Environmental Research 200 (2021) 111326

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

The relationship between residential proximity to outdoor play spaces and children's mental and behavioral health: The importance of neighborhood socio-economic characteristics

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ARTICLE INFO

Keywords:
Childhood mental and behavioral health
Disorders of psychological development
Urban environment
Green space
Play space

ABSTRACT

Urban outdoor play spaces are reported to improve children's health. However, there is little empirical evidence on the impact of outdoor play spaces on childhood mental and behavioral health. To fill this gap, we investigated the associations between residential proximity to outdoor play spaces and the prevalence of diagnosed mental and behavioral disorders. We explored whether these associations differ by individual and area-level socio-economic status (SES). This cross-sectional study included 151 110 children who were 0–12 years old in 2014 and were visited in public primary health care centers in Barcelona (Spain). Each child's demographic and mental and behavioral disorders information was extracted for 2005–2014, including diagnoses on disorders of psychological development together with other four types of mental and behavioral disorders. The pediatrician diagnosed mental and behavioral disorders we explored in this study were: mood/affective; neurotic, stress-related and somatoform; psychological development; behavioral and emotional; and overall mental and behavioral disorders. We assessed 300 m network buffer residential proximity to overall outdoor play spaces (i.e., the overall sum of play spaces of any type), outdoor green play spaces, and to a diversity of outdoor play spaces. We used robust Poisson regression models to investigate the association between proximity to outdoor play spaces indicators and each health outcome. We tested interaction terms for indicators of proximity to outdoor play spaces and individual and area SES. For measures with significant interaction terms, we conducted stratified models. We found residential proximity to outdoor play spaces to be protective of disorders of psychological development. Proximity to overall outdoor play spaces, proximity to outdoor green play spaces and proximity to a greater diversity of outdoor play spaces were associated with a 4% (95% CI: 1,7), 4% (95% CI: 1,7) and 5% (95% CI: 2,9) lower prevalence rates of disorders of psychological development respectively. Most of the associations were found to be in the same direction-although more pronounced-in low SES areas, but in the opposite direction for children living in high SES areas. No differences in these associations were found by individual SES.

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https://doi.org/10.1016/j.envres.2021.111326
Received 7 January 2021; Received in revised form 16 April 2021; Accepted 10 May 2021
Available online 21 May 2021

Residential proximity to outdoor play spaces is protective of children's mental and behavioral health living in low SES areas.

1. Introduction

Today, cities in the Global North face the challenge of having unprecedented high prevalence levels of childhood mental disorders (Amoly et al., 2014; Flies et al., 2019). A growing field of research at the intersection of public health and urban planning is enquiring the specific urban social and built-environment conditions that benefit or harm human development in the first years of life (Derr et al., 2017; Flouri et al., 2014; Malone, 2013). Increasing attention is also paid to environmental (health) justice questions enquiring inequities in the distribution of urban social and built-environment conditions and their associated health benefits or harms by neighborhood disadvantage, racial and ethnic characteristics (Anguelovski, 2013; Byrne and Wolch, 2009; Hughey et al., 2016; Kamel et al., 2014; Pérez del Pulgar et al., 2020; Rigolon and Flohr, 2014; Strife and Downey, 2009; Vaughan et al., 2013).

Neighborhood social conditions related with the concentration of disadvantage, such as poverty, crime and unemployment rates have been associated with mental, behavioral and cognitive problems (Christian et al., 2015). In terms of the relation of the available outdoor play spaces – which are a fundamental part of children's social life in dense cities (Busquets, 2006)- with children's mental and behavioral health, links have been found for different types of residential green space availability (Christian et al., 2015; McCormick, 2017; Markevych et al., 2018; Vanaken and Danckaerts, 2018; Alderton et al., 2019; Engemann et al., 2019; Madzia et al., 2019; Mnich et al., 2019; Bijnens et al., 2020; Thygesen et al., 2020). Specifically, green space availability has been associated with better emotional and behavioral outcomes (Amoly et al., 2014; Balseviciene et al., 2014; Flouri et al., 2014; Markevych et al., 2014; Sobko et al., 2018), better mood indicators for depression and anxiety (Maas et al., 2009), stress reduction and attention restoration (Huynh et al., 2013; Taylor and Kuo, 2011) and self-discipline (Taylor et al., 2002). The diversity of outdoor play spaces (i.e. diversity of types of outdoor play spaces such as green, sports-oriented, socially exposed, quiet, or with different sets of play equipment) to which a child is exposed to has been found to provide opportunities for different types of play experiences and meet a broader array of needs of children of different genders, physical abilities, ages and developmental stages (Dyment and O'Connell, 2013; Luken et al., 2011; Stanley, 2011) and potentially associated health benefits. The congestion of green spaces has been identified as an access barrier -as it may decrease the attractiveness of the space - (Biernacka and Kronenberg, 2018) which can reduce its use and the associated health benefits.

To our knowledge, no study has accounted for the differential associations between the residential proximity to green and non-green outdoor play spaces – such as parks, plazas, sport fields or playgrounds – as well as the proximity to a diversity of play opportunities and children's mental and behavioral health. Furthermore, few studies have explored differences in the distribution of the benefits of outdoor play space proximity for children's mental health by individual or area-level socio-demographic characteristics (for exceptions see Flouri et al., 2014; Wells, 2000). In response to those research gaps, the aim of our study is to investigate the association between residential proximity to outdoor play spaces and the prevalence of diagnosed mental and behavioral disorders in children.

We further incorporate some insights from environmental justice by exploring potential inequities in the distribution of the mental and behavioral health benefits of outdoor play space (Anguelovski et al., 2020), by examining whether play space-health associations differ by individual and area-level socio-demographic characteristics.

2. Materials and methods

2.1. Study design and population

We designed a semi-individual cross-sectional study in Barcelona (Spain) using individual health data from the Information System for Research in Primary Care (SIDIAP; www.sidiap.org) in Catalonia, Spain (Bolíbar et al., 2012). The Mediterranean coastal city of Barcelona had in 2014 a population of 1.6 million inhabitants, 200.890 of whom were children aged 0–12 (Barcelona City Council Statistical Yearbook, 2014). The city was divided in 1061 census tracts in 2014 with a median size of 3.6 ha and average population per tract of 1511 residents. Outdoor play spaces are fundamental for children's social life in a city with an urban form as dense and compact as Barcelona (Busquets, 2006). The SIDIAP database is a large pseudo-anonymized database of electronic health records for all visits in primary care centers managed by the Catalan Health Institute since 2005. It has a catchment of 5.5 M people, approximately 74% of the population living in Catalonia. SIDIAP includes demographic data, clinical variables, immunizations, specialists' referrals, prescriptions and dispensation of medications, history of sick leave and any acute and chronic health problems registered during a primary care visit.

The selection of children with ages from 0 to 12 registered in the SIDIAP database and living in the municipality of Barcelona in 2014 resulted in the extraction of data of 151 110 individuals corresponding to 75.22% of the age group in the city of Barcelona in 2014. We chose 12 years old as a cut-off age defining the end of childhood and the onset of adolescence (Britannica, 2020). . For the selected individuals their complete data history on demographic data (date of birth, gender and nationality) and mental and behavioral health diagnoses from 2005 until 2014 was retrieved. This study was approved by the ethics committee of the Jordi Gol i Gurina Institute for Research in Primary Care (IDIAPJGol, 20/163).

2.2. Outdoor play space indicators

We collected comprehensive spatial data on public outdoor play spaces in the city of Barcelona either specifically planned for children or where children frequently play in the city (Lynch, 1977). Data was obtained from the Urban Ecology Department. We identified 1665 play spaces, including playgrounds, plazas, parks, gardens, urban forests and recreational sports fields for 2014.

We applied a geospatial analysis of residential proximity to these play spaces based on the intersection between 300 m-network buffers around play spaces and the census tracts (Graph 1). The 300 m threshold was chosen for being the average walking independent mobility standard for children defined by UNICEF (United Nations, 2018). Network buffers were calculated based on the centroid of the play spaces, except for fenced parks and urban forests, for which the main access point (i.e., main entrance) was used as the center of the network buffer. Based on this analysis, for each census tract we calculated the following indicators: 1) **total** number of 300 m network buffers around play spaces intersecting each Barcelona census tract; 2) number of 300 m network buffers around outdoor **green** play spaces intersecting each Barcelona census tract; 3) number of 300 m network buffers around outdoor **playgrounds** intersecting the census tract; 4) number of 300 m network buffers around **sport**-oriented outdoor play spaces intersecting the census tract; and 5) number of 300 m network buffers around **community** outdoor public play spaces intersecting the census tract. Whereas indicator 1 counted each play space buffer once, indicators 2–5 were sometimes overlapping with one outdoor play space possibly

falling into several categories. (e.g., a play space with play equipment located in a park was considered both a playground and a green play space). Indicators 2–5 were meant to capture the type of play opportunities and experiences offered by the outdoor play space (Gibson, 1979; Hart, 1979; Frost, 1992). Parks, gardens, urban forests and playgrounds and recreational sports fields located inside parks were counted as outdoor green play spaces (Indicator 2). Outdoor play spaces with traditional play equipment were counted as playgrounds (Indicator 3). Sports fields were counted as sport-oriented outdoor play spaces (Indicator 4) and plazas were considered as outdoor community play spaces (indicator 5) (Graph 1).

Based on these indicators, we computed our three main exposure variables: a) Residential proximity to overall play spaces, defined as the total number of outdoor play spaces whose 300 m network buffer intersects the census tract divided by the number of children living in the census tract; b) Residential proximity to green play spaces, defined as the total number of green outdoor play spaces whose 300 m network buffer intersects the census tract divided by the number of children living in the census tract and c) Residential proximity to a diversity of play spaces, calculated as an index of the diversity of play types offered by play spaces whose 300 m network buffer intersected the census tract (Graph 1).

For exposure variables a) proximity to overall outdoor play spaces and b) proximity to outdoor green spaces, we divided the number of outdoor play spaces by the number of children living in each census tract to account for the potential pressure of use of each outdoor play space. This is based on the assumption that a high competition for outdoor play space (i.e. low number of proximate outdoor play spaces per child) can be considered an entry barrier (Biernacka and Kronenberg, 2018) and be associated to lower mental health benefits.

The variable c) proximity to a diversity of play spaces index was calculated using the Shannon index of diversity (Spellerberg and Fedor, 2003)) considering the types of outdoor play space defined in indicators 2–5: green play spaces; playgrounds; sport-oriented play spaces; and community play spaces, as follows:

$$H = -\sum_{i=2}^{5}\left(\frac{ni}{N} * \log\left(\frac{ni}{N}\right)\right)$$

where, n is the total amount of outdoor play spaces of each type, N the total amount of play spaces in the census tract and i the indicator.

2.3. Mental and behavioral disorders

We extracted information on children's mental and behavioral health diagnoses that were not associated with physiological disturbances, physical factors or psychoactive substance use. These health diagnoses are registered by pediatricians following the International Statistical Classification of Diseases and Related Health Problems-10 (ICD-10) clinical evaluation and coding criteria. Each child can have several entries for the same and/or different diagnoses over the years. Accordingly, the mental and behavioral health indicators we included in our study were:

Mood/affective disorders: containing disorders in which the fundamental disturbance is a change in affect or mood to depression or to elation, ICD-10 codes: F30–F39.

Neurotic, stress-related and somatoform disorders: including several phobias, anxiety and severe stress, ICD-10: F40–F48.

Disorders of psychological development: which in most cases refer to disorders in language, visuo-spatial skills, and motor coordination, ICD-10: F80–F89.

Behavioral and emotional disorders: with onset usually occurring in childhood and adolescence and characterized by a lack of persistence in activities that require cognitive involvement, ICD-10: F90–F98.

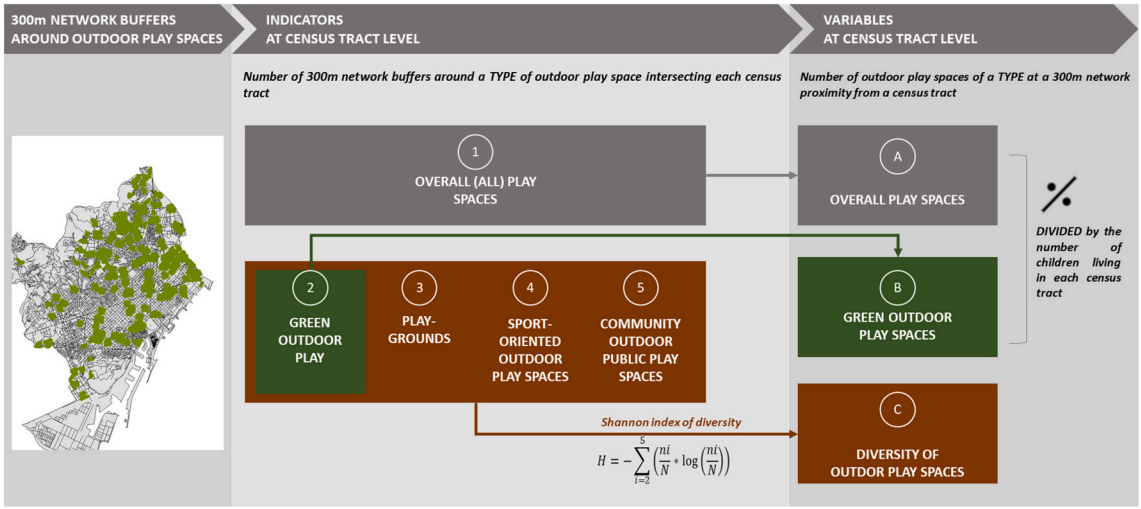
Overall mental and behavioral disorders: indicating the presence of any of the previously mentioned disorders (ICD-10: F30–F39, F40–48, F80–F89, F90–F98) and/or unspecified mental disorder (ICD-10: F99).

To assess prevalence for each mental and behavioral indicator, we created dichotomous variables for each of the previously cited mental and behavioral disorder groups where 1 indicated that the child had one or more diagnoses of the considered indicator in the period 2005–2014. For all health indicators, the date of the diagnosis was defined as the first recorded date at which the disorder appeared in their record.

2.4. Individual and area-level socio-economic status covariates

Individual variables on gender (dichotomous variable), age in 2014 (as a continuous variable), and nationality (dichotomous variable defined as either nationality from Global South – i.e., Latin-America and the Caribbean, Africa and Asia/Middle East- or Global North – i.e. Europe and Anglo-Saxon America-were retrieved from the SIDIAP database. Nationality was used as a proxy of racial and ethnic characteristics, as used in other recent studies in the context of Barcelona (Anguelovski et al., 2018).

To estimate area-level socio-economic status (SES), we developed a census tract SES index linked to the children's census tract of residence. To do so, first we selected relevant variables a priori using information from similar indicators developed in the Spanish context to theory-inform our selection (Anguelovski et al., 2018; Domínguez-Berjón



Graph 1. Illustration of the process of composition of the exposure variables.

et al., 2008). Accordingly, we used the following area-level data: index of family income (household disposable income); percentage of population (i) with university degree or higher, (ii) with non-western nationality (i.e. all African Countries, Philippines, Pakistan, Peru, Bolivia, Ecuador, Colombia, Dominican Republic, those being the most numerous and identifiable Global South nationalities in Barcelona's census tract available statistical data), (iii) aged 65 or more, (iv) unemployed; percentage of mono-parental households; percentage of housing stock (i) privately owned, (ii) occupied by the owner, (iii) in deficient condition; and average monthly rent (€/m^2). All the variables used to develop the area level SES index were available at the Barcelona city Statistics Department, were at the census tract level (apart from family income which was at neighborhood level) and referred to year 2014 (apart from percentage of housing stock occupied by the owner or in deficient condition and percentage of population unemployed which was available from 2011). Second, following the same methodology as the one used to develop the previously-used MEDEA indicator (Domínguez-Berjón et al., 2008), we performed a principal component analysis (PCA) to identify clustered variables whose variation could be explained by one index. For that purpose, we used an orthogonally rotated principal component analysis (PCA) according to the Varimax method and selected the extraction of components with Eigenvalues greater than 1. The analysis indicated a first component that explained 25.94% of the total variance of the initial ten variables. We considered that indicators were highly correlated with the first component if their component loadings were greater or equal to 0.70 (Domínguez-Berjón et al., 2008), which resulted in the selection of three variables related to the economic and educational capital of the census tract (percentage of population with university degree or higher, family income and average monthly rent), ruling out the rest of variables. We then conducted a second orthogonally rotated PCA including only the three selected indicators and adopted the extraction of one component. We used the first (and only) component factor, which explained 84.05% of the total variance of the three indicators (percentage of population with university degree or higher component loading 0.93, family income component loading 0.93 and average monthly rent component loading 0.82), as our census tract SES index. Using this index, Barcelona census tracts were classified alongside four equal groups according to the distribution of de value of the index across the city's census tracts.

2.5. Statistical analysis

We conducted descriptive analyses of the prevalence of our mental and behavioral health indicators by gender, age, nationality and area-level SES index. Then, we estimated the relationship between outdoor play space indicators and prevalence of mental and behavioral disorders outcomes. For each outcome/exposure combination, we developed robust Poisson regression models to estimate the change in the prevalence of each health outcome associated with an interquartile range (IQR) increase of each play space indicator. We used Poisson regression with robust variance for understanding that it provides correct estimates and is a better alternative for the analysis of cross-sectional studies with binary outcomes than a logistic regression, since the prevalence ratio (PR) is more interpretable and easier to communicate than the odds ratios (OR) (Barros and Hirakata, 2003). We adjusted for gender, age, nationality and area level SES index and calculated prevalence ratios and 95% Wald confidence intervals in all models. Then, to evaluate the effect modification of individual and area-level SES variables, we included interaction terms between IQR increases in outdoor play space indicators and SES variables in the robust Poisson regression models (one interaction by each SES variable in each outcome/exposure combination model). For measures with significant interaction terms, we then conducted stratified models. We used SPSS, version 26 and set statistical significance at p-value$<$0.05.

2.6. Sensitivity analyses

We conducted several sensitivity analyses to evaluate the robustness of our findings. First, to explore whether differences between the area-level SES indicators influenced our findings we performed models substituting the adjustment of our area-level SES index by the disaggregated variables for area-level average monthly rent per census tract, income (household disposable income per neighborhood), education (percentage of population with university degree or higher per census tract) and nationality (percentage of population with non-Western nationality per census tract), which are the variables included in the area level SES index, plus, an indicator of the percentage of population with non-Western nationality per census tract which did not show to be correlated with other socio-economic variables in the PCA but is theoretically relevant according to the literature (Domínguez-Berjón et al., 2008; Anguelovski et al., 2018).

Second, to evaluate the robustness of our findings to variations in the individual nationality indicator we performed: 1)models categorizing individual nationality as Spanish and non-Spanish, given the high share of children with Spanish nationality (87.4%) and the potential confounding effect it can have on the Global South/Global North individual nationality categorization and 2) models excluding children with Asian nationality and from Central and Eastern Europe from the analysis, considering that these nationalities included an especially heterogeneous mix of social, economic and ethnic statuses in the context of Barcelona. Models excluding children with Asian nationality from the Global South category and children with Central and Eastern European nationality from the Global North category reduced the sample to 145 026 children.

Third, since we use the outdoor play space proximity indicators associated to the children's census tract of residence in year 2014 but some children might have changed census tract of residence in the period 2005–2014, we performed models excluding children who changed census tract of residence in the period 2011–2014 (data on change of residency is not available prior to 2011). Models excluding children who moved in the studied period reduced the sample to 114 460 children.

Last, we conducted sensitivity analyses with the indicators of children's residential proximity to outdoor play spaces as a categorical versus continuous variable to assess the assumption of a linear relationship between proximity to outdoor play spaces and mental and behavioral disorder outcomes in the robust Poisson model.

3. Results

3.1. Descriptive statistics

Descriptive statistics for the characteristics of study participants, the prevalence of our investigated disorder outcomes and the play space indicators are presented in Table 1. Maps of our outdoor play space indicators, and area-level SES index are presented in Supplemental Material, Figures S1–S3.

Our sample had a balanced presence of both genders (51.43% of boys). Most children had a Global North nationality (91.2%), mainly Spanish (87.41%) but also South European (1.43%), Central and Eastern European (1.57%), Northern European (0.79%) and Anglo-Saxon American (0.15%) (data not shown). For the children that had a Global South nationality, most were from Latin-America and the Caribbean (4.35%), and the rest were: 2.45% Asia and Middle Eastern, 1.44% Northern African, and 0.39% Central and Southern African. The study population had an even distribution of children in different ages 0–12 (median 6 and IQR = 6).

In our study population, bit more than 10% of the children - more frequently boys (62.51%) than girls (data not shown) - were diagnosed in the period 2005–2014 with any mental and behavioral disorder, at a median age of 6 (IQR = 4). From these, the disorder outcome most

Table 1
Descriptive statistics of sample sociodemographic characteristics, health outcomes and outdoor play space proximity variables (n = 151 110).

Variable	n (%)/median (IQR)
Sociodemographic characteristics	
Gender, *Girls* [n (%)]	73403 (48.57)
Nationality, *Global South* [n (%)]	13073 (8.65)
Age [years: median (IQR[1])]	6 (6)
Area-level SES index [index: median (IQR)]	−0.39 (1.34)
Area-level SES index 1st quartile, lowest SES [n (%)]	49650 (32.85)
Mood/affective disorders, *Diagnosed* [n (%)]	107 (0.22)
Neurotic, stress-related and somatoform disorders, *Diagnosed* [n (%)]	1027 (2.07)
Disorders of psychological development, *Diagnosed* [n (%)]	1998 (4.02)
Behavioral and emotional disorders *Diagnosed* [n (%)]	3747 (7.55)
Overall mental and behavioral disorders, *Diagnosed* [n (%)]	6101 (12.29)
Area-level SES index 2nd quartile [n (%)]	45089 (29.84)
Mood/affective disorders, *Diagnosed* [n (%)]	51 (0.11)
Neurotic, stress-related and somatoform disorders, *Diagnosed* [n (%)]	800 (1.77)
Disorders of psychological development, *Diagnosed* [n (%)]	1494 (3.31)
Behavioral and emotional disorders *Diagnosed* [n (%)]	2699 (5.99)
Overall mental and behavioral disorders, *Diagnosed* [n (%)]	4527 (10.04)
Area-level SES index 3rd quartile [n (%)]	29953 (19.82)
Mood/affective disorders, *Diagnosed* [n (%)]	52 (0.17)
Neurotic, stress-related and somatoform disorders, *Diagnosed* [n (%)]	593 (1.98)
Disorders of psychological development, *Diagnosed* [n (%)]	870 (2.90)
Behavioral and emotional disorders *Diagnosed* [n (%)]	1673 (5.59)
Overall mental and behavioral disorders, *Diagnosed* [n (%)]	2826 (9.43)
Area-level SES index 4th quartile, highest SES [n (%)]	26418 (17.48)
Mood/affective disorders, *Diagnosed* [n (%)]	48 (0.18)
Neurotic, stress-related and somatoform disorders, *Diagnosed* [n (%)]	333 (1.26)
Disorders of psychological development, *Diagnosed* [n (%)]	482 (1.82)
Behavioral and emotional disorders *Diagnosed* [n (%)]	1097 (4.15)
Overall mental and behavioral disorders, *Diagnosed* [n (%)]	1807 (6.84)
Mental and behavioral disorders	
Mood/affective disorders, *Diagnosed* [n (%)]	258 (0.17)
Neurotic, stress-related and somatoform disorders, *Diagnosed* [n (%)]	2753 (1.82)
Disorders of psychological development, *Diagnosed* [n (%)]	4844 (3.21)
Behavioral and emotional disorders *Diagnosed* [n (%)]	9216 (6.10)
Overall mental and behavioral disorders, *Diagnosed* [n (%)]	15261 (10.10)
Outdoor play space indicators	
Overall play spaces per 1000 children [number of play spaces: median (IQR)]	67 (64)
Green play spaces per 1000 children [number of play spaces: median (IQR)]	34 (36)
Diversity of play spaces [index: median (IQR)]	0.9 (0.29)

diagnosed was behavioral and emotional disorders, again mostly boys (64.59%) and at the same median age than for the overall diagnosed. Less than 5% of our study population were diagnosed from each of the remaining disorder outcomes. From these remaining disorders, children in our sample were diagnosed of disorders of psychological development at a median age of 5 (IQR = 4), with the prevalence being higher among boys (65.28%). Similarly, children (particularly boys, 54.09% of the diagnosed in our sample) were diagnosed of neurotic, stress-related and somatoform disorders at a median age of 7 (IQR = 4). Last, the average age of mood/affective disorders was slightly higher, 8 years old (IQR = 4), despite those more frequently diagnosed were also boys (51.16%)

The distribution of our study population across the four quartiles of area-level SES index followed a decreasing trend, with over 30%of the study population living in census tracts with the lowest area-level SES index and around 18% of the study population living in census tracts with the highest area-level SES index. The prevalence of all mental and behavioral disorder outcomes also followed a decreasing trend as the area-level SES index increased. Over 12% of the study population living in census tracts with the lowest area-level SES index were diagnosed with any mental and behavioral disorder, whereas the prevalence of any mental and behavioral disorder decreased to over 6% among the study population living in census tracts with the highest area-level SES index.

There was a big variability within all indicators of proximity to outdoor play spaces from the census tracts of residence. The minimum number of overall play spaces per 1000 children within 300 m from children's census tracts of residence was 0.37 and the maximum 77.53 (data not shown). Similarly, the minimum number of green play spaces per 1000 children within 300 m from children's census tracts of residence was 0 and the maximum 60.67. Children of our study were exposed to a diversity of outdoor play spaces between 0 and 1.28. The indicator of proximity to overall outdoor play spaces was strongly correlated with the indicator of proximity to green play spaces (Spearman's correlation coefficient r = 0.82). Contrary, the correlation between overall play spaces and diversity of play spaces and between green play spaces and diversity of play spaces was very weak (r = 0.05 and r = 0.16 respectively).

3.2. Main results

Lower prevalences of disorders of psychological development were associated with higher values of the indicators of outdoor play space (Table 2). For all play space indicators, an IQR increase of the play space indicator was significantly associated with lower prevalence of disorders of psychological development. That is, an increase in 64 overall play spaces per 1000 children (i.e., an IQR increase in the overall play spaces indicator) within 300 m from children's census tracts of residence was associated with a 4% (95% CI: 1,7) decrease in the prevalence of disorders of psychological development. Each IQR (36) increase in the number of green play spaces per 1000 children within 300 m from the census tracts of residence was associated with a 4% (95% CI 1,7) lower prevalence of disorders of psychological development. And an increase in 0.29 units of the Shannon index within 300 m from children's census tracts of residence was associated with a 5% (95% CI 2,9) lower prevalence of disorders of psychological development.

An increase in 64 overall play spaces per 1000 children (i.e., an IQR increase) within 300 m from children's census tracts of residence was also associated with a 2% (95% CI: 1,3) decrease in the prevalence of overall mental and behavioral health disorders. The rest of mental and behavioral health outcomes were not statistically significantly associated with any of the play space indicators.

We did not find any suggestion of differences on the associations between outdoor play space indicators and individual nationality (p-value>0.08 for the interaction terms). However, we found indications of differences by area-level SES index on the associations between prevalence of disorders of psychological development with overall play spaces and also with diversity of play spaces (p-value = 0.02 and p-value = 0.01 for the interaction terms, respectively). We also found some marginal indication of differences by area-level SES index on the associations between prevalence of disorders of psychological development with green play spaces (p-value = 0.07), which we considered worth exploring given the significance of the interaction terms of all other exposures with this outcome. Moreover, we found indications of differences by area-level SES index on the association of overall mental and behavioral disorders with overall play spaces (p-value<0.01 for the interaction term).

Stratified models by area-level SES index revealed a general trend of proximity to overall outdoor play spaces and diversity of play spaces being protective of disorders of psychological development for children living in low SES census tracts but a risk factor for children living in high SES census tracts (see Table 3). An IQR (64) increase in the number of overall proximate outdoor play spaces per 1000 children within 300 m from children's census tract of residence was associated with an 8% lower prevalence of disorders of psychological development for children living in the first and second lowest area-level SES index census tracts (i.e. area-level index first quartile with 95% CI: 2,13 and area-level index second quartile with 95% CI: 2,14). Similarly, an IQR (0.29) increases in

Table 2
Adjusted associations between prevalence of mental and behavioral disorders and residential proximity to outdoor play space indicators derived from robust Poisson regression models. Associations reported for 1-IQR increase in outdoor play space indicators within 300 m from children's census tracts of residence.

	Overall play spaces		Green play spaces		Diversity of play spaces	
	Prevalence Ratio (95% CI)	p-value	Prevalence Ratio (95% CI)	p-value	Prevalence Ratio (95% CI)	p-value
Mood/affective disorders	0.95 (0.83, 1.09)	0.48	0.96 (0.85, 1.08)	0.51	1.04 (0.88, 1.23)	0.68
Neurotic, stress-related and somatoform disorders	0.98 (0.94, 1.02)	0.37	0.99 (0.95, 1.02)	0.46	1.02 (0.97, 1.09)	0.41
Disorders of psychological development	0.96 (0.93, 0.99)	0.02	0.96 (0.93, 0.99)	<0.01	0.95 (0.91, 0.98)	<0.01
Behavioral and emotional disorders	0.98 (0.96, 1.01)	0.15	0.99 (0.97, 1.01)	0.31	0.99 (0.96, 1.01)	0.32
Overall mental and behavioral disorders	0.98 (0.97, 0.99)	0.05	0.99 (0.97, 1.00)	0.09	0.98 (0.96, 1.01)	0.14

Note: All models include individual gender, nationality, age and area-level SES index as covariates.

Table 3
Adjusted associations between prevalence of mental and behavioral disorders and residential proximity to outdoor play space indicators derived from robust Poisson regression models. Associations reported for 1-IQR increase in outdoor play space indicators within 300 m from children's census tracts of residence. Models stratified by area-level SES index.

	Overall play spaces		Green play spaces		Diversity of play spaces	
	Prevalence Ratio (95% CI)	p-value	Prevalence Ratio (95% CI)	p-value	Prevalence Ratio (95% CI)	p-value
Disorders of psychological development						
Area-level SES index 1st quartile (lowest SES)	0.92 (0.87, 0.98)	<0.01	0.94 (0.89, 0.99)	0.02	0.92 (0.86, 0.97)	<0.01
Area-level SES index 2nd quartile	0.92 (0.86, 0.98)	<0.01	0.92 (0.87, 0.97)	<0.01	0.97 (0.90, 1.05)	0.44
Area-level SES index 3rd quartile	1.09 (1.01, 1.18)	0.04	1.04 (0.96, 1.13)	0.35	0.93 (0.85, 1.01)	0.06
Area-level SES index 4th quartile (highest SES)	1.02 (0.90, 1.16)	0.71	1.02 (0.90, 1.15)	0.80	1.16 (1.03, 1.32)	0.02
Overall mental and behavioral disorders						
Area-level SES index 1st quartile (lowest SES)	0.94 (0.92, 0.97)	<0.01	(not estimated)[2]		(not estimated)	
Area-level SES index 2nd quartile	0.98 (0.95, 1.01)	0.23	(not estimated)		(not estimated)	
Area-level SES index 3rd quartile	1.04 (0.99, 1.08)	0.10	(not estimated)		(not estimated)	
Area-level SES index 4th quartile (highest SES)	1.08 (1.02, 1.14)	0.01	(not estimated)		(not estimated)	

Note: All models include individual gender, nationality and age as covariates.

the diversity of proximate play spaces was associated with 8% (95% CI:3,14) lower prevalence of disorders of psychological development for children living in the lowest SES census tracts (i.e., area-level index first quartile). Also, an increase in 36 green play spaces per 1000 children within 300 m from children's census tracts of residence was associated with a 6% (95%CI: 1, 11) lower prevalence of disorders of psychological development for children living in the lowest area-level SES index census tracts, and with an 8% (95%CI: 3, 13) lower prevalence for those living in the second lowest area-level SES index census tracts. However, for children living in the highest SES census tracts these associations reversed their direction: Each IQR (64) increase in the proximate overall outdoor play spaces was associated with 9% (95%CI: 1,18) higher prevalence of disorders of psychological development for children living in the second highest area-level SES index census tracts (third quartile). IQR increases in the diversity of proximate outdoor play spaces were associated with a 16% (95% CI:3,32) higher prevalence of disorders of psychological development for children living in the highest area-level SES index census tracts (i.e., area-level index forth quartile) (see Table 3).

Similar results were found for proximity to overall outdoor play spaces in its associations with overall mental and behavioral disorders: An IQR (64) increase in the overall proximate outdoor play spaces was a protective factor for children living in low SES census tracts but a risk factor for children living in high SES census tracts (see Table 3). That is, each IQR (64) increase in the proximate overall outdoor play spaces was associated with 6% (95%CI: 3,8) lower prevalence of disorders of psychological development for children living in the lowest SES census tracts (i.e., area-level index first quartile) and an 8% (95%CI: 2,14) higher prevalence of disorders of psychological development for children living in the highest SES census tracts (i.e. area-level index forth quartile).

3.3. Sensitivity analyses

Our findings - when substituting the adjustment of our area-level socio economic indicator by the disaggregated variables; when categorizing nationality as Spanish and non-Spanish, when excluding children with Asian nationality and from Central and Eastern Europe, or when excluding children who changed census tract of residence from the analysis - were generally consistent with those of the main analyses in terms of direction and statistical significance (Supplemental material, Tables S1–S4). Only some minor differences were found when substituting the adjustment of our area-level socio economic indicator by the disaggregated variables of income, education, nationality, and monthly rent, were we found negative associations between proximity to overall outdoor play spaces and green outdoor play spaces and behavioral and emotional disorders, at the expense of the associations with disorders of psychological development (Supplemental Material Table S1).

4. Discussion

In this study including 151 110 children living in Barcelona, we found that lower prevalence of disorders of psychological development was consistently associated to increases in the residential proximity to overall and green outdoor play space as well as to a greater diversity of play opportunities. Meanwhile, lower prevalence of overall mental and behavioral disorders was also found to be associated with increases in the proximity to overall outdoor play spaces. Our findings also indicate that these associations are not equal across area-level SES characteristics. We found that, for those children living in the lowest SES census tracts, the indicators of residential proximity to different indictors of outdoor play space had a protective role for their mental and behavioral health. However, residential proximity to overall play spaces and to a diversity of proximate play spaces were risk factors for those children living in higher SES census tracts.

The association we found between proximity to overall outdoor play spaces with lower prevalence of disorders of psychological development is novel. We hypothesize that our findings could be explained by the activities that outdoor play spaces have been shown to offer. For example, previous research has indicated that a higher presence of outdoor play spaces is associated with greater overall physical activity

(Dunton et al., 2014; Timperio et al., 2008). Outdoor play spaces have also been linked to other precursors of better mental health such as active participation and interaction (WHO, 2001), negotiation of one's identity and sense of purpose (Cederborg, 2020; Compton-Lilly et al., 2017), increased sense of community (Anguelovski, 2014; Perez-del-Pulgar et al., 2020), awareness of one's self and others (Mayer et al., 2009), experience of independent mobility (Schoeppe et al., 2016), free play and exploratory thinking (Holt et al., 2015), stress mitigation (Ulrich et al., 1991), and attention restoration (Taylor and Kuo, 2011).

Our findings with regards to the protective role of the proximity to outdoor green play spaces are in line with previous studies reporting better children's development (Alderton et al., 2019; Christian et al., 2015; Vaden-Kiernan et al., 2010; Wells, 2000; Wu et al., 2014) and general mental health outcomes (Sobko et al., 2018; Tillmann et al., 2018) associated with higher exposure to green spaces. However, our findings differ from previous studies with regards to the particular mental and behavioral health disorders significantly associated with exposure to green spaces. Whereas previous studies present exposure to green being protective of mood disorders (Maas et al., 2009), neurotic and stress related disorders (Huynh et al., 2013) or behavioral and emotional disorders (Amoly et al., 2014; Balseviciene et al., 2014; Flouri et al., 2014; Markevych et al., 2014; Mårtensson et al., 2009; Taylor et al., 2002; Taylor and Kuo, 2011), our results show mainly a protection to disorders of psychological development. We argue that these differences are secondary and could point to the difficulty to clearly distinguish and separate each category of mental disorders given the porosity between the different mental health disorders and the heterogeneity of their clinical presentations (American Psychiatric Association, 2013).

We are unaware of previous studies on the association of the proximity to a greater diversity of play spaces and the prevalence of children's mental and behavioral health outcomes overall or disorders of psychological development in particular. In this respect our results are novel. However, our results are coherent with previous research drawing attention to the importance of the built environment (Derr and Tarantini, 2016; Malone, 2013; Moore-Cherry, 2014; Pérez del Pulgar et al., 2020; Woolcock et al., 2010), its richness, diversity of purposes and play experiences (Dyment and O'Connell, 2013; Luken et al., 2011; Stanley, 2011) for children's wellbeing.

Our results point to a modification of the association between residential proximity to outdoor play space and mental and behavioral health by area-level socio-demographic characteristics in a manner consistent with previous literature, suggesting that outdoor play spaces may mitigate the negative influences of other aspects of the physical environment, such as poor housing, deteriorated neighborhoods, overcrowded schools, or the prevalence of crime and violence (Engemann et al., 2019). Thus, the role of residential proximity to overall outdoor play spaces, green outdoor play spaces as well as to a diversity of these could be especially important and protective for children's mental health in lower SES areas, indicating strong environmental justice and health equity benefits. Meanwhile, for children living in high SES areas, proximity to outdoor play spaces seems to be working as a socio-environmental risk factor vis a vis children's mental and behavioral health outcomes. This difference may reflect spatially bounded class-based differences in the use and meaning of children's play spaces (Pérez del Pulgar et al., 2020) influenced by cultural, social and historical perspectives and ideologies of outdoor recreation as well as material socioeconomic factors (Byrne and Wolch, 2009; Floyd, 2001; Strife and Downey, 2009; Tierney et al., 2001).

In this line, previous research suggests that upper- and middle-class cultures of parenting (Villanueva et al., 2016), time management (Loukaitou-Sideris and Sideris, 2010) and perceptions of safety (Arroyo-Johnson et al., 2016; McCarthy et al., 2017; Pérez del Pulgar et al., 2020; Tappe et al., 2013) have a strong impact on the actual use (and likely restorative effect) of these play spaces and could be influencing the negatively associated health benefits we observed for high SES areas. Higher-income families also have greater access to larger backyards and private gardens, second homes -which is especially prevalent in Spain (Módenes and López-Colás, 2007) -or are financially able to travel further distances and provide alternative access to outdoor play spaces, meaning that municipal outdoor play spaces might not be the primary outdoor play spaces and the determinants of high SES children's good mental health. In contrast, children from urban low SES areas are those for whom urban outdoor play and contact with nature tend to be mostly facilitated by formal municipal play spaces rather than private play spaces, to which they tend to have more limited access, hence the protecting effects our findings indicate. In addition, residents of Barcelona's working-class neighborhoods have long mobilized for public play spaces and value their construction, design, access, and use. Under these conditions outdoor play spaces tend to become a source of pride for the community (Pérez del Pulgar, 2020) which potentially gets transmitted to children (Putra et al., 2021) having an impact on how children use, experience and care for these spaces. More regular uses of these spaces and feelings of safety and attachment might explain some of the positive health outcomes. Last, we might hypothesize that the tendency of high SES families with children to move to areas with better children's facilities, including outdoor play spaces (Lilius, 2019) is enhanced amongst high SES families with children with mental health disorders. In any case, more research on the pathways through which proximity to outdoor play spaces is associated to higher risks of disorders of psychological development in children living in the higher SES areas.

Our study faced some limitations. First, our study considered the 300 m network distance from the outdoor play spaces to the census tract boundaries as a proxy for residential proximity to the play space because we did not have children's individual residential addresses. This exposure introduced an ecological bias and, in some cases the actual walking distance from the child's home to the outdoor play space might be higher than 300 m. Second, the study's cross-sectional design, limits its ability to determine causality. Third, mental and behavioral health is associated with a wide range of individual child and parental factors (e.g. physiological conditions of the child, family members with mental and behavioral health disorders or specific traumatic events in the child's life) that, for data limitations, cannot be included in the present study as confounder variables. Fourth, individual race and ethnicity have been suggested to influence the association between the exposure to outdoor play spaces and health outcomes, but that information was unavailable to us for this study. The most similar available data was on individual nationality, aggregated in mixed categories that included children with very different types of advantages and disadvantage, access to material and cultural resources, education, incomes, language etc. We ran a sensitivity analysis to test the effect of this factor, but we cannot rule out that other (not available) data may have been better estimates of ethnicity in our study. Fifth, our study considered the number of outdoor play spaces per 1000 children within 300 m or less from each census tract. Testing the impact of the available area of play or quality of the area was not possible due to data limitations. Sixth, there could be some measurement error due to the linkage of the cross-sectional play-space proximity for year 2014 with the census tract residential data of the period 2005–2014. However, due to the nature of Barcelona's little post 2005 urban transformation in terms of the outdoor play space amenities here analyzed we assume this measurement error to be potentially very minor. Seventh there might be an under-reporting of health outcomes, since the used database does not capture diagnoses performed in private health centers. Despite Spain has a universal coverage of healthcare and that children visit their pediatricians even when they are healthy to follow vaccinations protocols – between others -, our number of diagnoses could be underestimated given the double coverage of public and private healthcare. However, this measurement error would be underestimating the associations we observe in our study.

The study also has several strengths. First, to our knowledge, this is

the first study to report the association between different types of residential outdoor play spaces and diagnosed mental and behavioral disorders in children. Second, this study has a large sample size that enables the exploration of associations and effect modifications without affecting statistical power. Third, we uniquely include several measures of outdoor play spaces. Fourth, we report objectively assessed health outcomes and outdoor play space proximity measures. Last, we conducted a range of sensitivity analyses of importance for assessing health equity, including testing the effect of the nationality and area SES index indicators, and our findings were robust across all the analyses.

5. Conclusions

Our findings are suggestive of a possible beneficial effect of overall outdoor play space proximity, and its greenness and diversity, on childhood mental and behavioral health disorders, especially for disorders of psychological development. These benefits, nevertheless, were only found for children living in low SES areas.

We recommend future studies to more closely investigate the importance of outdoor play space types and diversity for children's disorders of psychological development as well as the pathways through which proximity to outdoor play spaces is associated with higher prevalence of children's disorders of psychological development in high SES areas. Examining the qualities of the built environment as well as its actual uses a function of gender, physical ability, age or ethnicity and its impact on children's mental and behavioral health is a promising and compelling area of study that requires further research.

Our finding should be of interest for policy makers in planning for healthier cities for children through equitable place-based interventions that aim to remedy urban environments currently criticized for overlooking children's needs for participation and play (Derr and Tarantini, 2016; Malone, 2013; Moore-Cherry, 2014; Woolcock et al., 2010). Environmental planners should place particular attention to creating new play and green space opportunities for children of working-class neighborhoods, since those seem to both particularly benefit from such interventions while, traditionally, lacking equitable access to those, and this beyond the case of Barcelona. Placing children at the center of public space interventions (including play spaces such as parks or plazas) is essential for building accessible, green, and healthy cities for all.

Author contribution

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Approval and funding sources

Approval: This study was approved by the ethics committee of the Jordi Gol i Gurina Institute for Research in Primary Care (IDIAPJGol, 20/163).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

This work was supported by the GREENLULU's Project under the European Union's Horizon 2020 research and innovation framework [grant number 678034]; the NATURVATION Project under the European Union's Horizon 2020 research and innovation framework [grant number 730243]; the ECHOCAT project of La Marató de TV3 Foundation [grant number 201621–30] and the the María de Maeztu Program for Units of Excellence of the Spanish Ministry of Science and Innovation [grant number CEX 2019-000940-M]. HC and MTM are funded by Juan de la Cierva fellowships awarded by the Spanish Ministry of Economy and Competitiveness [grant number FJCI-2018-035322 and FJCI-2017-33842]. The sponsors had no role in the design or analysis of this study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.envres.2021.111326.

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