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Park availability and major depression in individuals with chronic conditions: Is there an association in urban India?

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ABSTRACT

Green space exposure has been positively correlated with better mental-health indicators in several high income countries, but has not been examined in low- and middle-income countries undergoing rapid urbanization. Building on a study of mental health in adults with a pre-existing chronic condition, we examined the association between park availability and major depression among 1208 adults surveyed in Delhi, India. Major depression was measured using the Mini International Neuropsychiatric Interview. The ArcGIS platform was used to quantify park availability indexed as (i) park distance from households, (ii) area of the nearest park; and within one km buffer area around households - the (iii) number and (iv) total area of all parks. Mixed-effects logistic regression models adjusted for socio-demographic characteristics indicated that relative to residents exposed to the largest nearest park areas (tertile 3), the odds [95% confidence interval] of major depression was 3.1 [1.4–7.0] times higher among residents exposed to the smallest nearest park areas (tertile 1) and 2.1 [0.9–4.8] times higher in residents with mid-level exposure (tertile 2). There was no statistically significant association between other park variables tested and major depression. We hypothesized that physical activity in the form of walking, perceived stress levels and satisfaction with the neighborhood environment may have mediating effects on the association between nearest park area and major depression. We found no significant *mediation* effects for any of our hypothesized variables. In conclusion, our results provide preliminary and novel evidence from India that availability of large parks in the immediate neighborhood positively impacts mental well-being of individuals with pre-existing chronic conditions, at the opportune time when India is embarking on the development of sustainable cities that aim to promote health through smart urban design – one of the key elements of which is the inclusion of urban green spaces.

1. Introduction

Today, more than 50% of the world's population live in urban areas (WHO, 2014). Rapid and unplanned urbanization continues to reduce the availability of green spaces in people's living environments, which is unfortunate in light of accumulating evidence indicating that green environments enable recovery from urban stressors (Berto, 2014). Exposure to green spaces has been positively associated with lower mortality, better physical and mental health indicators, and higher levels of physical activity (Gascon et al., 2015a; Hartig et al., 2014; Lachowycz and Jones, 2013; Maas et al., 2009; Mytton et al., 2012; van den Berg et al., 2015; Villeneuve et al., 2012; Vries et al., 2016; Wilker et al., 2014). Green spaces have also been shown to reduce air and noise pollution, and mitigate heat island effects (James et al., 2015). The corollary that low exposure to green spaces is associated with higher prevalence of chronic conditions has been demonstrated (Astell-Burt et al., 2014a; Gascon et al.,

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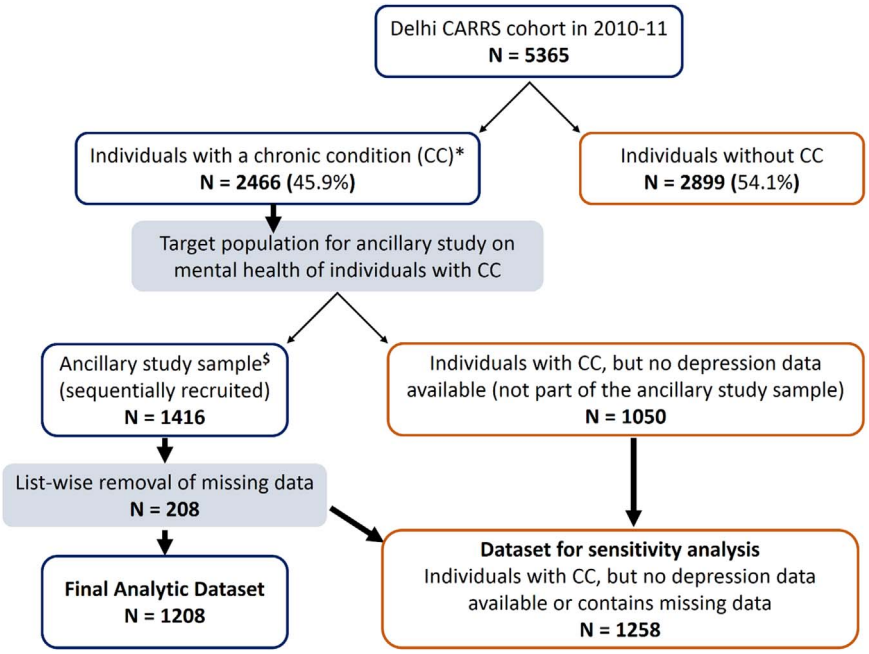

Fig. 1. Flowchart of participant recruitment.

2015b; Richardson et al., 2013b; Tamosiunas et al., 2014), particularly for depressive symptoms (Alcock et al., 2014; Beyer et al., 2014; McEachan et al., 2016).

Individuals with chronic conditions are particularly vulnerable to developing depression. For example, individuals with type 2 diabetes mellitus have twice the risk of developing depression (Katon, 2008), and an estimated 9.3–23% of individuals with one or more chronic conditions are depressed, which is significantly higher compared to the general population (Moussavi et al., 2007). However, the potential for green space exposure to buffer against major depression among individuals with a pre-existing chronic condition has not received adequate attention. This aspect is of high societal relevance to India, since chronic conditions, including major depression, account for more than 50% of the disease burden in India, which for a population of 1.2 billion people translates to more than 260 million disability adjusted life years at the national level (Global Burden of Diseases, 2015). Green spaces in the form of neighborhood parks may be a valuable buffer against depression in cities by offering a space for physical activity, lowering mental stress, and increasing one's satisfaction with the immediate living environment. However, rapid socioeconomic development in Indian metropolitan cities is leading to shrinking green spaces, the impact of which is hitherto unknown. Therefore, understanding the potential mitigating role of green spaces on mental health in urban India is particularly relevant.

This study aims to fill two important gaps in the available literature. First, most studies on the association between green space exposure and health are based in high income countries. It is unknown whether green space exposure impacts physical and mental health in large urban metropolises of low and middle income countries (LMICs) like India, whose socio-cultural and socio-economic milieus are very distinct and diverse, currently experiencing rapid rates of unplanned urbanization and shrinking green space, and where urban stressors (crowding, noise, traffic), the burden of disease and related risk factors, as well as health inequalities are more severe than in high income countries (Glaeser, 2014; Nambiar et al., 2017).

Second, given India's low per capita income and large income disparities prevalent in metropolitan cities, another set of findings compel inquiry in the Indian context. Prior studies have indicated a stronger association between green space exposure and mental health among low SES groups compared to high SES groups (Maas et al., 2009; van den Berg et al., 2015). Green spaces have also been shown to buffer mental-health inequalities of individuals with varying levels of economic hardship (Mitchell et al., 2015). Empirical evidence generated from India on this topic would not only enable comparisons with studies based in high income countries, but also provide alternate solutions to pressing public health needs of the country.

In this study, we specifically assess the association between park availability and major depression among individuals with one or more chronic conditions in Delhi, India - one of the largest metropolitan cities in the world undergoing rapid rates of unplanned urbanization, and providing an excellent example of an urban setting with environmental, health and social stressors typically found in the Indian subcontinent. As a secondary objective, we also explore if there is evidence to indicate that physical activity, mental stress, and satisfaction with the neighbouring environment mediates the association between park availability and major depression.

2. Methods

2.1. Study design and sample

We utilized data from the baseline cross-sectional survey of the Centre for Cardio-Metabolic Risk Reduction in South Asia (CARRS) study. Details of CARRS surveillance protocol, indicators and study instruments have previously been published (Nair et al., 2012). Briefly, CARRS is a multi-centre (Delhi and Chennai, India and Karachi, Pakistan) study that collected data on cardio-metabolic disorders, their risk factors (central obesity, insulin resistance, glucose intolerance, dyslipidaemia), associated morbidity and mortality, socio-demographic characteristics and physical activity, in non-pregnant adults aged ≥ 20 years. Baseline data was collected in 2010–11 through questionnaires, laboratory estimates of biological samples and anthropometric measurements. Data was collected from at most 20 households from each primary sampling unit (municipal wards in Delhi and Chennai; census enumeration blocks in Karachi), selected using a multistage cluster random sampling technique. The average population size of the primary sampling units (wards) in Delhi was ~ 30,000.

The sample for this study was drawn from a Delhi-only ancillary study designed to estimate the prevalence of Axis I psychiatric disorders among individuals with an underlying chronic condition

(CC) (Fig. 1). The definition of a chronic condition was the presence of at least one of the following: self-reported heart disease and/or stroke, and either self-reported or newly diagnosed hypertension and/or diabetes (criteria: blood pressure ≥ 140/90 mmHg, fasting plasma glucose ≥ 126 mg/dL, respectively). Of the 5365 participants recruited from Delhi during the CARRS survey in 2010–11, 2466 (45.9%) had a CC. To achieve the target sample size for the ancillary study, 1416 of 2466 CARRS participants with CC were sequentially enrolled (refer to Fig. 1 for participant recruitment plan). After list-wise deletion of records with missing data on one or more variables included in our fully adjusted model (N = 208), the final analytic sample comprised 1208 participants. With the exception of mean age, baseline characteristics of the 1208 participants included in this analysis did not statistically differ from the remaining 1258 participants who were not assessed for depression or excluded from the analysis due to missing data in one or more other variables (Supplemental Table 1). Importantly, there was no significant difference between the two groups with respect to park availability.

*CC: Chronic conditions, defined in this study as the presence of at least one of the following: self-reported heart disease and/or stroke, self-reported or newly diagnosed hypertension (systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mm Hg), and/or self-reported or newly diagnosed type 2 diabetes mellitus (fasting blood glucose ≥ 126 mg/dL)

2.2. Measures and data collection

2.2.1. Major depression

The Mini International Neuropsychiatric Interview (MINI) is a brief, structured diagnostic interview instrument that assesses the presence of major Axis I psychiatric disorders according to the DSM-IV and ICD-10 criteria (Sheehan et al., 1998). It provides information on episodes that occur across one's lifetime, the past 12 months, and currently (past 2 weeks). Data on current major depression was obtained using the "Major Depressive Episode" section (Section A) of the MINI, which evaluates the presence of depression symptoms in the past two weeks. If an individual answered 'yes' to either Question A1 (having a depressed mood) and/or Question A2 (loss of interest in most things), and answered 'yes' to ≥ five out of nine questions (Questions A1, A2, A3a-g), major depression was coded as 1, else coded 0. This allowed the outcome variable to be treated as a binomial variable.

2.2.2. Park availability

In this study, the definition of green space was restricted to parks. Data on parks was obtained through the CARRS-Geographical Information System ancillary study. Participant household location was geocoded using hand-held global positioning system (GPS) devices and validated by comparing household geo-locations overlaid on satellite data (Google Earth) with addresses collected during the survey. Validated household locations were marked on a Google Earth map, and the outermost houses within each primary sampling unit (municipal wards in Delhi) were connected to form a polygon. A one km buffer around the polygon was used for analysis of parks, and hereafter defined as the neighborhood for the set of households within the buffer boundary. One km buffer was chosen because previous literature suggests that green space closer to the participant's household is more likely to influence mental health and physical activity than environmental features further away (Berke et al., 2007; Frank et al., 2005; Lee and Moudon, 2006).

Parks were defined and identified using high spatial resolution (0.5 m) satellite images (Google Earth), if they fulfilled any one of the following criteria: 1) named as a park on the map, or 2) clearly visible as a usable green space with a defined boundary and curated landscaping. To be considered as a neighborhood park, at least 50% of the park area had to fall within the one km buffer boundary.

ArcGIS® software hosted by Esri (www.esri.com) was used to quantify neighborhood park data, measured in four ways: 1) network distance (shortest distance by road) from the participant's household to the nearest park, 2) square footage area of the nearest park; and within one km buffer around participant households – 3) number of neighborhood parks, and 4) total area of all parks in the neighborhood. These continuous neighborhood park measures (distance in metres and area in square metres), were then categorized into tertiles during analysis for ease of interpretation, following a similar approach as described in other studies (Astell-Burt et al., 2014b; McEachan et al., 2016; Reklaitiene et al., 2014; Richardson et al., 2013a; van den Berg et al., 2010). Details of the three tertiles are as follows: 1) distance to park – tertile 1: 0–234 m; tertile 2: 235–561 m; tertile 3: 562–1750 m, 2) Area of the nearest park – tertile 1: 0–1900 sq m; tertile 2: 1901–3830 sq m; tertile 3: 3831–1,090,000 sq m, 3) number of neighborhood parks – tertile 1: 0–10; tertile 2: 11–17; tertile 3: 18–46, and 4) total park area in the neighborhood - tertile 1: 0–40,100 sq m; tertile 2: 40,101–92,300 sq m; tertile 3: 92,300–413,000 sq m.

2.2.3. Confounding variables

Analyses considered several self-reported demographic and socio-economic variables that could potentially confound the association between park availability and major depression: age in years; gender; highest attained education (number of years of formal education categorized into 'primary school' (≤ 4 years), 'high school' (> 4 and ≤ 12 years), 'graduation and above' (> 12 years); marital status ('currently married' or 'separated, widowed or divorced'); household wealth (categorized into tertiles – method described in (Ali et al., 2016); and family size (number of family members ≥ 18 years residing in the same household categorized into ≤ 3 and > 3, 3 being the median).

2.3. Hypothesized mediating variables

We hypothesized three possible mechanisms through which low park availability may negatively impact mental health: 1) lower physical activity; 2) higher mental stress; 3) lower satisfaction with the local environment, as shown in Fig. 2A–C. The hypothesized mediating measures were operationalized as less time spent walking, high perceived stress, and low satisfaction with the local environment, respectively, as described below.

2.3.1. Less time spent walking

The physical environment is thought to influence both health related behaviours and psychological states. Access to green spaces encourage physical activity (Cohen et al., 2007; Mytton et al., 2012; Richardson et al., 2013a). Time spent walking per week was selected because in the Indian context, walking is the most popular form of exercise and it is culturally normative to use neighborhood parks for walks. Outdoor physical activity (for example, in a park), promotes mental wellbeing more than physical activity indoors (Thompson Coon et al., 2011). Therefore, we hypothesize that the time spent walking per week would have a mediating effect on the association between park availability and major depression. Walking data for the entire CARRS cohort was obtained using the International Physical Activity Questionnaire (IPAQ).

2.3.2. Perceived stress

Stress is an important precursor of depression (Gold, 2014). Chronic conditions can induce stress, since individuals not only have to deal with a lifelong physical ailment, but need to adhere to prolonged behaviour alterations and medical regimens to keep a check on their conditions (for example – daily medications for hypertension and diabetes, along with food restrictions). Green spaces are known to have calming effects and induce a deep sense of restoration, especially when coping with stressful life events (Tyrväinen et al., 2014; van den Berg et al., 2010). From an evolutionary perspective, natural environments inherently promote mental wellbeing from pre-modern humans having spent thousands of years

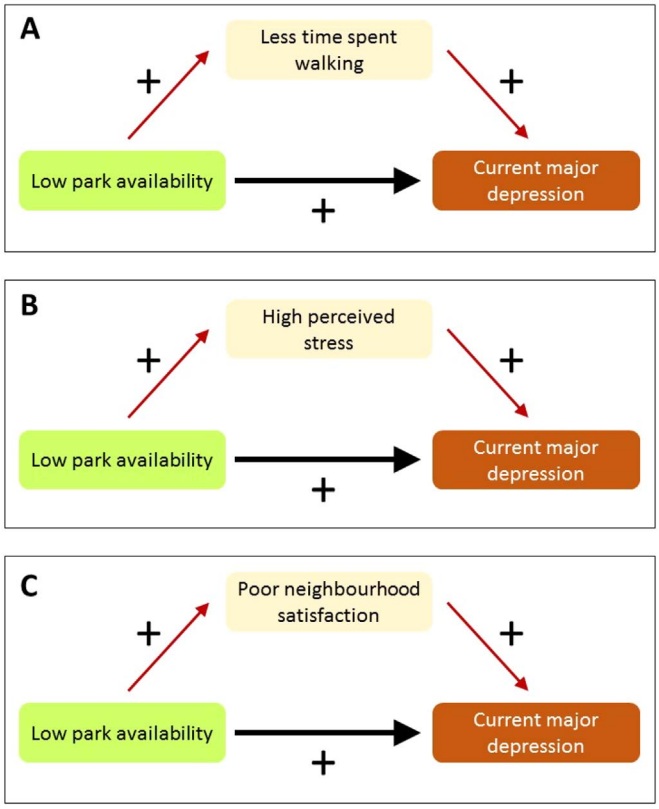

Fig. 2. Low park availability is positively associated with current major depression (Table 2). We hypothesize that this association may be positively mediated by A) less time spent walking B) high perceived stress score and C) poor neighborhood satisfaction score.

in natural green spaces (Lundberg, 1998). Therefore, we hypothesize that more park availability would help reduce stress perception, which in turn could downregulate the severity and incidence of depression. Data on perceived stress was measured using the ten-item Cohen's Perceived Stress Scale (PSS-10, 1983), which quantifies how stressful an individual has perceived his life condition to be in the past month. Items are loaded to tap the degree of unpredictability and burden that participants' experience. Scoring is based on a Likert-type five-point scale and can range from 0 to 40 (0–4 for each question), with higher scores indicating higher perceived stress.

2.3.3. Neighborhood satisfaction

Physical and social attributes of the neighborhood are important determinants of both physical and mental health. They can either enable behaviours and mental states that promote health, or provide restrictions and barriers that make it more difficult to follow a healthy and happy lifestyle. Dissatisfaction with the neighborhood environment can arise from lack of opportunities for leisure time activity, poor conditions of the living area, restrictive access to health services and transport, poor safety perception and poor social capital. Any of these can act as chronic stressors and contribute to depression (Chen and Chen, 2015). Low neighborhood satisfaction directly impacts park use, and therefore, hypothesized to be on the causal pathway of the association between park availability and major depression. Data on satisfaction with the local environment was collected using the cross-culturally applicable World Health Organization-Quality of Life-BREF (WHO-QOL-BREF) scale, comprising 26 items categorised into four domains. Domain 4 was included in our analysis, which measures how satisfied a participant was with resources available in his local environment within the past month. Lower scores indicate lower levels of satisfaction with the local environment.

All tools described have been validated and used extensively in population based studies in India (Aggarwal et al., 2014; Chakraborti et al., 2013; Salve et al.; Sathyanarayana Rao et al., 2014), and were administered by trained investigators. All questionnaires are either available in the public domain or permission has been acquired to use them free of cost in this study.

2.4. Statistical analysis

The R package for statistical computing was used for all statistical analysis (Core Team, 2015).

2.4.1. Comparison of individuals with and without major depression

We first conducted a bivariate analysis of participant background characteristics and exposures, with major depression. Chi-square test of goodness of fit was used to determine differences in proportions among categorical variables tabulated against major depression. Significance testing of continuous variables were done using the Student's *t*-test (two groups) or one-way ANOVA (> two groups). Level of significance was set at $\alpha = 0.05$.

2.4.2. Modelling the association between park availability and current depression

The association (odds ratio [OR] with 95% confidence interval [CI]) between park availability (categorized into tertiles) and major depression (dichotomized depression or no depression) was estimated using mixed-effects logistic regression using municipal wards (primary sampling unit in Delhi) as level 2 units. Tertile 3 of park availability was used as the reference. Both unadjusted and confounder-adjusted models were estimated. Test for departure from linear trend in OR was computed by first treating tertiles of park availability as categorical variables (Model A) and then treating the same tertiles as continuous variables (Model B). Model A and Model B were compared using ANOVA, and $p > 0.05$ indicated no evidence for departure from linear trend.

2.4.3. Exploratory mediation analysis

Based on Fig. 2A–C, we expected positive mediation by each of less time spent walking, high perceived stress, and low satisfaction with the neighborhood environment. We statistically assessed mediation using the 'product of coefficients' approach as discussed by MacKinnon (2008) and MacKinnon et al. (2007b). Briefly, we derived coefficients ('a' and 'b') from the following two regression equations – $M = i_1 + \mathbf{a}\ X + d\ Z + e_1$; $Y = i_2 + c'\ X + \mathbf{b}\ M + d'\ Z + e_2$. M refers to the hypothesized mediating variable, X is the independent variable (park availability variable), Y is the dependent variable (current major depression) and Z refers to the combination of confounding variables. The product of coefficients (a*b) provides an estimate of the mediated effect. Confidence interval for the mediated effect was calculated as $a*b \pm 1.96*(\sigma_{ab})$, with the standard error (σ_{ab}) calculated using the formula $\sigma_{ab} = \sqrt{\sigma_a^2 b^2 + \sigma_b^2 a^2}$. The mediating effect was considered statistically significant if the estimated confidence interval did not include zero.

2.4.4. Severity of diabetes/hypertension and prior knowledge of one's chronic condition – impact on the association between park availability and major depression

Higher severity of the affected chronic condition may increase the risk of current depression, as well as alter the use of parks. Therefore, to determine the association between park availability and major depression independent of chronic condition severity, continuous measures of fasting blood glucose and mean of systolic and diastolic blood pressures were included in the adjusted model (Supplemental Table 2). Conclusions were drawn based on the change in OR observed for models with and without severity of chronic conditions included.

Prior knowledge of one's diagnosis of a chronic condition may also impact the likelihood of being depressed, and could influence park use independent of depression status (for example, due to physical ailments). To investigate whether knowledge of one's disease status

Table 1
Socio-demographic characteristics of study participants **(N = 1208)**.

Socio-demographic characteristics		Total	Not Depressed (% or mean)[a]	**Depressed (% or mean)**[a]	p-value[$]
Mean Age (yrs)		1208	53.67	**54.02**	0.81
Gender	Men	641	96.72	**3.27**	< 0.001
	Women	567	89.24	**10.75**	
Highest attained education	Primary school	213	84.51	**15.49**	< 0.001
	High School	679	94.55	**5.45**	
	Graduation & above	316	96.20	**3.80**	
Marital Status	Currently Married	1093	93.50	**6.50**	0.21
	Separated, Widowed or Divorced	115	90.43	**9.57**	
Work Status	Housewife	487	89.53	**10.47**	< 0.001
	Unemployed	29	82.76	**17.24**	
	Retired	151	94.04	**5.96**	
	Employed	541	96.86	**3.14**	
Family Size	≤ 3 adults	737	95.39	**4.61**	< 0.001
	> 3 adults	471	89.81	**10.19**	
Monthly household income (INR)	≤ 20,000	766	91.64	**8.36**	< 0.01
	20,001–40,000	286	96.15	**3.85**	
	≥ 40,001	146	95.89	**4.11**	
Household Wealth (Tertile)	First	219	89.95	**10.05**	< 0.01
	Second	297	90.91	**9.09**	
	Third	692	95.23	**4.77**	
Knowledge of existing chronic condition	Known	698	91.84	**8.16**	< 0.05
	Newly diagnosed	506	95.06	**4.94**	
Presence of heart disease or stroke[b]	No	1093	94.06	**5.94**	< 0.001
	Yes	115	85.22	**14.78**	
Hypothesized mediators					
Mean walk time (min/week)		1208	337.91	**233.71**	< 0.001
Mean Perceived Stress Score		1208	19.51	**20.15**	< 0.01
Neighborhood satisfaction score		1208	31.01	**27.64**	< 0.001

[a] Row percentages are shown.
[b] Heart disease and stroke is self-reported.
[$] p-value is based on the X^2 test for differences in proportions among categorical variables tabulated against current depression, or based on Students' t-test for continuous variables.

impacted the observed associations, we performed a moderation analysis by introducing an interaction term to the confounder adjusted model (park availability variable X prior knowledge of one's diagnosis). Moderation by prior knowledge of disease status was considered statistically significant if the estimate of the interaction term was significant, else no moderation effect was concluded.

3. Results

3.1. Description of study participants

The socio-economic and demographic characteristics, stratified by depression status of 1208 adults with underlying CC included in this analysis, are listed in Table 1. The overall point prevalence of major depression as measured by the MINI was 6.78% (95% CI: 5.46–8.39%). There was no significant difference in mean age between individuals who were affected by major depression at the time of the survey, versus those who were not. However, prevalence of major depression differed by all other socio-demographic characteristics measured, and was found to be significantly higher among women; the least educated group; unemployed; living in a household with more than three adults; those with household monthly income < 20,000 INR; or within the lower two tertiles of household wealth. With respect to hypothesized mediators, individuals reporting major depression spent significantly less time walking per week (mean: 233.7 vs 337.9 min, $p < 0.001$), had small but significantly elevated perceived stress scores (mean: 20.1 vs 19.5, $p < 0.01$) and had significantly lower neighborhood satisfaction scores (mean: 27.6 vs 31.0, $p < 0.001$).

With respect to an individual's prior knowledge of an existing chronic condition, as measured by self-reported heart disease, stroke, diabetes or hypertension, versus a new diagnosis during the baseline survey, through laboratory measurements of fasting blood glucose (≥126 mg/dl) and/or blood pressure (average systolic blood pressure ≥140 mm Hg or average diastolic blood pressure ≥ 90 mm Hg), prevalence of major depression was lower in newly diagnosed participants (4.9%) versus those who were aware of their existing condition (8.2%); and the difference was statistically significant ($p < 0.05$; Table 1). Prevalence of current depression was also significantly higher among individuals reporting a previous diagnosis of a diseased state (heart disease and/or stroke), compared to those with risk factors alone (diabetes or hypertension; prevalence: 14.78% vs 5.94%, $p < 0.001$; Table 1).

To evaluate potential confounding by residential selection of socio-economically disadvantaged individuals to areas with low park availability, we plotted park measures, categorized into tertiles, by socio-demographic characteristics (Supplemental Fig. 1A–D). As demonstrated in the figures, for each measure of park availability, there were distinct sets of socio-demographic features that were significantly different across tertiles of park exposure. For example, mean age was significantly higher in individuals living closest to parks (tertile 1) and those living in neighborhoods with the largest number of parks (tertile 3), but similar trends were not observed for either area of the nearest park or total area of all parks in the neighborhood. Further, individuals with high socioeconomic status indicators, namely, higher education (graduation and above), higher monthly income (> 40,000 INR) and greater household wealth (tertile 3) tended to live in neighborhoods with the highest park availability, specifically in terms of distance to parks (tertile 1), number of neighborhood parks and total park area (tertile 3; Supplemental Fig. 1). With respect to area of the nearest park (Supplemental Fig. 1B), individuals with large family sizes tended to live close to small parks, and significant differences were observed in distribution of household monthly income, perceived stress, and neighborhood satisfaction scores across tertiles.

3.2. Association between park availability and major depression

Results of bivariate mixed-effect logistic regression analysis estimating the unadjusted odds ratios for the associations between park availability (reference = tertile 3) and dichotomized major depression (reference = no depression) are shown in Table 2. Residents with lower exposure to parks were more likely to report major depression for all exposure measures in the unadjusted models, with the exception of total park area in the neighborhood (Table 2: Unadjusted). In models adjusting for potential confounders (age, gender, highest attained education, marital status, household wealth and family size), the positive association between the area of the *nearest* park and major depression was the only one which remained statistically significant (smallest versus largest tertile, aOR=**3.1** [1.4–7.0]; middle versus largest tertile, aOR=**2.1** [0.9–4.8]; reference = tertile 3). Further, we found a positive linear trend between small area of the nearest park and major depression, such that progressively lower area of the nearest park was associated with increasingly higher odds of depression (Table 2: p for linear model < 0.05).

When continuous measures of fasting blood glucose and average systolic+diastolic blood pressures were included as independent variables to the adjusted model, no appreciable change in aOR [95% CI] was observed for any of the park availability variables tested

Table 2
Strength of association between park availability and current depression.

Park availability		Depressed (%)[a]	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Distance to Nearest Park (m)	Tertile 1	5.49	0.6 (0.3–1.3)	0.9 (0.4–2.0)
	Tertile 2	6.20	0.8 (0.4–1.6)	0.8 (0.4–1.8)
	Tertile 3	8.66	1	1
Area of Nearest Park (sq m)	Tertile 1	10.22	**3.5** (1.6–7.6)	**3.1** (1.4–7.0)
	Tertile 2	6.63	2.1 (0.9–4.8)	2.1 (0.9–4.8)
	Tertile 3	3.50	1	1
No. of Parks (within 1 km buffer area)	Tertile 1	7.91	1.4 (0.6–3.0)	1.1 (0.5–2.4)
	Tertile 2	6.72	1.1 (0.5–2.5)	1.0 (0.5–2.4)
	Tertile 3	5.46	1	1
Total Area of all Parks (sq m) (within 1 km buffer area)	Tertile 1	7.50	0.9 (0.4–1.8)	0.6 (0.3–1.3)
	Tertile 2	4.80	0.6 (0.3–1.2)	0.5 (0.2–1.1)
	Tertile 3	8.18	1	1

Notes: *Park availability measures were reported as continuous variables (distance in metres and area in square metres), and then categorized into tertiles during analysis for ease of interpretation. Tertile 3 (reference category) represented – 1) furthest distance to park, 2) largest nearest park area, 3) most number of neighborhood parks, and 4) largest total park area in the neighborhood (Neighborhood defined as 1 km buffer area around the polygon connecting outermost participant households within the primary sampling unit).
*Model was adjusted for the following confounding variables: age, gender, education status, marital status, household wealth and family size.
[a] Row percentages are shown.

Table 3
Potential mediation of the association between near park area and current depression by time spent walking/week (IPAQ questionnaire), perceived stress score (Cohen's Perceived Stress Scale) and neighborhood satisfaction score (Domain 4 of the WHO-QoL-BREF scale).

Hypothesized mediators	Coefficients[a]	Estimate	Standard Error
Time spent walking per week	a	– 4.84E–05	6.27E–04
	b	– 1.28E–03	6.59E–04
	ab (mediated effect)	6.18E–08	
	95% CI	(– 1.51E–06 – 1.63E–06)	
	Significance	**Not significant**	
Perceived stress score	a	– 2.05E–06	4.84E–06
	b	1.56E–01	6.24E–02
	ab (mediated effect)	– 3.21E–07	
	95% CI	(–1.8E–06 – 1.81E–06)	
	Significance	**Not significant**	
Neighborhood satisfaction score	a	– 2.83E–06	1.15E–05
	b	– 2.15E–01	3.56E–02
	ab (mediated effect)	6.08E–07	
	95% CI	(– 4.25E–06 – 5.47E–06)	
	Significance	**Not significant**	

Notes: Mediation analysis was performed using the 'product of coefficients approach' (MacKinnon, 2008; MacKinnon et al., 2007a).
[a] 'a' and 'b' refer to the estimated regression coefficients in the following two equations – $M = i_1 + \mathbf{a}\ X + d\ Z + e_1$; $Y = i_2 + c'\ X + \mathbf{b}\ M + d'\ Z + e_2$ (MacKinnon, 2008). M refers to the hypothesized mediator, X is the independent variable (near park area), Y is the dependent variable (current major depression) and Z refers to all confounding variables combined. Standard error of the product of coefficients (ab) was calculated using the following equation – $\sigma_{ab} = \sqrt{\sigma_a^2 b^2 + \sigma_b^2 a^2}$ and 95% confidence interval (CI) calculated using equation – $ab \pm 1.96*(\sigma_{ab})$. Since all the estimated confidence intervals contained 0, we concluded that none of the hypothesized mediating variables had significant mediating effects.

(Supplemental Table 2). Moderation analysis was performed to test if prior knowledge of an existing chronic condition had an impact on the association between park availability and major depression. As shown in Supplemental Table 3, none of the interaction terms (park variable X prior knowledge of disease status) were significant, leading to the conclusion that prior knowledge of disease status does not moderate the association between park availability and major depression. Interestingly, mean walk time was higher among individuals with a newly diagnosed chronic condition, compared to those with a prior diagnosis (359.8 min vs 308.9 min, $p < 0.05$).

3.3. Exploratory mediation analysis

Analysis of potential mediation of the association between low park availability and current depression by time spent walking, and scores on perceived stress and neighborhood satisfaction is shown in Table 3. Since area of the nearest park was the only significant park availability measure associated with major depression in the adjusted model, we limit our discussion of mediation to this variable. We found that the proportion of individuals walking ≥ 150 min/week was marginally higher among those living near large park areas, compared to those living near small parks (72.8% in tertile 3 vs 65.1% in tertile 1; $p = 0.06$), although the mean time spent walking/week was not significantly different across the three tertiles (Supplemental Fig. 1B). Additionally, individuals living near large parks had higher mean neighborhood satisfaction scores (31.22 in tertile 3 vs 30.33 in tertile 1; $p = 0.02$), and unexpectedly, slightly higher mean perceived stress scores (19.77 in tertile 3 vs 19.37 in tertile 1; $p = 0.04$; Supplemental Fig. 1B). Table 3 shows the estimated mediated effect, focusing on near park area. We found no evidence of statistically significant mediation by any of the hypothesized mediating variables (confidence intervals of all three estimates included zero).

4. Discussion

Our study provides preliminary evidence on the protective association between large parks near participant households and current major depression in a vulnerable population (those with a pre-existing chronic condition) in India. We found a statistically significant ***inverse*** association between the area of the nearest park and current major depression, after considering numerous confounding factors. However, we did not find similar associations with other park variables, namely distance to the nearest park, or the number and total area of all parks within one km buffer area around participant households.

Previous research has detailed some of the mechanisms by which urban parks improve mental health. They include improving cognitive functioning (Fuller et al., 2007), providing restorative experiences (Berto, 2014; Hartig and Kahn, 2016; Kaplan, 1995), and reducing mental stress (Hull and Michael, 1995). Urban parks also improve physical activity by providing free and comfortable accessible locations (Shanahan et al., 2016a, 2016b), and improves social cohesion by acting as a forum for social contact among neighborhood residents (Peters et al., 2010).

Although evidence based on the literature is lacking, our observations suggest that large parks in Delhi are more attuned to providing the above benefits of green space exposure, by enabling the above mechanisms to function. Large parks in Delhi are better maintained, have larger areas of natural settings and diverse landscapes, and are more likely to receive regular and more frequent visitors, providing an opportunity for users to meet and socialize with each other regularly. In other words, parks with large areas in Delhi are generally of higher quality compared to those with smaller areas, and our speculation is supported by higher neighborhood satisfaction scores of residents living near large parks. On the other hand, we speculate that the quality of the smaller parks fails to encourage use for either walking/physical activity, or social interactions. Small parks could become noisy and polluted if they are adjacent to trafficked roads, disrupting the restorative properties that green spaces provide. In many cases, small

parks lack aesthetics and diversity of flora and fauna. This could be a potential reason as to why no associations were found for the other three park variables tested – park distance, number of parks and the total area of all parks within the neighborhood, since large number of parks in the neighborhood translates to smaller individual parks.

We had hypothesized that time spent walking, high perceived stress and poor neighborhood satisfaction may mediate the association between near park area and current depression. Although our data does not support mediation by any of our hypothesized variables, some interesting observations emerge. In our sample, individuals living near small parks were less likely to adhere to the World Health Organization recommendation of engaging in at least 150 min of physical activity per week, compared to participants residing near large park areas. Therefore, living near large parks does encourage walking in India, which we know has several physical and mental health benefits (Morris and Hardman, 1997). To build on this preliminary observation and in order to test if the quality and size of neighborhood parks play a role in motivating individuals to use outdoor spaces for physical activity in India, or contribute to improved neighborhood social cohesion, as evidenced elsewhere (McCormack and Shiell, 2011; Van Cauwenberg et al., 2015), further prospective studies specifically designed and powered to test this hypothesis are needed in India.

Contrary to expectations, we noted that perceived stress was significantly higher among residents living near large parks compared to those near smaller parks – which conflicts with prior understanding of green spaces providing restoration and stress relief. Our data indicates that the majority of individuals living near large parks belong to the higher socioeconomic status (based on higher education and income levels), and are married – both characteristics that lower perceived stress (see Supplemental Fig. 1B, and supported by our data tabulating perceived stress with education, income levels and marital status). Perceived stress is also significantly higher among depressed individuals, the proportion of which is lower near large parks. Therefore, we are unable to pinpoint the exact reason as to why perceived stress is higher among those living near large parks, and propose a qualitative study to investigate this further. In this context, one should note that we do not have information on actual park usage by participants in this study; and that although significant, the difference in perceived stress scores between the highest and lowest tertiles of park area is very minimal – (19.77 in tertile 3 vs 19.37 in tertile 1 of near park area, $p = 0.04$).

As expected, our results demonstrate that the prevalence of major depression is significantly higher among individuals who have been diagnosed with a disease (heart disease/stroke), compared to those identified with risk factors alone (diabetes/hypertension). Additionally, prevalence of major depression among individuals who are newly diagnosed with a CC is significantly lower than those with prior knowledge of an existing condition – possibly indicating that diagnosis of a CC carries its own stress and may lead to higher depression risk. It is well documented that health system challenges in LMICs often result in limited access to diagnosis and treatment facilities, especially for low SES individuals (World Health Organization, 2006). Since the large majority of individuals in our study belong to the low SES category, difficulties in managing their disorders in urban India may be reflected in the higher prevalence of major depression among those who are already aware of their chronic condition. In this context, it is interesting to note that mean walk time was higher among individuals with a newly diagnosed chronic condition, compared to those with a prior diagnosis, possibly suggesting that physical ailments associated with prolonged chronic illness may prohibit physical activity, or that those who are newly diagnosed with a chronic condition may be more motivated to increase their physical activity levels. Teasing apart the mechanisms of the protective association between green space exposure and mental well-being in vulnerable populations in LMICs is an area of active investigation within the group.

4.1. Strengths and limitations

Major strengths of this study were the use of objective measures of park availability in a population-based sample of individuals at high risk for depression, due to the presence of a chronic condition. We would like to highlight that the apparently low prevalence of major depression in a vulnerable population reported in this study, compared to other reports, may be due to the strict definition used in this study (we used the criteria described in the MINI), instead of the more commonly used output of screening questionnaires (the Patient Health Questionnaire (PHQ) – 9 for example) (Katon, 2011).

Primary limitations were the lack of clinical confirmation of major depression, the fact that prior events of stroke and heart disease were self-reported, and the cross-sectional design, precluding an understanding of the causal ordering between park exposure, potential mediating factors, and major depression. All the same, we utilized a validated, structured questionnaire to measure major depression and used a definition that is standard in epidemiologic literature. Further, we were able to examine a comprehensive set of social demographic factors that may have confounded the relationship of interest.

Our models could be limited by two potentially important confounding factors that could not be adjusted for. We did not have any data to verify if the participants used neighborhood parks closest to their household, and if they did, for what purpose and for how long. It is entirely possible that individuals used a large park further from their household, instead of a small park close by, for reasons cited above. We also do not know the length of residence in the neighborhood prior to data collection. There may also be residual confounding by SES, since education and household wealth may not have completely characterised participant SES variations. Residential selection bias could not be avoided. Park size and presence could be influenced by specific neighborhood characteristics we have not controlled for. Finally, it is possible that the observed association is driven by neighborhood or individual factors/characteristics that have not been considered by our or any other study, which is always a concern in cross-sectional epidemiological studies.

4.2. Conclusion

Our results provide preliminary evidence that large parks in the immediate vicinity of an individual's residence is associated with lower likelihood of current major depression in a vulnerable subpopulation – those with an existing chronic condition. This is an opportune moment for further investigations on this topic, given that development of sustainable cities is ongoing in 109 cities selected across India (The US$ 15 billion SMART Cities Mission - smartcities.gov.in). Since the inclusion of urban green spaces is a major component of the SMART Cities Mission, it provides the perfect setting to design natural experiments to understand physical and mental health ramifications of integrating green spaces in urban design in India. The case of the association between green space and depression being stronger for low SES individuals is also highly relevant for low and middle income countries like India, where the per capital income is significantly lower than countries that have provided prior data supporting the association between green space and depression. Since 50% of the Indian population is projected to live in urban areas by 2050 (United Nations Department of Economic and Social Affairs, 2014), we highlight this as an important area for future research.

5. . Disclosure

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.healthplace.2017.07.004.

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