Availability, use of, and satisfaction with greenspace, and children's mental wellbeing at age 4 in a multicultural urban deprived area: results from the Born in Bradford cohort study.

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Abstract

Background:

It is unknown whether quantity or quality of greenspace is more important for wellbeing. We aimed to explore relationships between mental wellbeing amongst 4 year-old children with availability of, satisfaction with, and use of greenspace in a multi-ethnic sample.

Methods:

Parent-reported mental wellbeing, assessed using the Strengths and Difficulties questionnaire was collected for N=2594 four-year-olds. Total, internalising and externalising difficulties and prosocial scales were computed. Residential greenspace using the Normalised Difference Vegetation Index around home addresses, and distance to major greenspaces was computed. A sub-sample (N=832) completed measures of satisfaction with, and use of, local greenspaces. Multiple regressions examined relationships and explored moderation by ethnicity (White British, South Asian) or socio-economic status.

Findings:

Ethnicity moderated relationships between residential greenspace and wellbeing. Greenspace was negatively associated with internalising difficulties for South Asian children only across all buffer zones (100m: B=-2.35 95%CI -4.20, -.05; 300m: B=-3.15, 95%CI: -5.18, -1.13; 500m: B=-2.85 95%CI: -4.91, -0.80, N=1504), but this effect was rendered non-significant after controlling for satisfaction with, and use of, greenspace. Satisfaction with greenspace was significantly associated with fewer total , and internalising difficulties, and greater prosocial behaviour.

Interpretation:

Positive effects of greenspace on wellbeing differ by ethnicity. Satisfaction with the quality of greenspace is a more important predictor than quantity of greenspace. Health and urban planners need to focus on both quality and quantity of urban greenspaces in order to promote health, particularly amongst ethnic minority groups.

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Keywords

Greenspace, Preschool, Ethnicity, Strengths and Difficulties, SDQ, Mental Health,

Research in context

Evidence before this study

We searched Web of Science, Medline and Psycinfo databases up to the 12th December 2017 with the following search terms: ('Green space') and ('child' or 'preschool', both MESH headings) and ('mental health', MESH Term or 'strengths and difficulties' or 'SDQ'). We also searched reference list of previous systematic reviews in the area. We included quantitative studies which calculated an objective measure of greenspace availability using geographical information systems data (for example, % greenspace within a predefined buffer or satellite derived estimates of greenspace density), included child or preschool aged samples and used the standardised 'Strengths and Difficulties Questionnaire' as the primary outcome measure. We located 8 studies examining relationships between aspects of greenspace and wellbeing assessed using the SDQ with inconsistent findings. None of these compared the relative contribution of quantity, quality and use in associations between greenspace and wellbeing. Few studies explored whether associations were moderated by socio-economic status and no studies explored variations by ethnicity. Limitations of previous literature included being unable to control for parental wellbeing.

Added value of this study

Our study is the first to explore relative contributions of quantity, quality and use in relationships between greenspace and wellbeing in a multi-ethnic urban deprived sample of preschool children. We found that more greenspace was associated with fewer total, and internalising difficulties in South Asian origin children living in the UK, but found no association for White British children. We found that South Asian children spent less time playing outside in greenspaces, and that their parents were less satisfied with their greenspaces. We found that satisfaction with quality of with local greenspaces was a more important predictor of wellbeing than either quantity, or use of greenspace amongst South Asian Families. Unlike some previous studies, we found no evidence of moderation by socio-economic status.

Implications of all the available evidence

Greenspace is a promising intervention to promote positive wellbeing in children. However, quantity of greenspace is not in itself sufficient to promote health. Ethnic minority groups typically have less access to high quality greenspaces which heightens health inequalities. Urban planners and public health professionals should work together to increase the availability and quality of greenspaces for marginalised communities using a combination of structural and community based interventions.

INTRODUCTION

Mental ill-health is a major source of disease ,(1) with costs estimated to be $2.5 trillion globally.(2) Natural environments are important determinants of physical and mental health(3-5) and, with over 50% of the global population and 73% of Europe's population (6) living in urban areas, urban greenspaces (UGS) have an important role in improving the quality of life for urban dwellers. Despite a body of evidence linking UGS to mental health amongst adults, a recent systematic review highlighted the paucity of evidence exploring relationships between natural environments and children's mental health. (4) As mental ill-health in childhood is an important predictor of mental health in adulthood(7) it is important to ascertain the potential of UGS in promoting mental wellbeing amongst children.

Studies have reported mixed effects of the impact of UGS on mental wellbeing (8-15) as assessed by the Strengths and Difficulties Questionnaire (16).A limitation of these studies is that, with the exception of one (10), none were able to control for the impact of maternal mental wellbeing on children's outcomes, a factor which has been shown to predict later distress amongst children (e.g. (17)). Differences in measurement of greenspace exposure also likely played a role in the mixed research findings. Many studies use area-based measures of greenspace such as a percentage of greenspace within a predefined geographic unit (e.g. (10)) or the normalised difference vegetation index (NDVI), which estimates density of green vegetation within a predefined area (e.g.(11)). However, these measures do not assess the actual or perceived quality of local greenspace, and how it is used by local communities. Quality can be measured objectively through use of standardised audit tools (e.g. (18)) or via asking participants to rate attributes of environments according to a range of criteria (e.g. (19)). Quality of greenspace has been shown to independently predict adult's mental wellbeing in addition to indicators of quantity (e.g. (19) and for a review see (5)). A recent study explored relationships between objectively assessed quality, satisfaction with, and use of local greenspace in a multi-ethnic deprived community.(20) Poorer quality greenspaces assessed via park audits influenced perceived satisfaction with greenspaces, suggesting that satisfaction can be a useful proxy for objective assessments of quality. Further, quality of greenspace predicted subsequent use of these spaces. To fully investigate the differences in the relationships between greenspace and health outcomes for different groups, it is important to have information about how these spaces are perceived and used. However with some notable exceptions (e.g. (9, 10)) there is a paucity of literature in this area and studies exploring the relative contribution of availability of, satisfaction with and use of greenspace on mental wellbeing amongst children are warranted.

There is important debate in the literature about for whom interventions to promote greenspace availability and use might be most effective. Interventions such as increasing access to nature may function as a tool to reduce health inequalities by disproportionately benefiting those in greatest need.(21) Beneficial effects also appear to vary by ethnicity, although results are mixed (e.g. (22, 23)) and there are no studies exploring variations in the context of

children's mental wellbeing. Reasons for ethnic differences are unclear, but it may be that minority groups use greenspaces less due to dissatisfaction and perceived safety concerns. (24) These findings highlight the importance of including measures of satisfaction and use of greenspace in studies aiming to identify relationships between greenspace and health in addition to measures of availability.

The aim of the current study was to explore the relationships between availability of, satisfaction with, and use of, urban greenspace (subsequently referred to as greenspace) and mental wellbeing amongst 4 year old children. Secondary aims were to explore whether or not ethnicity or socio-economic status moderated any impact of greenspace.

METHODS

Design and setting

This study was nested within a follow-up subsample of the 'Born in Bradford' cohort, a longitudinal study of 13776 children and 12453 mothers recruited during pregnancy at the City's main maternity unit between 2007-2011. Full methods can be found in Wright et al. (25) Bradford is the 5th largest metropolitan city in the UK and is characterised by high levels of ethnic diversity and deprivation (25). Fifty percent of the cohort are of South Asian origin.

Participants consented to long term follow-up, and to routine data linkage for health and education records. The current study reports data from respondents who participated in a follow-up assessment when their child was 4 years old. The data reported came from information collected at baseline (during pregnancy), from bespoke questions asked during the 4 year assessment, and from routine data linkage. Ethical approval was obtained from Bradford Research Ethics Committee (reference 07/H1302/112).

Participants and procedure

2594 mothers attended a follow-up appointment during which they completed a detailed questionnaire assessing the health of their child. Data were collected between October 2012 and June 2015. Appointments were offered in English, Punjabi or Mirpuri languages; 69% were conducted in English. Of these, a subsample (N=832) completed an additional detailed questionnaire on greenspace use and satisfaction. Due to resource constraints, the additional questionnaire was offered only to English-speaking participants.

Measures

Primary outcome

The primary outcome for the study was parent-reported mental wellbeing assessed using the standardised Strengths and Difficulties Questionnaire (SDQ). (16) The SDQ contains 25 items assessing 4 core dimensions of difficulties, two of which are externalising (conduct problems and hyperactivity), and two of which are internalising (emotional problems and peer problems). The questionnaire also assesses one area of strength: prosocial behaviour (range 0-5, with higher scores indicating more prosocial behaviour towards others). The four difficulty domains can be summed to create a 'total difficulties' score (range 0-40, with higher scores indicating greater difficulties); they can also be combined into the two broader internalising and externalising subscales (both range 0-20, with higher scores indicating greater difficulties.

Greenspace measures

We calculated measures of residential greenspace for each participant using the Normalised Difference Vegetation Index (NDVI). To explore residential 'greenness', we calculated the NDVI within three straight line buffers of 100, 300 and 500m around participants' geocoded home address. NDVI ranges between -1 and 1, with higher numbers indicating more green vegetation. We used the Landsat 5 TM (USGS) remote sensing data at 30m resolution of to calculate NDVI values using the best available images between 2006-2011 (images from 10/06/2006 with the exception of a small number of participants to the north of Bradford where a separate image was required and taken on 28/09/2011). We excluded major water bodies >0.5 hectares because these values can skew the results of an otherwise 'green' neighbourhood. Straight-line distances to major greenspaces (greater than 5000 square metre) were calculated in metres.

A subsample of respondents (n=832) were asked to rate satisfaction with, and use of, local greenspaces. Greenspaces were defined as public parks (including play areas specifically for children), sports playing fields or other natural habitats (e.g. woodland) where there are plants and other vegetation. In order to ascertain how often children used green spaces, we asked parents to report i) 'how many days their child spent playing outside in greenspace per week' in summer months and winter months and ii) 'for how long on average their child spent playing outside in green spaces on these days' (minutes per day). Responses were multiplied to create a 'weekly playing outside index' for summer and winter. These indices were averaged to create an overall 'weekly playing outside index' (minutes / week) as a proxy measure of time spent outside. Parents were then asked to report which green space they used most frequently in summer months and were asked 'how satisfied are you with the quality of this park?' with responses recorded on a five-point Likert-type scale ranging from 1 (very dissatisfied) to 5 (very satisfied), where 3 was a neutral response.

Ethnicity and socio-economic status

Ethnicity was self-reported at baseline using standard classifications.(26) Due to large numbers in two main ethnic groups, we split ethnicity into three groups: South Asian Origin, White British Origin and Other origin. This last

category represents a diverse group including Bangladeshi, Black-African and Mixed Race individuals. When comparing results of findings by ethnicity, we contrast results for South Asian and White British groups only.

We assessed individual- and area-level indicators of socio-economic status following previous literature (e.g. (23)). At an individual level we recorded mothers' educational status as 1 (not reached high school diploma level, including those who marked 'unknown', 'foreign qualification' or 'other'), or 2 (high school diploma equivalent or higher). A measure of subjective poverty was included using the item 'How well would you say you or you and your husband / partner are managing financially these days'. Response options 'just about getting by', 'quite difficult' and 'very difficult', 'does not wish to answer' were coded as 1 (struggling financially). Response options 'living comfortably' and 'doing alright' were coded as 2 (not struggling financially).

At an area level we included the Index of Multiple Deprivation (IMD) (27) as a measure of relative deprivation at a national level. The IMD is constructed from seven domains of deprivation (income, employment, education, health, crime, barriers to housing and service and living environment) at a lower super output area level (LSOA). Postcode of mothers' place of residence at registration was mapped to LSOA which were then matched to IMD 2015 scores. Given the high level of deprivation observed in the current sample (with 66% of the sample living in the in the most deprived quintile of deprivation relative to UK averages), we split IMD scores into local quintiles of deprivation (where 1=most deprived with in the sample and 5=least deprived).

Other variables

Other variables included: mother's age, mother's smoking, child's age, cohabitation status (married and living with partner, not married and living with partner, not living with partner). Tertiles of household size were calculated for the total sample population and for each ethnic group. We constructed a dichotomous variable indicating whether the mother had a record of treatment for any 'common mental disorder' (for example anxiety, depression) during the previous year from their routine primary health care data using a validated algorithm.(17)

Statistical analyses

We explored relationships between measures of greenspace with child's total, externalising, and internalising SDQ scores as the outcome, as well as the prosocial scale. Analyses were carried out in R 3.3.1.(28) Analyses were conducted for the total sample and separately for White British and South Asian groups for comparison. Mean (standard deviation [SD]) and median (interquartile range [IQR]) were calculated for parametric and non-parametric variables, respectively. Comparisons between the White British and South Asian groups were conducted with Welch's *t*-tests and Mann-Whitney U-tests for continuous variables and Chi-square and Fisher's exact tests for categorical variables. Ten high outlying responses for 'minutes spend playing outside per week' were identified. We

ran a sensitivity analysis removing these outlying responses and results were not altered. These participants were thus retained. P-values were also calculated to test for differences in characteristics between the total sample size and subsample of participants with the additional greenspace questionnaire.

Unadjusted regression models were computed, then covariates were entered sequentially in logical blocks after ethnicity was first adjusted for in the total sample population: demographic covariates (child's age, child's sex, mother's age, cohabitation status), socioeconomic covariates (maternal education, subjective poverty, household size, and IMD [quintiles were created for the total sample population and within each ethnic group]), and health behaviours (maternal smoking, record of any 'common mental disorder'). Analyses were calculated for all three buffer sizes (100, 300, and 500m). IMD quintiles and satisfaction with outdoor greenspace were entered as continuous variables. In the sub-sample of participants (n=832) we included data on satisfaction and use of local greenspace as predictors of wellbeing after controlling for all other confounding variables. These analyses therefore allow the comparison of quantity (NDVI), quality (satisfaction with), and use of greenspaces in associations with children's wellbeing.

To explore effect moderation by ethnicity or socio-economic status, we assessed inclusion of an interaction term between residential surrounding greenness and ethnicity, maternal education, or financial struggles by comparing fully-adjusted models with and without the interaction term using likelihood ratio tests. Moderation by ethnicity was significant; therefore we stratified the fully-adjusted models by ethnic groups.

Role of funding source

The study funders had no role in the study design, data collection, analysis, interpretation of data, drafting of the manuscript or in the decision to submit the paper for publication.

RESULTS

The final sample included 2594 mothers; of these, 58% were of South Asian Origin, 29% of White British Origin, and 13% reported other ethnicity (Table 1). The average age of mothers was 33 years (SD 5.5) and the average age of their child was 4.5 years (SD 0.4). Cronbach's alpha for total difficulties, internalising, externalising and the prosocial scale were 0.75, 0.62, 0.70 and 0.67 respectively. NDVI was significantly higher (greener) for White British mothers compared with South Asian mothers across all buffer zones. On average the sample lived 221 metres from a major greenspace, and there were no significant differences in distance to greenspace between ethnic groups (see Table 1).

Of the subsample who completed the additional questionnaire on greenspace use and satisfaction participants reported lower SDQ scores, higher NDVI scores, fewer mothers as "married and living with partner" ,a higher proportion of mothers with higher levels of education, and less deprivation (Supplemental file 1). No differences were noted when comparing the White British subsample with those who did not complete the additional

questionnaire. However, the South Asian population in the subsample reported lower SDQ scores, higher NDVI scores at all three buffers, mothers with higher levels of education, fewer reports of financial struggles, fewer household members, and slightly greater numbers of families in the quintile of least deprivation.

More residential greenspace assessed using NDVI was associated with fewer total, internalising, and externalising difficulties in unadjusted models across all buffer zones (Supplemental file 2). However, after controlling for socio-demographics, ethnicity, maternal smoking, and maternal mental health these effects were non-significant. There were no relationships between NDVI and prosocial behaviour. We found no relationships between distance to major greenspaces and any outcomes after adjustment. Distance to major greenspaces is thus not reported further within the results.

With regards to residential greenspaces assessed using NDVI and children's mental wellbeing, there was no moderation by socio-economic status (maternal education or financial struggles; results not reported), but significant moderation of residential greenspace with total and internalising difficulties by ethnicity ($p<0.05$ for all). Table 2 reports stratified analyses for the two main ethnic groups within the sample: White British (N=663) and South Asian (N=1504). In the unadjusted analyses, there were no relationships between residential greenspace assessed using NDVI and behavioural difficulties or prosocial behaviour for children of White British mothers. However, amongst South Asian participants, more residential greenspace was associated with fewer behavioural difficulties across all three buffer zones in both unadjusted and adjusted models (fully adjusted model 4: 100m B=-4.3, 95%CI -7.7, -0.9; 300m B=-5.2; 95%CI -8.9, -1.5; 500m B=-4.8, 95%CI -8.6, -1.1). We repeated analyses amongst South Asian participants exploring externalising and internalising subscales and the prosocial scale separately. After adjusting for all relevant variables we found that the impact of greenspace was apparent for internalising behavioural difficulties only. This effect was apparent across all three buffer zones (fully adjusted model 4: 100m -2.4, 95%CI -4.2, -0.5; 300m -3.2, 95%CI -5.2, -1.1; 500m -2.9, 95%CI -4.9, -0.8).

276 **Table 1 Characteristics of study participants by ethnic group (full sample)**

	Total		White British		South Asian		Other Ethnicity		P-value*
SDQ	N	Median (IQR)	N	Median (IQR)	N	Median (IQR)	N	Median (IQR)	
Total difficulties	2591	10 (6,14)	738	8 (5, 12)	1518	11 (7, 15)	333	8 (5, 12)	<0.001
Internalizing	2591	3 (2, 5)	738	2 (2, 6)	1518	4 (2, 6)	333	3 (1, 5)	<0.001
Externalizing	2591	6 (4, 9)	738	5 (3, 8)	1518	6 (4, 9)	333	5 (3, 7)	<0.001
Prosocial	2590	9 (7, 10)	738	9 (7, 10)	1518	9 (7, 10)	332	9 (7, 10)	0.6
Greenspace									
NDVI									
100m	2488	0.36 (0.30, 0.44)	665	0.41 (0.35, 0.48)	1505	0.33 (0.29, 0.41)	316	0.39 (0.33, 0.45)	<0.001
300m	2488	0.38 (0.32, 0.45)	665	0.43 (0.36, 0.49)	1505	0.35 (0.32, 0.42)	316	0.39 (0.34, 0.46)	<0.001
500m	2488	0.40 (0.08)	665	0.43 (0.37, 0.51)	1505	0.36 (0.32, 0.43)	316	0.39 (-.34, 0.46)	<0.001
Distance to major greenspace (m)	2487	221 (108, 406)	664	211 (100, 383)	1505	231 (116, 422)	316	214 (97, 381)	0.05
Demographics	N	Mean (SD)/%	N	Mean (SD)/%	N	Mean (SD)/%	N	Mean (SD)/%	
Age of child (year)	2594	4.5 (0.4)	740	4.5 (0.4)	1519	4.5 (0.4)	333	4.5 (0.4)	0.4
Gender of child									
Male	1302	50	386	52	741	49	175	53	0.1
Female	1292	50	354	48	778	51	158	47	

	Total		White British		South Asian		Other Ethnicity		P-value*
Age of mother (year)	2594	33.6 (5.5)	740	33.9 (6.1)	1519	33.4 (5.3)	333	34.1 (5.5)	0.1
Cohabitation status									
Married and living with partner (%)	2056	79	383	52	1418	93	253	76	<0.001
Not married and living with partner (%)	314	12	168	23	97	6	48	14	
Not living with partner (%)	224	9	188	25	4	1	32	10	
Socioeconomic status (mother)									
Maternal education									
A-level equivalent or higher (%)	1058	41	338	46	550	36	170	51	<0.001
Maximum of 5 GCSE, unknown, foreign, or other (%)	1530	59	402	54	965	64	162	49	
Subjective poverty									
Struggling financially (%)	817	32	245	33	485	32	88	26	0.6
Not struggling financially (%)	1775	68	495	67	1034	68	245	74	
Household size	2587	5.3 (2.0)	738	4.1 (1.2)	1516	6.1 (2.2)	331	4.5 (1.4)	<0.001
Tertile 1 (%)	1071	41	541	73	341	22	189	57	
Tertile 2 (%)	960	37	172	23	676	45	111	34	
Tertile 3 (%)	556	21	25	4	499	33	31	9	
IMD quintile									

	Total		White British		South Asian		Other Ethnicity		P-value*
Quintile 1	566	22	334	46	163	11	69	21	<0.001
Quintile 2	492	19	139	19	283	19	69	21	
Quintile 3	560	22	85	12	404	27	70	22	
Quintile 4	444	17	86	12	320	21	38	12	
Quintile 5	505	20	88	12	338	22	79	24	
Health behaviours									
Mother smoking									
Yes (%)	234	9	166	23	40	3	28	8	<0.001
No (%)	2353	91	570	77	1476	97	305	92	
Mother any CMD from in previous year									
Yes (%)	328	13	159	22	141	9	27	8	<0.001
No (%)	2266	87	581	78	1378	91	306	92	

Key: SDQ: Strengths and Difficulties Questionnaire (higher score indicates more difficulties, with the exception of the prosocial scale where higher scores indicate more prosocial behaviour); NDVI: Normalised difference vegetation index (higher scores indicate greener environments); IMD: index of multiple deprivation (lower scores indicate more deprived areas); CMD: Common mental disorder. Note: the total number of participants with SDQ scores does not mirror the scores when combined by ethnicity due to two participants with missing ethnicity data but with SDQ scores. *P-values test differences between White British and South Asian groups. Mann-Whitney U tests were used for non-parametric data, t-tests for parametric, Chi-square for categorical.

Table 2 Associations between NDVI and wellbeing by White British, and South Asian Origin groups (full sample)

	White British								South Asian							
	Total Difficulties[a]		Internalising[a]		Externalising[a]		Prosocial[b]		Total Difficulties[a]		Internalising[a]		Externalising[a]		Prosocial[b]	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Unadjusted[1]																
Mean NDVI 100 m	-0.11	(-4.3, 4.1)	0.59	(-1.5, 2.7)	-0.71	(-3.7, 2.3)	0.49	(-0.98, 2.0)	***-5.90***	***(-9.2, -2.6)***	***-3.21***	***(-5.0, -1.4)***	***-2.68***	***(-4.8, -0.53)***	0.18	(-0.92, 1.30)
Mean NDVI 300 m	-0.30	(-4.4, 3.8)	0.63	(-1.4, 2.6)	-0.92	(-3.8, 1.9)	0.46	(-0.96, 1.9)	***-6.90***	***(-10, -3.4)***	***-4.01***	***(-5.9, -2.1)***	***-2.89***	***(-5.2, -0.58)***	0.59	(-0.58, 1.80)
Mean NDVI 500 m	-0.47	(-4.5, 3.5)	0.49	(-1.5, 2.4)	-0.95	(-3.8, 1.8)	0.43	(-0.95, 1.8)	***-6.42***	***(-9.9, -2.9)***	***-3.65***	***(-5.6, -1.7)***	***-2.77***	***(-5.1, -0.45)***	0.65	(-0.53, 1.8)
Adjusted[2]																
Mean NDVI 100 m	-0.02	(-4.01, 3.97)	0.61	(-1.37, 2.59)	-0.63	(-3.43, 2.16)	0.51	(-0.91, 1.93)	***-6.03***	***(-9.22, -2.78)***	***-3.21***	***(-4.99, -1.43)***	***-2.82***	***(-4.95, -0.67)***	0.32	(-0.76, 1.39)
Mean NDVI 300 m	-0.36	(-4.22, 3.51)	0.59	(-1.32, 2.52)	-0.95	(-3.67, 1.75)	0.45	(-0.93, 1.82)	***-6.99***	***(-10.47, -3.52)***	***-3.99***	***(-5.89, -2.09)***	***-3.01***	***(-5.31, -0.71)***	0.71	(-0.45, 1.86)
Mean NDVI 500 m	-0.56	(-4.33, 3.21)	0.47	(-1.40, 2.35)	-1.04	(-3.68, 1.61)	0.45	(-0.89, 1.79)	***-6.51***	***(-10.01, -3.01)***	***-3.67***	***(-5.58, -1.75)***	***-2.84***	***(5.52, -0.53)***	0.72	(-0.44, 1.88)
Adjusted[3]																
Mean NDVI 100 m	-0.70	(-4.58, 3.17)	0.35	(-1.61, 2.33)	-1.05	(-3.78, 1.66)	0.7	(-0.71, 2.11)	***-4.54***	***(-7.92, -1.16)***	***-2.49***	***(-4.35, -0.64)***	-2.05	(-4.29, 0.20)	0.28	(-0.86, 1.43)
Mean NDVI 300 m	-0.29	(-4.05, 3.46)	0.62	(-1.29, 2.53)	-0.92	(-3.55, 1.72)	0.5	(-0.87, 1.87)	***-5.44***	***(-9.14, -1.76)***	***-3.28***	***(-5.31, -1.26)***	-2.16	(-4.62, 0.29)	0.74	(-0.51, 1.99)
Mean NDVI 500 m	-0.09	(-3.77, 3.58)	0.64	(-1.22, 2.51)	-0.74	(-3.31, 1.84)	0.47	(-0.87, 1.81)	***-4.99***	***(-8.74, -1.23)***	***-2.95***	***(-5.01, -0.88)***	-2.04	(-4.54, 0.46)	0.77	(-0.50, 2.04)
Adjusted[4]																
Mean NDVI 100 m	-0.67	(-4.54, 3.19)	0.41	(-1.56, 2.39)	-1.09	(-3.79, 1.61)	0.71	(-0.71, 2.12)	***-4.27***	***(-7.65, -0.90)***	***-2.35***	***(-4.20, -0.50)***	-1.93	(-4.17, 0.31)	0.36	(-0.78, 1.49)
Mean NDVI 300 m	-0.2	(-3.95, 3.55)	0.61	(-1.30, 2.52)	-0.81	(-3.43, 1.81)	0.44	(-0.94, 1.81)	***-5.22***	***(-8.91, -1.54)***	***-3.15***	***(-5.18, -1.13)***	-2.07	(-4.52, 0.39)	0.81	(-0.44, 2.05)
Mean NDVI 500 m	-0.01	(-3.68, 3.66)	0.59	(-1.28, 2.47)	-0.6	(-3.17, 1.96)	0.39	(-0.95, 1.73)	***-4.82***	***(-8.57, -1.07)***	***-2.85***	***(-4.91, -0.80)***	-1.98	(-4.47, 0.52)	0.86	(-0.41,2 .18)

Notes: [a]: higher scores indicate more difficulties; [b]: higher scores indicate greater prosocial behaviour; NDVI: Normalised difference vegetation index (higher scores indicate greener environments); 1: White British N=663; South Asian N=1504; 2: adjusted for child age, child gender, maternal age, cohabitation status. White British N=663; South Asian N=1504; 3: model 2 + maternal education, subjective poverty, household size, IMD, White British N=657; South Asian N=1489; 4: model 3 + maternal smoking, mother's CMD in previous year. White British N=653; South Asian N=1486. Significant findings are highlighted in ***bold italics***.

Table 3 Satisfaction with, and use of, greenspace by ethnic group (subsample)

	Total		White British		South Asian		Other Ethnicity		
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	P-value*
Mins/week spent outside - Winter	831	95.75 (186.56)	336	130.68 (214.07)	365	58.12 (129.50)	130	104.69 (224.38)	0.001
Mins/week spent outside - Summer	831	372.07 (358.33)	336	401.71 (369.45)	365	357.44 (363.16)	130	336.52 (308.83)	0.03
Satisfaction with greenspace	805	4.04 (1.02)	328	4.16 (1.00)	352	3.93 (1.02)	125	4.05 (1.05)	0.001

Note: IQR –Interquartile range; SD: Standard deviation. *P-values test differences between White British and South Asian groups using Mann-Whitney U tests.

We repeated stratified analyses within the subsample of respondents. Satisfaction with, and use of, greenspace varied by ethnic group (Table 3). White British children spent significantly more time outside than South Asian children or children in the 'Other Ethnicity' category and parents of White British children also reported significantly higher levels of satisfaction with their local greenspace. In this subsample, there was a significant negative association between greenspace and internalising difficulties only amongst children of South Asian mothers, with increasing greenspace associated with fewer internalising difficulties. This association was strongest in the unadjusted models (100m B-4.05, 95%CI, -7.3, -.083; 300m B -4.96, 95%CI -8.4, 1.5, 500m B-4.6, 95%CI -8.1, -1.1). Significant effects remained after adjustment for demographics (model 2) across all three buffer zones. When controlling further for deprivation (model 3), and maternal smoking and mental health (model 4), significant associations were found only for the 300m and 500m buffer zones (see Supplemental File 3).

In the final model, inclusion of time spent outside and satisfaction with greenspace rendered the influence of NDVI non-significant across all buffer zones. Within the South Asian subsample (N=363), satisfaction with local greenspaces was associated with significantly fewer internalising difficulties within 100m and 300m buffer zones (B=-0.28, 95%CI -0.56, -0.003; B=-0.28, 95%CI -0.56, -0.002 respectively). It was also associated with lower total difficulties across all three buffer zone (B=-0.59,

95% CI -1.11, -0.07 for all three zones) and greater prosocial behaviour across all three buffer zones (B=0.2, 95% CI 0.02, 0.38). There were no relationships between satisfaction and externalising difficulties across any buffer zones. Finally, there was no effect of time spent outdoors on total, externalising, internalising difficulties or prosocial behaviour (Table 4, 100m buffer results reported). Amongst the White British sample, satisfaction with, and use of greenspaces was not associated with any measure of difficulty or prosocial behaviour (results not reported).

Table 4 Fully adjusted model for South Asian Parents in the subsample (N=344 complete data sets, 100m buffer only reported)

	Total Difficulties[a]		Internalising[a]		Externalising[a]		Prosocial[b]	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI
NDVI	-1.63	(-8.20, 4.94)	-2.03	(-5.56, 1.50)	0.39	(-4.03, 4.82)	-1.03	(-3.31, 1.24)
Child's age	-0.57	(-2.08, 0.94)	-0.63	(-1.44, 0.18)	0.06	(-0.95, 1.07)	0.11	(-0.41, 0.63)
Child's sex								
Male	-	-	-	-	-	-	-	-
Female	-0.58	(-1.53, 0.47)	0.10	(-0.46, 0.67)	-0.68	(-1.39, 0.02)	***0.43***	***(0.06, 0.79)***
Mother's age	-0.02	(-0.12, 0.08)	-0.01	(-0.06, 0.05)	-0.01	(-0.08, 0.05)	0.01	(-0.03, 0.04)
Mother's cohabitation								
Married and living with partner	-	-	-	-	-	-	-	-
Not living with partner	-1.24	(-3.37, 0.89)	-0.63	(-1.77, 0.52)	-0.61	(-2.05, 0.82)	0.34	(-0.40, 1.07)
Not married and living with partner	0.99	(-8.71, 10.69)	3.15	(-2.06, 8.37)	-2.16	(-8.69, 4.37)	2.07	(-1.28, 5.43)
Mother's education								
A-level equivalent or higher	-	-	-	-	-	-	-	-
Maximum of 5 GCSE, unknown, foreign, or	***1.50***	***(0.41, 2.58)***	***0.65***	***(0.07, 1.24)***	***0.84***	***(0.11, 1.57)***	-0.01	(-0.38, 0.37)

	Total Difficulties[a]		Internalising[a]		Externalising[a]		Prosocial[b]	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI
other								
Subjective poverty								
Not struggling financially	-	-	-	-	-	-	-	-
Struggling financially	0.74	(-0.50, 1.98)	0.37	(-0.30, 1.03)	0.37	(-0.46, 1.21)	0.11	(-0.32, 0.54)
Number of members in household	-0.05	(-0.35, 0.22)	0.03	(-0.11, 0.18)	-0.09	(-0.27, 0.09)	0.03	(-0.32, 0.54)
IMD	-0.08	(-0.48, 0.32)	-0.01	(-0.23, 0.20)	-0.07	(-0.34, 0.20)	-0.07	(-0.21, 0.07)
Mother's smoking								
No	-	-	-	-	-	-	-	-
Yes	0.10	(-2.63, 2.83)	-0.19	(-1.66, 1.28)	0.29	(-1.55, 2.13)	***-1.00***	***(-1.94, -0.05)***
Mother had mental disorder in previous year								
No	-	-	-	-	-	-	-	-
Yes	0.99	(-0.75, 2.73)	0.81	(-0.13, 1.74)	0.18	(-0.99, 1.35)	0.32	(-0.28, 0.92)
Time spent outside (min)	0.0000	(-0.003, 0.002)	-0.001	(-0.002, 0.001)	0.001	(-0.001, 0.002)	0.0005	(-0.0004, 0.001)
Satisfaction with greenspace	***-0.59***	***(-1.11, -0.07)***	***-0.28***	***(-0.56, -0.003)***	-0.31	(-0.66, 0.04)	***0.2***	***(0.02, 0.38)***

Notes: [a]: higher scores indicate more difficulties; [b]: higher scores indicate greater prosocial behaviour; NDVI: Normalised difference vegetation index (higher scores indicate greener environments); significant results are highlighted in ***bold italics***

Discussion

We explored relationship between children's mental wellbeing and the availability of, use of, and satisfaction with greenspace. We found a significant association between availability of greenspace assessed using the NDVI and both total, and internalising behavioural difficulties amongst South Asian children living in the UK, but not amongst White British children. When satisfaction and use of greenspace were included in our analyses only satisfaction displayed a significant association with wellbeing. Reported satisfaction with greenspace was independently predictive of internalising difficulties, total difficulties and prosocial behaviour amongst South Asian children. Finally, we found that most of our sample lived close to greenspaces, and that there were no associations between distance to greenspace and mental wellbeing.

Unlike some previous studies (8, 23), we found no evidence of moderation of effects by socio-economic indicators such as maternal education or subjective poverty. However, the current study was situated in a highly deprived location in the UK, and this lack of variability may have contributed to an inability to identify any differences by socio-economic status. There may also be issues of residual confounding due to our inability to control, for example, for income or social class.

Moderation by ethnicity was apparent, with relationships between greenspace and children's mental wellbeing observed amongst South Asian children only. We found South Asian families faced a triple count of inequity in relation to greenspace. Not only did NDVI scores indicate that South Asian families had less residential greenspace than their White British counterparts, they also reported less satisfaction with their greenspaces, and that their children spent less time playing in greenspaces. Further, when satisfaction with greenspace was included in our analyses, it rendered the association of residential greenness non-significant. Satisfaction with greenspace was independently predictive of South Asian children's wellbeing after controlling for demographics, socio-economic status, maternal health behaviours and maternal mental wellbeing. This is an important finding, suggesting that quality, in addition to quantity, of greenspace is important for health. Some authors suggest that quality of greenspace may act as a moderating factor, meaning that relationships between quantity of greenspace and health outcomes are stronger when quality is higher.(29) We were unable to explore this in the current study as there was a mismatch in specificity for our quality indicator (satisfaction with a specific local greenspace) and our measure of quantity (NDVI in pre-specified buffer zones around residential addresses). Future research should aim to explore the potential moderating role of greenspace quality in relationships with health outcomes (i.e. are relationships between wellbeing and quantity of greenspace stronger when they are of higher quality).

Internationally, there is evidence that more deprived groups have less access to greenspaces(30) These inherent inequalities are further exacerbated if the quality of available greenspaces in marginalised communities is worse. Within the current setting, Roberts et al(31) explored how the quality of local parks was linked to satisfaction and use. They found ratings of satisfaction were predicted solely by structural park features relating to quality such as the presence of amenities (for example, presence of toilets, benches, shelters) and incivilities within the park (for example, presence of litter or evidence of anti-social behaviour) rather than due to ethnic or socio-economic characteristics of respondents. Poor quality parks and greenspaces can discourage use by marginalised communities. Fears about safety and anti-social behaviour, and concerns about cleanliness and maintenance, are key barriers to greenspace use. (32, 33) Policy makers need to recognise these inequities and work to improve the perceptions of local greenspaces, in addition to prioritising continued investment for maintenance and improvement of local greenspaces. Effective interventions will take into account the needs and preferences of all groups who use greenspace to ensure that they are acceptable to all, and to increase community ownership of local space. Co-design will be central to this process, and, although evaluations of these types of interventions are rare, there is evidence to suggest that co-designing interventions with local communities can result in increased quality of(34), and use of (35) greenspaces. Implementation of system-wide changes to improve local environments will be challenging and will require concerted multi-sector efforts and co-operation from health, public policy and urban planning, and community perspectives in order to be successful. (36, 37)

The current study had a number of strengths. To our knowledge, it is the first to explore the relative contribution of availability, satisfaction with, and use of, greenspace on children's mental wellbeing. It was conducted within a deprived urban area with a multi-ethnic group of participants, and thus findings are likely to be transferable to other multi-ethnic urban settings in the UK. We were able to control for an extensive array of potential confounding variables including the impact of maternal mental distress on children's wellbeing to disentangle the independent effects of greenspace on health in this group.

There are however a number of limitations. We used a validated parent-reported measure of children's wellbeing; however, parental self-report may be subject to bias, including response bias. A recent study found that relationships between greenspace and wellbeing differed depending on whether parents or teachers were the primary informant. (9) Future research should aim to replicate

these findings using different tools to assess mental wellbeing within children. As mentioned above, our sample was predominantly of South Asian origin and included individuals living within a highly deprived area. Whilst this is reflective of our study setting(25), our findings may not be generalizable to other more affluent and less ethnically diverse areas of the UK. Although we assessed the extent to which children played outside in greenspaces, this was self-reported by parents and potentially subject to response bias. In addition, bias in responses to questions on greenspace satisfaction and use may have been introduced due to the subsample questions only being available to English speakers. We were unable to control for more general physical activity within our analyses. Whilst we assessed a wide range of potential confounders, there may be other unmeasured variables which may contribute to residual confounding. Our measure of greenspace was calculated using NDVI scores from two images assessed five years apart (selected as they had minimal cloud cover). Whilst this may have introduced bias in our assessment of greenspace, previous research has found NDVI to be highly stable across this time period in the current setting.(22) Finally, our measure of greenspace satisfaction was based on respondents' frequently used parks rather than general neighbourhood greenspace, and we did not include an objective audit assessments of park quality. Future research should aim to include both objective and subjective assessments of quality when exploring relationships with health outcomes, and explore whether satisfaction with specific frequently used greenspaces is more important for wellbeing than perceptions of the neighbourhood as a whole.

Conclusions

Quality, in addition to quantity, of greenspace may be important for the mental wellbeing of ethnic minority groups. Provision of greenspace alone is unlikely to produce health benefits for these groups. Multi-sector approaches combining health, urban planners, policy makers and communities are needed to develop new and creative solutions to improve the quality of local greenspaces, and to increase satisfaction with greenspaces among marginalised communities.

Contributor's statement

RRCM, MN, JW, KP, and CG conceived study. RRCM drafted manuscript. TY performed analysis and drafted manuscript with RRCM. RRCM, JW, KP, HR and DAP were responsible for data collection and contributed to analysis. All authors revised manuscript and provided intellectual input. All authors approved final manuscript.

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Ethical approval

The research reported here was approved by Bradford NHS Research Ethics committee (reference 07/H1302/112).

Conflict of interest

The authors report no conflict of interest.

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The corresponding author (RRCM) has full access to all the data in the study and final responsibility to submit the manuscript for publication.

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564 Supplemental Table 1. Characteristics of study participants by ethnic group in sub-sample of women who completed the additional green space questionnaire (n=832).

		Total		White British		South Asian		Other Ethnicity				
		N=832		N=337		N=365		N=130	P-value*	P-value - total**	P-value - White British**	P-value - South Asian**
SDQ												
Total	829	8 (5, 11)	335	7 (5, 11)	364	9 (6, 12)	130	8 (5, 11)	<0.001	<0.001	0.1	<0.001
Internalizing	829	3 (1, 5)	335	2 (1, 4)	364	3 (2, 5)	130	2.5 (2.5, 5)	<0.001	<0.001	0.07	<0.001
Externalizing	829	5 (3, 8)	335	5 (3, 8)	364	6 (3, 8)	130	5 (3, 7)	0.3	<0.001	0.3	<0.001
Prosocial												
Greenspace												
NDVI												
100m	796	0.38 (0.32, 0.45)	310	0.41 (0.34, 0.47)	363	0.34 (0.29, 0.42)	123	0.40 (0.40, 0.45)	<0.001	<0.001	0.3	0.006
300m	796	0.39 (0.33, 0.46)	310	0.42 (0.36, 0.48)	363	0.36 (0.32, 0.43)	123	0.41 (0.34, 0.46)	<0.001	<0.001	0.2	0.01
500m	796	0.40 (0.34, 0.46)	310	0.43 (0.36, 0.50)	363	0.37 (0.33, 0.44)	123	0.41 (0.36, 0.45)	<0.001	<0.001	0.3	0.008
Distance to major greenspace (m)	796	217 (98, 381)	310	194 (91, 381)	363	231 (106, 372)	123	231 (87, 403)	0.02	0.7	0.7	0.3
Demographics												
Age of child (year)	832	4.5 (0.4)	337	4.5 (0.4)	365	4.5 (0.4)	130	4.4 (0.3)	0.08	<0.001	0.09	<0.001
Age of mother (year)	832	33.7 (5.57)	337	34.0 (6.0)	365	33.2 (5.2)	130	34.0 (5.2)	0.05	0.9	0.5	0.3
Cohabitation status												
Married and living with partner	595	72	167	50	337	92	91	70	<0.001	<0.001	0.3	0.6
Not married and living with partner	112	13	95	28	1	0	16	12				

		Total		White British		South Asian		Other Ethnicity				
		N=832		N=337		N=365		N=130	P-value*	P-value - total**	P-value - White British**	P-value - South Asian**
Not living with partner	125	15	75	22	27	7	23	18				
Socioeconomic status (mother)												
Maternal education												
A-level equivalent or higher	413	50	150	45	190	52	57	44	0.05	<0.001	0.6	<0.001
Maximum of 5 GCSE, unknown, foreign, or other	419	50	187	55	175	48	73	56				
Subjective poverty												
Struggling financially	229	28	110	33	90	25	29	22	0.02	0.003	0.9	<0.001
Not struggling financially	603	72	227	67	275	75	101	78				
Household size	828	4.8 (1.77)	337	4.1 (1.1)	363	5.7 (2.0)	128	4.4 (1.4)	<0.001	<0.001	0.8	<0.001
Tertile 1	425	51	249	74	100	27	76	60				
Tertile 2	171	21	56	17	89	25	26	20				
Tertile 3	232	28	32	9	174	48	26	20				
IMD quintile												
Quintile 1	236	29	145	47	54	15	26	20	<0.001	<0.001	0.8	0.04
Quintile 2	150	18	63	19	65	18	22	17				
Quintile 3	171	21	38	11	100	28	33	26				
Quintile 4	124	15	34	10	73	20	17	13				
Quintile 5	142	17	43	13	70	19	29	23				
Health behaviours												
Mother smoking												
Yes	100	12	71	21	14	4	15	12	<0.001	<0.001	0.5	0.1
No	738	88	264	79	349	96	115	88				
Mother any CMD from in previous year												

		Total		White British		South Asian		Other Ethnicity				
		N=832		N=337		N=365		N=130	P-value*	P-value - total**	P-value - White British**	P-value - South Asian**
Yes	116	14	68	20	39	11	9	7	<0.001	0.2	0.5	0.3
No	716	86	269	80	326	89	121	93				

NOTES: Child SDQ and greenspace variables reported as median (interquartile range: IQR); remaining variables reported as mean (standard deviation: SD) or percent (%).

IMD quintile 1 [most deprived], quintile 5 [least deprived]

*P-values test differences between White British and South Asian groups. Mann-Whitney U tests were used for non-parametric data, t-tests for parametric, chi-square for categorical.

**P-values testing differences between full sample compared to subsample.

570 Supplemental Table 2 Associations between NDVI, distance to greenspace and wellbeing (full sample)

	Total Difficulties		Internalising Difficulties		Externalising Difficulties		Prosocial Behaviour	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Unadjusted[1]								
Mean NDVI 100 m	***-6.22***	***(-8.6, -3.9)***	***-3.6***	***(-4.9, -2.3)***	***-2.63***	***(-4.2, -1.1)***	-0.02	(-0.81, 0.77)
Mean NDVI 300 m	***-6.62***	***(-9.0, -4.2)***	***-3.9***	***(-5.2, -2.6)***	***-2.72***	***(-4.3, -1.1)***	0.17	(-0.64, 0.98)
Mean NDVI 500 m	***-6.43***	***(-8.8, -4.0)***	***-3.75***	***(-5.0, -2.5)***	***-2.69***	***(-4.3, -1.1)***	0.17	(-0.64, 0.97)
Distance to greenspace (m)	***-0.003***	***(-0.005, -0.001)***	-0.001	(-0.002, 0.0004)	***0.0001***	***(-0.003, -0.001)***	0.0005	(-0.0001, 0.001)
Adjusted[2]								
Mean NDVI 100 m	***-3.05***	***(-5.47, -0.63)***	***-1.59***	***(-2.88, -0.29)***	-1.47	(-3.09, 0.15)	0.15	(-0.67, 0.98)
Mean NDVI 300 m	***-3.53***	***(-6.01, -1.05)***	***-1.9***	***(-3.23, -0.57)***	-1.63	(-3.29, 0.03)	0.36	(-0.48, 1.2)
Mean NDVI 500 m	***-3.38***	***(-5.83, -0.92)***	***-1.75***	***(-3.06, -0.43)***	-1.63	(-3.27, 0.01)	0.36	(-0.48, 1.2)
Distance to greenspace (m)	***-0.002***	***(-0.004, -0.004)***	***-0.001***	***(-0.002, 0.001)***	***-0.002***	***(-0.003, -0.001)***	***0.0005***	***(-0.0002, 0.001)***
Adjusted[3]								
Mean NDVI 100 m	***-3.1***	***(-5.49, -0.71)***	***-1.54***	***(-2.83, -0.25)***	-1.56	(-3.15, 0.03)	0.25	(-0.56, 1.06)
Mean NDVI 300 m	***-3.59***	***(-6.04, -1.14)***	***-1.89***	***(-3.21, -0.57)***	***-1.7***	***(-3.33, -0.07)***	0.41	(-0.41, 1.24)
Mean NDVI 500 m	***-3.41***	***(-5.83, -0.99)***	***-1.75***	***(-3.06, -0.45)***	***-1.66***	***(-3.27, -0.05)***	0.37	(-0.45, 1.19)
Distance to greenspace (m)	-0.002	(-0.004, -0.0004)	-0.0004	(-0.002, 0.001)	-0.002	(-0.003, -0.001)	0.0005	(-0.0001, 0.001)
Adjusted[4]								
Mean NDVI 100 m	-1.33	(-3.73, 1.08)	-0.74	(-2.05, 0.56)	-0.58	(-2.2, 1.03)	0.07	(-0.76, 0.91)
Mean NDVI 300 m	-1.34	(-3.84, 1.16)	-0.88	(-2.24, 0.47)	-0.45	(-2.13, 1.21)	0.16	(-0.71, 1.03)
Mean NDVI 500 m	-0.99	(-3.48, 1.50)	-0.65	(-2.01, 0.70)	-0.34	(-2.01, 1.33)	0.09	(-0.78, 0.95)
Distance to greenspace (m)	-0.001	(-0.003, 0.001)	0.0001	(-0.001, 0.001)	-0.001	(-0.003, 0.00001)	0.0003	(-0.0003, 0.001)
Adjusted[5]								
Mean NDVI 100 m	-1.35	(-3.75, 1.05)	-0.7	(-2.01, 0.61)	-0.66	(-2.26, 0.95)	0.16	(-0.68, 0.99)
Mean NDVI 300 m	-1.33	(-3.82, 1.16)	-0.86	(-2.22, 0.49)	-0.47	(-2.13, 1.20)	0.19	(-0.67, 1.06)
Mean NDVI 500 m	-1.01	(-3.49, 1.47)	-0.66	(-2.01, 0.69)	-0.35	(-2.01, 1.32)	0.11	(-0.75, 0.97)
Distance to greenspace (m)	-0.001	(-0.003, 0.001)	0.0001	(-0.001, 0.001)	0.001	(-0.001, 0.001)	0.0003	(-0.0004, 0.001)

571 Notes: [1]N=2485; [2]Adjusted for ethnicity, N=2483; [3] Model 2 + child age, child gender, maternal age, cohabitation status, N=2483; [4] Model 3 + maternal education, subjective

572 poverty, household size, IMD, N=2454; [5] Model 4 +maternal smoking, mother's CMD in previous year, N =2447. Significant findings in ***bold italics.***

573 Supplemental Table 3 Associations between NDVI and wellbeing by White British, and Social Asian Origin groups within the subsample

	White British								South Asian							
	Total Difficulties		Internalising		Externalising		Prosocial		Total Difficulties		Internalising		Externalising		Prosocial	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Unadjusted[1]																
Mean NDVI 100 m	1.15	(-5.4, 7.7)	1.15	(-1.93, 4.2)	-0.003	(-4.7, 4.7)	0.49	(-1.7, 2.7)	-4.8	(-10.7, 1.1)	***-4.05***	***(-7.3, -0.83)***	-0.75	(-4.7, 3.2)	-0.06	(-2.2, 2.0)
Mean NDVI 300 m	1.31	(-4.9, 7.5)	1.56	(-1.38, 4.5)	-0.25	(-4.7, 4.2)	0.39	(-1.7, 2.5)	-5.61	(-11.9, 0.72)	***-4.96***	***(-8.4, -1.5)***	-0.65	(-4.9, 3.6)	0.67	(-1.6, 2.9)
Mean NDVI 500 m	0.31	(-5.7, 6.3)	1.12	(-1.72, 4.0)	-0.82	(-5.2, 3.5)	0.63	(-1.4, 2.7)	-5.35	(-11.7, 1.00)	***-4.60***	***(-8.1, -1.1)***	-0.75	(-5.0, 3.5)	1.08	(-1.2, 3.3)
Adjusted[2]																
Mean NDVI 100 m	1.25	(-4.81, 7.31)	1.23	(-1.68, 4.15)	0.02	(-4.37, 4.41)	0.48	(-1.71, 2.67)	-3.49	(-10.40, 1.60)	***-3.75***	***(-7.00, -0.51)***	-0.64	(-4.65, 3.35)	-0.28	(-2.40, 1.83)
Mean NDVI 300 m	1.44	(-4.35, 7.23)	1.74	(-1.04, 4.53)	-0.3	(-4.50, 3.89)	0.36	(-1.73, 2.45)	-5.22	(-11.59, 1.15)	***-4.65***	***(-8.09, -1.21)***	-0.57	(-4.82, 3.68)	0.5	(-1.74, 2.75)
Mean NDVI 500 m	0.91	(-4.71, 6.53)	1.48	(-1.21, 4.19)	-0.57	(-4.64, 3.49)	0.54	(-1.48, 2.57)	-4.91	(-11.36, 1.52)	***-4.29***	***(-7.77, -0.81)***	-0.62	(-4.92, 3.67)	0.88	(-1.38, 3.15)
Adjusted[3]																
Mean NDVI 100 m	0.46	(-5.38, 6.30)	1.00	(-1.90, 3.87)	-0.53	(-4.74, 3.67)	0.58	(-1.62, 2.79)	-3.09	(-9.46, 3.28)	-2.91	(-6.36, 0.54)	-0.18	(-4.46, 4.09)	-0.51	(-2.80, 1.76)
Mean NDVI 300 m	1.49	(-4.09, 7.07)	1.64	(-1.13, 4.40)	-0.14	(-4.16, 3.87)	0.41	(-1.71, 2.52)	-4.44	(-11.39, 2.50)	***-4.09***	***(-7.85, -0.34)***	-0.34	(-5.01, 4.33)	0.34	(-2.14, 2.83)
Mean NDVI 500 m	1.47	(-3.94, 6.87)	1.52	(-1.16, 4.20)	-0.06	(-3.95, 3.83)	0.54	(-1.51, 2.59)	-4.83	(-12.01, 2.36)	***-4.03***	***(-7.92, -0.14)***	-0.8	(-5.63, 4.03)	0.87	(-1.69, 3.44)
Adjusted[4]																
Mean NDVI 100 m	0.56	(-5.30, 6.43)	1.15	(-1.77, 4.06)	-0.58	(-4.81, 3.64)	0.6	(-1.62, 2.83)	-2.79	(-9.19, 3.61)	-2.83	(-6.31, 0.64)	0.04	(-4.26, 4.35)	-0.81	(-3.09, 1.47)
Mean NDVI 300 m	1.42	(-4.17, 7.02)	1.68	(-1.10, 4.46)	-0.26	(-4.29, 3.77)	0.38	(-1.75, 2.50)	-4.12	(-11.09, 2.85)	***-3.96***	***(-7.74, -0.18)***	-0.16	(-4.85, 4.54)	0.13	(-2.35, 2.62)

Mean NDVI 500 m	1.25	(-4.17, 6.68)	1.51	(-1.18, 4.21)	-0.26	(-4.17, 3.65)	0.47	(-1.59, 2.53)	-4.56	(-11.76, 2.64)	***-3.91***	***(-7.81, -0.00003)***	-0.66	(-5.51, 4.19)	0.7	(-1.87, 3.27)

NOTES: 1 Unadjusted, White British N=308, South Asian N=363 ; 2 model 1 + child age, child gender, maternal age, cohabitation status, White British N=308, South Asian N=363; 3: model 2 +maternal education, subjective poverty, household size, IMD, White British N=307, South Asian N=358; 4: model 3 + maternal smoking, mother's CMD in previous year, White British N=305, South Asian N=356. Significant findings are highlighted in ***bold italics***.