



The evaluation of the 3-30-300 green space rule and mental health

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ABSTRACT

Background and aims: Urban green space has many health benefits, but it is still unclear how much actually is needed for better health. Recently a new 3-30-300 rule of thumb for urban forestry and urban greening has been proposed, but this rule has not been evaluated for benefits on health. The rule requires that every citizen should be able to see at least three trees from their home, have 30 percent tree canopy cover in their neighbourhood and not live more than 300 m away from the nearest park or green space. The aim of this study was to evaluate the relationship between the 3-30-300 green space rule and its components in relation to mental health.

Methods: We conducted a cross-sectional study based on a population-based sample of 3145 individuals aged 15–97 years from in Barcelona, Spain who participated in the Barcelona Health Survey (2016–2017). We created 3-30-300 green space indicators using questionnaire data, GIS, remote sensing and land cover maps. Mental health status was assessed with the 12-item General Health Questionnaire (GHQ-12) and also the use of tranquilizer/sedatives or antidepressants and psychiatrist or psychologist visits. Analyses were conducted using mixed effects logistic regression models with districts as the random effect, adjusted for relevant covariates.

Results: We found that people in Barcelona had relatively little exposure to green space, whether through window view, living in an area with sufficient greenness, or access to a major green space, and only 4.7% met a surrogate 3-30-300 green space rule. Residential surrounding greenness, but not tree window view or access to major green space, was significantly associated with better mental health, less medication use, and fewer psychologist or psychiatrist visits. Meeting the full surrogate 3-30-300 green space rule was associated with better mental health, less medication use, and fewer psychologist or psychiatrist visits, but only for the latter combined the association was statistically significant (Odds ratio = 0.31, 95% CI: 0.11, 0.91).

Conclusion: Few people achieved the 3-30-300 green space in Barcelona and we used a surrogate measure. We observed health benefits when the full surrogate rule was met.

1. Introduction

Urban green space has many health benefits including longer life expectancy, fewer mental health problems, improved cognitive functioning, better mood and healthier babies (Gascon et al., 2015; Nieuwenhuijsen et al., 2017a; Markevych et al., 2017; Rojas-Rueda et al., 2019). It also mitigates air pollution, heat and noise levels, is associated with lower air pollution emissions and contributes to CO₂ sequestration and therefore helps with mitigation and adaptation to the climate crisis (Nieuwenhuijsen, 2020). Green space can improve ecosystems and

increase biodiversity in cities, particularly through well-designed green infrastructure and networks throughout the city (Coutts and Hahn, 2015; Nieuwenhuijsen, 2021).

The availability of green space varies quite considerably between cities and is also not equally distributed within cities, with some people having easy access to green space, while many others have no or little access (Schüle et al., 2017; Pereira Barboza et al., 2021; Mushangwe et al., 2021). Green space does not only include parks, but also green such as trees in streets or gardens (Salmond et al., 2016; Wolf et al., 2020) and green infrastructure like green roofs and walls

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(Nieuwenhuijsen, 2021).

We know that green space is good for health, but it is still not clear how much exactly and in which form, but urban planners need some guidance. Recently Cecil Konijnendijk, an urban forester, proposed the new 3-30-300 rule of thumb for urban forestry and urban greening, or in short 3-30-300 green space rule, where he suggested that every citizen should be able to see at least three trees (of a decent size) from their home, have 30 percent tree canopy cover in their neighbourhood and not live further than 300 m away from the nearest park or green space (IUCN, 2021; Konijnendijk et al., 2022).

There is some good evidence that 30 percent tree canopy cover in the neighbourhood is beneficial for health, but for access to a major green space and visibility of trees from the window, the evidence is more mixed or has been less reported (Gascon et al., 2015; Triguero-Mas et al., 2015; Labib et al., 2020; Astell-Burt et al., 2021; Astell-Burt and Feng, 2019; Astell-Burt and Feng, 2020a; Astell-Burt et al. 2020b; Callaghan et al., 2021). A number of recent studies showed that green views from windows showed stronger associations with lower depressive symptoms and better mental health, particularly during the COVID19 pandemic (Dzhambov et al., 2021; Ribeiro et al., 2021; Soga et al., 2021; Spano et al., 2021). No study has evaluated all the three components combined.

The 3-30-300 green space rule is appealing and widely promoted by urban foresters and some urban planners, but there is an urgent need to test whether the 3-30-300 rule is actually associated with better health. The aim of this study was to evaluate the relationship between the 3-30-300 green space rule and its components in relation to mental health.

2. Methods

2.1. Study sample

This cross-sectional study was based on a population-based sample of 3145 individuals aged 15–97 years in Barcelona, Spain who participated in the Barcelona Health Survey (2016–2017). Recruitment occurred randomly from the municipal register of residents, while considering the age and sex structure of the 10 districts for representativeness purposes. Data collection was conducted through face-to-face interviews applying the Computer-Assisted Personal Interviewing (CAPI) system [26] for the 4000 recruited participants on socio-demographic characteristics and mental and physical health and well-being. The response rate was 33.5%. Non-participants were replaced by randomly selected individuals with identical characteristics: same district, sex and age. The organisation of the Barcelona HIS was in agreement with the Law of 23/1998 on Statistics of Catalonia regarding the fulfilment of statistical confidentiality. Further details on the recruitment process and data collected are presented elsewhere (Bartoll et al., 2018; Bauwelinck et al., 2020).

2.2. Green space exposure variables

Residential addresses at the time of the study were geocoded and used for the assessment of residential green space exposure. The 3-30-300 green space rule was assessed as follows:

- 3 trees from every home: Greenness of window view was assessed with a question on whether the participant was able to see green elements from their home (none, some, quite some, very much). We combined this information with information on the number of trees within 15 m of the residence. The information on the number of trees was obtained from Institut Cartogràfic i Geològic de Catalunya (ICGC, 2014). We created a variable “window view” with being able to see green space (no vs some, quite some, very much) and at least three trees within 15 m (yes/no). Participants with no in both were classified as no window view, while the rest (some, quite some, very much view and at least 3 trees) was classified having a window view.

- 30 percent tree canopy cover in every neighbourhood: Although we had access to tree canopy cover maps of the European Environment

Agency (2018), close visual inspection showed that the map missed out a lot of tree canopy cover in Barcelona, and using the map only three subjects had more than 30% tree canopy cover. Instead, we used residential surrounding greenness, as a surrogate for tree canopy cover, which was calculated as the average Normalized Difference Vegetation Index (NDVI) in 500 m buffers. NDVI imagery (30 m × 30 m resolution) was obtained from Landsat 8 image taken on August 14, 2016 and processed to remove the influence of negative pixels from water bodies and atmospheric attenuations. The NDVI can be calculated since healthy vegetation absorbs most visible light and reflects large parts of near-infrared light, and sparse vegetation reflects more visible light and less near-infrared light. Based on this distinction, a value between 0 and 1 indicates photosynthetically active vegetation with higher values indicating higher density of green vegetation (Weier and Herring, 2000). The correlation between the tree canopy cover map and NDVI was strong ($r = 0.88$) but it was driven by some extreme values and the tree canopy cover map did not perform well at the lower end. We dichotomized the NDVI into <0.3 and ≥ 0.3 assuming the latter coincides with a significant amount of surrounding greenness similar to a 30% tree canopy cover although in reality the canopy cover may have been lower.

- 300 m from the nearest park or green space: The linear distance to the nearest major green space was calculated with data inputs from Catalan and European land use maps (Land Cover Map of Catalonia, MCSC version 4 for amount of green space; and Urban Atlas, 2012 for distance to green space) (CREAF, 2009; European Environment Agency, 2014) and dichotomized into distance of ≤ 300 m and >300 m.

We developed a 3-30-300 green space score (range 0–3) by adding up the number of times that they met one of the components of the 3-30-300 green space rule, with a score of 3 meaning that the full 3-30-300 rule was met.

2.3. Mental health status

Different aspects of mental health status were characterized using three sources of information: (i) Perceived general mental health was assessed using the 12-item General Health Questionnaire (GHQ-12), which is a multidimensional scale that assesses distinct aspects of distress in the last 30 days (Sánchez-López and Dresch, 2008). Questions were answered on a 4-point Likert scale (from 1 to 4) and were dichotomized (0/1) and summed, resulting in a score ranging from 0 to 12. A score of ≥ 3 indicated being at risk of psychiatric problems (Goldberg, 1978). The GHQ-12 is shown to be a valid and reliable screening tool for non-psychotic psychiatric problems (i.e., mental health status) in the Spanish population (Sánchez-López and Dresch, 2008). (2) Data on the use of tranquilizer/sedatives and antidepressant in the last two days was collected with two questions regarding the medication use (yes/no) and included those prescribed by a doctor, suggested by a pharmacist, or self-prescribed. (iii) Data on psychiatrist or psychologist visits was obtained applying a question whether participants had visited a psychiatrist or psychologist during the last year (yes/no).

2.4. Covariates

The covariates were chosen *a priori* based on previous studies (Dadvand et al., 2016; Zijlema et al., 2015). Age, sex, marital status (single, married, widow (er) divorced/separated), place of birth (within Spain, outside Spain), education level (no formal education/primary education, secondary education, university), perceived income situation (very difficult/difficult, some difficulties, quite easy, (very) easy), employment status (employed, unemployed/pensioner/homemaker, student, incapacitated for work), social class (5 groups based on occupation, ranging from unskilled worker to company director with >10 employees), and length of residence (in months) were collected within the Barcelona Health Survey (Bartoll et al., 2018). Unemployment rate (% persons aged >16 years unemployed) at census tract level was used

as an indicator for area-level socioeconomic status and was obtained from the atlas of the Urban Vulnerability Index of Spain 2011) (Instituto Nacional de Estadística, 2015).

2.5. Statistical analysis

Descriptive statistics were used to characterize the study sample. Analyses were conducted using mixed effects logistic regression models with random intercepts for districts and robust standard errors to take into account clustering within districts (Cerin, 2011). Models were adjusted for age, sex, marital status, place of birth, education level, perceived income situation, employment status, social class, length of residence and area-level unemployment rate. We used the missing indicator method to account for missing covariate data. We also tested for effect modification by sex, age and social economic status. Analyses were undertaken using STATA version 14.2 (StataCorp, 2015).

3. Results

In total 3145 participants were included in the study. They were on average 49 years old, 52% were female, 37.5% had university education, and 76% were born in Spain (Table 1). Eighteen percent reported poor mental health, with 8.3% percent reporting visits to the psychologist or psychiatrist over the last year and 9.4% reporting the use of tranquilizers/sedatives and 8.1% the use of antidepressants in the last two days (Table 1). Just over 43% had a green window view and at least 3 trees within a 15-m buffer, 62.1% had a major green space within 300 m, and 8.7% lived in an area with sufficient surrounding greenness. Nearly 22.4% did not have any of these and 4.7% had all three and met the 3-30-300 rule for green space (Table 1).

A home window view with at least 3 trees within 15 m was not associated with any of the outcomes. Having a sufficient level of surrounding greenness ($= >0.3$) was associated with a lower risk for all the outcomes and this was statistically significant for poor mental health (Odds ratio (OR) = 0.60, 95% confidence interval (CI): 0.40–0.90), combined medication use in the last 2 days (OR = 0.60, 95% CI: 0.38–0.97), visit to the psychiatrist over the last 12 months (OR = 0.22, 95% CI: 0.08–0.62), and visit to the psychiatrist or psychologist over the last 12 months (OR = 0.37, 95% CI: 0.19–0.73) (Table 2). Although there was some suggestion for a reduced risk with distance to a major green space for all the outcomes, none of the associations were statistically significant (Table 2).

An increase in the 3-30-300 green space score was generally associated with a lower risk for all the outcomes, but only for visits to the psychiatrist or psychologist combined over the last 12 months (OR = 0.31 95%CI 0.11, 0.91) was this statistically significant when the 3-30-300 rule was fully met.

We found no evidence for a statistically significant effect modification by sex, age or social-economic status (stratified analyses results in Supplement Tables S1, S2, S3).

4. Discussion

To our knowledge, this is the first study evaluating the health benefits of the 3-30-300 green space rule, in which we used residential surrounding green space as a surrogate for tree cover canopy. We observed that in a population-representative sample of Barcelona inhabitants only 4.7% met all the three criteria of this rule. Residential surrounding green space, but not tree window view or access to major green space, was statistically significantly associated with better mental health, less medication use, and fewer psychologist or psychiatrist visits. Similarly, meeting the full surrogate 3-30-300 green space rule was associated with better mental health, less medication use, and fewer psychologist or psychiatrist visits, but only for the latter combined was this statistically significant.

This study evaluated the effect of the 3-30-300 green space rule on

Table 1
Study sample characteristics of the Barcelona Health Survey 2016 (n = 3145).

Population characteristics		n (%) / mean (SD)
Age (years)		49.2 (18.8)
Sex	Females	1640 (52.2)
	Males	1505 (47.9)
Marital status	Single	1147 (36.5)
	Married	1566 (49.8)
	Widow (er)	191 (6.1)
	Separated or divorced	241 (7.6)
Place of birth	In Barcelona/Catalonia/Spain	2399 (76.3)
	Outside Spain	746 (23.7)
Education	No formal education/primary	1113 (35.4)
	Secondary	852 (27.1)
	University	1180 (37.5)
Perceived income situation	Very difficult/difficult	447 (14.2)
	Somewhat difficult	727 (23.1)
	Somewhat easy	1117 (35.5)
	(very) Easy	854 (27.2)
Social class	Company director/manager with >10 employees; university-level profession	695 (22.1)
	Company director/manager with <10 employees; artist; sports professional	313 (9.9)
	Administrative worker; self-employed	761 (24.2)
	Manual worker	943 (30.0)
	Unskilled worker	433 (13.8)
	Employed	1721 (54.7)
	Unemployed/pensioner/homemaker	1107 (35.2)
	Student	203 (6.5)
	Incapacitated for work	97 (3.1)
	Missing	17 (0.5)
Length of residence (months)		239 (21.6)
Area-level unemployment rate (%)		21.7 (8.7)
3-30-300 rule Green space indicators		
Green window view (home) combined tree cover at least 3 trees in 15 m buffer (%)	Home view no (less than 3 trees or 3 or more trees) and Home view some, quite some and very much and less than 3 trees	1786 (56.8)
	Home view some, quite some and very much and more than 3 trees	1359 (43.2)
30% Tree cover/Residential surrounding greenness 500 m buffer (NDVI >0.3)	<30%	2870 (91.3)
	>30%	275 (8.7)
Distance to green space	<300 m	1952 (62.1)
	>300 m	1193 (37.9)
	None (reference)	703 (22.4%)
Score any criteria tree cover at least 3 trees & green window view (home), more 30% residential surrounding greenness (NDVI>0.3), less 300 m distance to green space		
	1/3 criteria	1445 (45.9%)
	2/3 criteria	850 (27%)
	3/3 criteria	147 (4.7%)
Health outcomes		
Mental health (GHQ-12)	Good	2578 (82.0)
	Poor	567 (18.0)
Psychiatrist visit in the last 12 months	Yes	166 (5.3)
	No	2976 (94.7)
Psychiatrist or Psychologist visit in the last 12 months	Yes	259 (8.3)
	No	2882 (91.7)
Antidepressant use in the last two days	Yes	254 (8.1)
	No	2891 (91.9)
Tranquilizer/sedative use in the last two days	Yes	296 (9.4)
	No	2849 (90.6)

Table 2

Associations between green space attributes and poor mental health in the Barcelona Health Survey 2016 (n = 3145).

	OR (95% CI)					
	Poor mental health (General Health Questionnaire)	Tranquilizer/sedative use in the last two days	Antidepressant use in the last two days	Medication combined	Psychiatrist visit in the last 12 months	Psychiatrist or Psychologist visit in the last 12 months
Home view (some, quite some and very much) and more than 3 trees within 15 m	0.88 (0.72, 1.09)	1.11 (0.85, 1.46)	1.14 (0.86, 1.51)	1.054 (0.83,1.34)	1.33 (0.95,1.86)	1.12 (0.85,1.47)
Residential tree cover >30% within 500 m with NDVI >0.3 as surrogate	0.60 (0.40, 0.90)	0.66 (0.39, 1.12)	0.71 (0.41, 1.22)	0.60 (0.38, 0.97)	0.22 (0.08, 0.62)	0.37 (0.19, 0.73)
Distance to green space <300 m	1.05 (0.85, 1.31)	0.89 (0.67, 1.17)	0.84 (0.63, 1.12)	0.83 (0.65, 1.06)	0.84 (0.60, 1.18)	0.97 (0.74, 1.28)
Score any criteria green view (home) & 3 or more trees, more 30%, less 300 m distance	None (reference)					
1/3 criteria	1.08 (0.83,1.40)	1.01 (0.71, 1.43)	0.75 (0.52, 1.07)	0.85 (0.63,1.15)	1.06 (0.69, 1.63)	1.10 (0.77,1.55)
2/3 criteria	0.87 (0.64,1.17)	0.92 (0.62, 1.36)	0.96 (0.65, 1.42)	0.87 (0.62, 1.21)	1.11 (0.69, 1.79)	1.13 (0.77, 1.67)
3/3 criteria	0.77 (0.44,1.36)	0.85 (0.42, 1.74)	0.54 (0.24, 1.23)	0.57 (0.29, 1.11)	0.24 (0.05, 1.05)	0.31 (0.11, 0.91)

health, specifically mental health. Previous evidence suggested that 30 percent tree canopy cover in the neighbourhood was beneficial for health, but for access to a major green space, the evidence was more mixed (Gascon et al., 2015; Triguero-Mas et al., 2015; Labib et al., 2020; Astell-Burt et al., 2021; Astell-Burt and Feng, 2020a; Astell-Burt et al. 2020b; Callaghan et al., 2021). Also in this study, we found that particularly residential surrounding greenness as a surrogate for 30% tree canopy cover was associated with better mental health outcomes. Access to a major green space did not show an association with mental health outcomes, which for the latter was also found in a similar study in the area (Triguero-Mas et al., 2015). However, access to a major green space, like a park may have other health related benefits such as physical activity (Bancroft et al., 2015). We did not find an association with the green window view which was surprising, given the number of recent studies that showed associations between green views from windows showed and lower depressive symptoms and better mental health, particularly during the COVID19 pandemic (Dzhambov et al., 2021; Ribeiro et al., 2021; Soga et al., 2021; Spano et al., 2021).

The 3-30-300 green space rule focuses on the presence of green space, but some studies have suggested that it is not (only) the presence, but the actual visits to nature that are important for better health and well-being and suggested at least 2 h per week of visits (White et al., 2019; Kruize et al., 2019). We did not evaluate the use of and visits to green space, but this may be an important factor. Also we did not include information on quality of green space which also may be an important factor for obtaining benefits (van Dillen et al., 2012; Kruize et al., 2019; Knobel et al., 2021).

The strength of this study is the fairly large sample size and its population representativeness, the detailed exposure measures such as the combination of window view and actual trees and a detailed characterization of mental health indicators, including perceived general mental health, medication use, and visits to psychiatrists and psychologists. But it has also a number of limitations including the cross-sectional nature of the study, the lack of large amount of tree canopy cover in Barcelona and the lack of high-quality data on tree canopy cover for which we had to use a surrounding greenness indicator (i.e. NDVI) instead. The 3-30-300 green space rule does not specify quality or use of green space, but information on this may have strengthened the analyses and helped the interpretation of results.

We used NDVI as a surrogate for tree canopy cover, which is far from

ideal. The correlation between the tree canopy cover map and NDVI was strong ($r = 0.88$) but it was driven by some extreme values and the tree canopy cover map did not perform well at the lower end. An NDVI value of 0.3 generally probably represents less than 30% tree canopy cover, but only with this measure we found statistically significant associations with mental health outcomes and it was most likely driving the associations we saw between the 3-30-300 indicator and mental health outcomes. We urgently need a high quality tree canopy cover map for Barcelona, although it may not help much with analyses presented here though because it may not change the distribution of people with sufficient tree canopy cover as there is relatively little in Barcelona.

Future studies should be conducted in cities with more tree canopy cover than Barcelona as the lack of green space, particularly sufficient tree canopy cover limits the ability to evaluate the 30 (%) aspect of the 3-30-300 rule. Of course, the question is how feasible a 30% tree canopy cover is, particularly in compact cities which have other advantages such as higher walkability and destination proximity. Higher tree canopy may be associated with sprawl, reduced walkability and larger distances to destinations. Furthermore, we combined the self-reported number of trees with a GIS based measure of the availability trees around the residence, which may give a good sense of what people perceive and what actually is there, but is also a bit subjective and not always feasible. Future studies possible could use deep learning methods to extract street view images to estimate the trees visible from windows. We did not find an association with access to a major green space within 300 m and it may be that access is only important and relevant if actual visits take place and this should be included in further studies. We found an association with an NDVI of 0.3 and although NDVI is a very crude measure, future studies should continue evaluating this, as an easy measure, although the absolute NDVI value may differ by city based on for example the season and type of green space.

What is obvious from the study is that there is relatively little green space in Barcelona with only a small percentage of people meeting the 3-30-300 green space rule, even though it has beneficial effects on mental health. There is an urgent need to provide more green space to the citizens. We may need to dig up asphalt and plant more trees, which will not only improve health but also reduce heat island effects and contribute to CO2 sequestration (Nieuwenhuijsen et al., 2017a). Barcelona initiatives such as turning a large roundabout in Plaza Glories into a large park, creating a green network and implementation of the

Superblocks may go some way to improve the provision of green space in the city and should be prioritized and fast tracked (Nieuwenhuijsen, 2020, 2021).

5. Conclusion

Meeting the full 3-30-300 green space rule was associated with better mental health, less medication use, and fewer psychologist or psychiatrist visits, but only for the latter combined was this statistically significant.

Credit statement

MJN came up with the concept and design of the study, supervised the analyses, MJN and WLZ wrote the first draft of the paper, MC, CB and XB collected the data, SM conducted the statistical, all authors contributed to the interpretation of results, editing of the paper and approved the final version.

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.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.envres.2022.114387>.

Mixed effects logistic regression models adjusted for age, sex, marital status, place of birth, education level, perceived income situation, employment status, social class, length of residence and area-level unemployment rate. Estimates in bold indicate p-value ≤ 0.05 .

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