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Residential landscape as a predictor of psychosocial stress in the life course from childhood to adolescence

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ABSTRACT

Background: The effects of residential landscape, i.e., land use and traffic, on psychosocial stress in children are unknown, even though childhood stress might negatively affect normal development. In a longitudinal study, we investigate whether the residential landscape predicts childhood psychosocial stress and whether associations are independent of noise and air pollution.
Methods: Belgian children aged 6.7–12.2 (N = 172, 50.9% boys) were followed for three years (2012–2015). Information on stress was obtained using standardized behavioral and emotional questionnaires and by a measure of hair cortisol. Residential landscape, including natural, agricultural, industrial, residential areas, and traffic, in a 100-m to 5-km radius around each child's home was characterized. Cross-sectional and longitudinal associations between psychosocial stress and the residential landscape were studied using linear regression and mixed models, while adjusting for age, sex, and parental socioeconomic status.
Results: Natural landscapes were positively associated with better emotional status (increased happiness and lower sadness, anxiousness, and total negative emotions, $\beta = 0.14–0.17$, 95% CI = 0.01–0.30). Similarly, we observed an inverse association between residential and traffic density with hyperactivity problems ($\beta = 0.13–0.18$, 95% CI = 0.01–0.34). In longitudinal analyses, industrial area was a predictor of increases in negative emotions, while a natural landscape was for increases in happiness. Only the effect of natural landscape was partly explained by residential noise.
Conclusion: Residential greenness in proximity to a child's residence might result in a better childhood emotional status, whereas poorer emotional status and behavioral problems (hyperactivity problems) were seen with residential and industrial areas and increased traffic density in proximity to a child's home.

1. Introduction

Exposure to nature has beneficial effects on human health, whereas decreased exposure to nature may result in poorer health. The literature shows that a lack of green environment might increase weight, type 2 diabetes, cardiovascular disease, anxiety disorders, and depression (Lachowycz and Jones, 2011; James et al., 2015; Bodicoat et al., 2014; Maas et al., 2009; McEachan et al., 2016; Beyer et al., 2014). Similar associations are also seen with urban environments, e.g., traffic and industrial areas, which could increase depressive symptoms and lower general psychological health (Orban et al., 2016; Marques and Lima, 2011). An explanation for these findings might be supported by the Biophilia hypothesis of Wilson (1984) which suggests that humans have evolved to focus on life and lifelike processes (e.g., nature and plants). Ulrich's psycho-evolutionary theory elaborates further on this, that exposure to nature might reduce stress (Ulrich et al., 1991).

Thus, land use might have an influence on an individual's psychological state and psychosocial stress level. Psychosocial stress refers to a chronic state of psychological and/or social stressor load, which leads to prolonged activation of three highly integrated systems, i.e., the immune, nervous, and endocrine systems, with detrimental physiological consequences, such as cardiovascular and neurodegenerative

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disorders (McEwen, 2007; Danese and McEwen, 2012). The literature on adults shows, in correspondence with the psycho-evolutionary theory, that green space could reduce stress (Roe et al., 2013; Thompson et al., 2012; Nielsen and Hansen, 2007; Lee and Maheswaran, 2011; Grahn and Stigsdotter, 2003).

Despite the current knowledge that land use might influence psychosocial stress in adults, empirical evidence of this effect during childhood and adolescence is lacking, even though psychosocial stress at this age might be harmful for future health conditions. Therefore, we evaluated an affluent and densely populated society to determine whether different types of residential landscape, described by land use (semi-natural and forested areas, agricultural areas, industrial areas, and residential areas) and traffic (residential traffic density and proximity to major roads) impact psychological stress during the development of a human from child to (young) adolescent. We collected data over a three-year follow-up period from childhood to adolescence and measured both subjective and objective stress levels to address this association. To shed light on a possible pathway by which the residential landscape might affect psychosocial stress, we additionally investigated whether associations between the residential landscape and stress are independent of noise and air pollution. After all, the effect of residential landscape on psychosocial stress might be (1) directly by natural (green) elements creating visual/psychological stimulations and physical activity possibilities which can be reflected by land use but (2) also indirectly by noise and air pollution as a result of the land use and traffic.

2. Methods

2.1. Study population

In 2015, 242 Belgian children and adolescents aged 9 to 15 years from the municipality of Aalter and its surroundings participated in the sixth wave of a large longitudinal study. The baseline survey was conducted in spring 2008, with follow-up surveys in spring 2010, 2011, 2012, 2013, and 2015, as part of different study projects (Ahrens et al., 2011; Michels et al., 2012). For the current article, we used data from 2012 onward because of incomplete stress questionnaires and address information before 2012. Children were included based on the availability of stress data, residential landscape, and parental socioeconomic data (parent with the highest achieved education based on the International Standard Classification of Education (2010)) in 2015, as can be seen in the flow-chart in Fig. 1. For the longitudinal analysis, we included children who did not move between 2012 and 2015. Children without stress data (N = 7) and socioeconomic status (N = 11) were excluded, which resulted in 224 subjects in 2015. The number of children with hair cortisol data (N = 153) is limited because this was an optional part of the survey, and sometimes the hair was not long enough for analyses. No differences in age, residential landscape, and stress were seen between children with and without hair cortisol data; however, included children were more often female and had a lower hyperactivity score. All children were Caucasian, except one of African origin. The study was conducted according to guidelines laid down in the Declaration of Helsinki, and the project protocol was approved by the Ethics Committee of the Ghent University Hospital. A written informed consent was obtained from the parents and a verbal assent from the children. In 2015, children older than 12 years also signed a written informed consent.

2.2. Geographical area

Study participants were from the municipality of Aalter and its surroundings, located approximately 20 km west of Ghent, Belgium, with a population density of 240.7 inhabitants per km^2 in 2011 (Municipality characteristics (Uw gemeente in cijfers), 2011). Location of study participants and the distribution of land-use indictors in this geographical area are shown in Supplemental Fig. S1. Directly south of the city is a major motorway and to the north are primarily food processing industries (milk, meat), which are mainly small to middle sized. Most of the hinterland consists of agricultural areas with a majority of grassland and maize areal. Approximately 10 km north of Aalter is a small airport used by ultra-light aircrafts during the weekends.

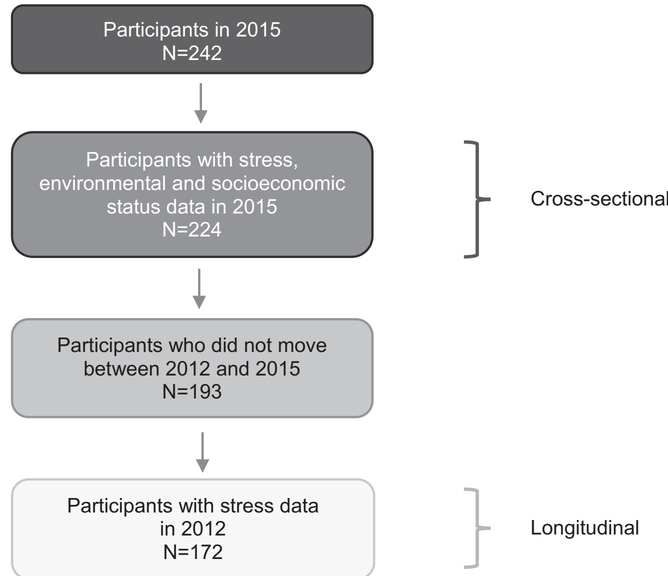

Fig. 1. Flow chart of inclusion and exclusion of study participants.

2.3. Psychosocial stress parameters

Stress arises when the demands of a situation exceed an individual's ability to cope and resolve the problem, resulting in emotional and behavioral disturbances (McCance et al., 2006). Three stress-related tests were used to assess different aspects of a child's stress in 2012 and 2015. First, children were questioned about recent feelings of happiness, sadness, anger, and anxiousness using a 0–10 Likert scale, with 0 as the lowest score and 10 as the highest score. Total negative emotions were obtained by adding up the negative emotions: sadness, anger, and anxiousness. Second, parents filled in the Strength and Difficulties Questionnaire (SDQ) to assess behavioral problems during the past six months (reliability: ICC = 0.80; concurrent validity: r = 0.70) (Goodman, 1997). The SDQ consists of 25 questions that can be divided into five subscales (each having five items): conduct problems, hyperactivity problems, emotional problems, peer relationship problems, and prosocial behavior (Goodman, 1997). In addition, a general total difficulty score was calculated by adding up all subscales except the prosocial behavior scale (since this is a strength). Finally, hair cortisol was used as an objective stress biomarker (higher cortisol representing higher stress); however, it was only used in 2015 (Wester and van Rossum, 2015). A hair strand with a diameter of 3–5 mm was cut close from the back of the scalp. Only the proximal 3 cm of the strand was analyzed, as this would reflect stress exposure during the last three months. Extraction and liquid chromatography coupled with tandem mass spectrometry was performed at the Laboratory for Hormonology, Ghent University Hospital, Belgium. For analysis on 15 mg of hair, inter-assay CV for cortisol is 10.8% with an LOQ of 1.6 pg/mg hair. Detailed laboratory analyses are described elsewhere (Michels et al., 2017). None of the participants took systematic corticosteroids.

2.4. Land use and residential proximity to traffic

Residential addresses of the participating children and adolescents were geocoded. Semi-natural, forested, and agricultural areas