR 1.14, 95% CI 1.02, 1.27), as was living in a less dense, low altitude and low area SES environment (OR 1.13, 95% CI 1.00, 1.26). Living in a less dense area with mixed land use, higher altitude and green space appeared to be protective for poor mental health, although not statistically significant (OR 0.93, 95% CI 0.83, 1.04).

4. Discussion

In this cross-sectional study of 3216 respondents from the Barcelona Health Survey, we observed protective and harmful associations between environmental exposures and mental health. This study was based on a rich dataset that enabled us to assess multiple environmental factors at a time whereas previous studies mostly focused on one environmental factor in isolation. However, the cross-sectional design does not allow for establishment of the direction of the observed associations. Furthermore, this study focused on residential exposures and this exposure does not reflect other exposure people have outside their residential environment. Future studies need to focus on environmental exposures and mental health over space and across time (18).

5. CONCLUSION

This cross-sectional study found that characteristics of the built environment and environmental exposures were associated with mental health. Further analysis is needed to shed light on interrelations between these factors and pathways to poor mental health. The preliminary results show that urban design could be a powerful tool to confront public health challenges and create healthier cities.

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