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Urban Green Space, Physical Activity, and Psychological Well-Being in Dhaka, Bangladesh: A Parallel Mediation Analysis of Restorative and Activity Pathways

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Abstract

Background: Urban green space may support mental health through physical activity and psychological restoration, but evidence from low- and middle-income settings is limited. This cross-sectional survey assessed 397 adults using public urban green spaces in Dhaka, Bangladesh, using measures of green space use and perceived quality, physical activity, perceived restorativeness, and WHO-5 well-being. Hierarchical regression and bootstrapped parallel mediation analyses tested physical activity and perceived restorativeness as simultaneous pathways between urban green space exposure and well-being.

Results: Mean WHO-5 well-being was 55.6 ± 21.7 on the 0–100 scale, and 34.8% of participants scored below the poor-well-being threshold. All five multi-item scales showed acceptable-to-excellent internal consistency (α = .74–.92). The four-block hierarchical regression explained 43.9% of WHO-5 variance (adjusted R^2 = .415, $F(16,380) = 18.57$, $p < .001$); perceived restorativeness (β = .242, $p < .001$) and perceived access quality (β = .321, $p < .001$) were the strongest final-model predictors. Across three parallel mediation models, perceived restorativeness consistently mediated the association between green space exposure and well-being (indirect effects 0.355–6.825, all $p < .001$). Physical activity mediated the association only when perceived benefits were the predictor (indirect effect = 0.988, 95% confidence interval [0.274, 2.044]). Perceived accessibility, but not perceived safety, moderated the green space use–physical activity relationship ($b = 0.191$, $p < .001$).

Conclusions: In a resource-constrained megacity with very low green space provision, restorative psychological experience was the dominant pathway linking urban green space to well-being. Improving the

perceived quality and accessibility of existing green spaces may yield greater well-being benefits than promoting physical activity alone.

Keywords

urban green space; physical activity; psychological well-being; WHO-5; attention restoration theory; mediation analysis; park prescription

Background

Urban green space (UGS), defined by the World Health Organization as "all urban land covered by vegetation of any kind," is increasingly recognised as a determinant of population mental health [1]. Two complementary psychological theories anchor this evidence base. Attention Restoration Theory (ART) proposes that natural environments restore directed-attention capacity depleted by sustained cognitive effort, through the properties of being away, fascination, coherence, and compatibility [2]. Stress Reduction Theory (SRT), in contrast, describes a more rapid, affective, and pre-cognitive recovery from stress upon exposure to natural scenes [3]. Markevych et al. [4] integrated these and related mechanisms into a tripartite pathway framework describing how green space affects health by reducing harm (lower exposure to air pollution, noise, and heat), restoring capacities (attention restoration and stress recovery), and building capacities (facilitating physical activity and social cohesion). The present study operationalises two of these three domains directly restoring capacities, through a perceived-restorativeness battery derived from Hartig et al.'s [5] Perceived Restorativeness Scale (PRS), and building capacities, through the International Physical Activity Questionnaire short form (IPAQ-SF) [6], while treating non-communicable disease (NCD) history and health behaviours as covariates that proxy the reducing-harm domain. This tripartite framework has itself been documented empirically in the Dhaka context, where a classic longitudinal study traced the co-evolution of rapid urbanization and green space loss across Greater Dhaka over several decades [7].

Despite a substantial evidence base in high-income settings, green space–mental health research remains geographically lopsided. A scoping review of 36 studies on UGS and mental health in low- and middle-income countries (LMICs) identified only four originating from lower-middle-income or low-income countries, meaning more than 90% of the world's LMICs have no published evidence at all on this relationship [8]. This

international gap is compounded by severe and worsening green-space attrition in the present study's own setting: longitudinal remote-sensing analysis found that Dhaka's overall green cover declined by 56% between 1989 and 2020, with the proportion classified as high-quality ("healthy") green space falling from approximately 17% to just 2% of the city's land area over the same period [9]. A more recent GIS-based assessment corroborates this scarcity, finding that only about 2% of Dhaka's land area is currently covered by urban green space and that its distribution and accessibility are highly uneven across the city's administrative units [10]. Within Bangladesh specifically, the published survey-based evidence is limited to a small handful of studies, most prominently Labib et al.'s [11] study of NCDs, park prescriptions, and UGS-use patterns among 169 adults in Dhaka, and Ahmad, Du and Rashid's [12] recent study of 276 Dhaka residents linking UGS accessibility to well-being (measured with SWEMWBS) via physical activity and social cohesion. This scarcity is set against a large and increasingly dense population: Bangladesh's most recent national census recorded a combined population of approximately 10.28 million residents across Dhaka's two city corporations, with population densities exceeding 30,000 people per km^2, while United Nations projections place the wider Dhaka metropolitan area at 36.6 million residents by 2025 [13,14]. Dhaka's green-space provision is extreme even by Global South standards, at approximately 0.039 hectares per 1,000 residents across 54 documented green spaces totalling 283.49 hectares [11] an extreme-case setting in which to test whether existing, scarce UGS still confer measurable well-being benefits. Recent work focused on Dhaka North City Corporation has further documented specific institutional and governance obstacles that constrain sustainable urban greening initiatives in the city, underscoring that green-space scarcity in Dhaka reflects planning and policy challenges as well as physical land constraints [15]. This context matters clinically as well as environmentally: non-communicable diseases account for approximately 71% of all deaths in Bangladesh, with many occurring prematurely [16], and national risk-factor surveillance shows both a higher hypertension prevalence in urban than rural households and an age-standardised adult diabetes prevalence of 13.2% [17,18]. Mental health disorders are similarly prevalent, affecting an estimated 16.8% to 18.7% of adults nationally across successive nationwide surveys, with only a modest urban-rural difference and a substantial treatment gap [19,20]. These co-occurring cardiometabolic and mental health burdens are unlikely to be evenly distributed: Dhaka's large slum population faces compounded environmental and social stressors that plausibly constrain routine physical activity, social interaction, and psychological restoration, the same three pathways central to the

green space–health literature [21]. Complementing these national NCD statistics, a Dhaka-focused study has separately reported associations between green-space exposure and non-communicable disease risk among urban residents, reinforcing the plausibility of the NCD-related covariates modelled in the present study [22].

A second, more specific gap concerns the mediation evidence itself. A PRISMA-guided systematic review of 26 observational studies found mixed or non-significant evidence for the mediating roles of physical activity, perceived restorativeness, and social cohesion in the greenspace–mental-health pathway, and attributed much of this inconsistency to measurement heterogeneity objective NDVI versus perceived greenness, ad hoc activity counts versus validated MET-minutes, and single-item versus multi-item well-being outcomes [23]. No study identified in the literature combines validated IPAQ-SF MET-minutes, the WHO-5 Well-Being Index, an ART-derived restorativeness battery, and a multi-item UGS perception/benefits scale within a single parallel-mediation model, in any country. The present study addresses this gap directly, using internationally standardised instrumentation including the already-validated Bangla WHO-5 translation (Cronbach's $\alpha = .754$, test–retest $r = .713$; see the Bangla validation study [24]) and bootstrapped (rather than Sobel-based) indirect-effect estimation, an explicit methodological upgrade over the Dhaka benchmark study of Ahmad, Du and Rashid [12]. A further, exploratory contribution is the measurement of park-prescription (ParkRx) awareness, a construct essentially unmeasured outside high-income countries: a narrative review of nature-prescription evidence found that all 11 included studies were conducted in the United States [25], and a 92-study systematic review found that only 39% of studies originated outside South Korea, the USA, Japan, the UK, and China, with no South Asian country among the leading contributors [26]. Gender may also shape how green space itself is perceived: a study of Bangladeshi university students found that female respondents held more positive perceptions of urban green space than male respondents, with academic year and perceived climate-change vulnerability also shaping perception, a pattern relevant to the gender-related covariates examined in the present study [27].

The general objective of this study was to examine the association between urban green space access, use, and perceived quality and psychological well-being (WHO-5) among adult residents of urban Bangladesh, testing physical activity and perceived restorativeness as parallel mediating pathways. Seven hypotheses were tested and are presented in Table 1:

Table 1. Study hypotheses and pathway framework

#	Hypothesis	Framework domain
H1	Higher frequency/duration of green space visits is positively associated with WHO-5 well-being.	Direct effect
H2	Physical activity (IPAQ-SF MET-min/week) mediates the relationship between UGS use/perception and WHO-5 well-being.	Building capacities
H3	Perceived restorativeness mediates the relationship between UGS perceived quality/benefits and WHO-5 well-being.	Restoring capacities
H4	Physical activity and restorativeness operate as parallel, partially independent (not fully redundant) mediators.	Building + Restoring
H5	Perceived safety and accessibility moderate the strength of the UGS-use → physical-activity relationship.	Moderation
H6	NCD status, tobacco/alcohol use, and unhealthy diet are inversely associated with WHO-5, independent of UGS exposure.	Reducing harm (covariate)
H7	(Exploratory) ParkRx awareness is positively associated with UGS visit frequency and self-rated importance of green space.	Novel/exploratory

Framework domains are adapted from Markevych et al. [4].

Methods

Study design and setting

This study used a cross-sectional survey design conducted among adult users of public urban green spaces in Dhaka, Bangladesh. Data collection combined park-intercept and community-based sampling at and around identified urban green spaces to capture both active users and non-users of UGS within the same catchment.

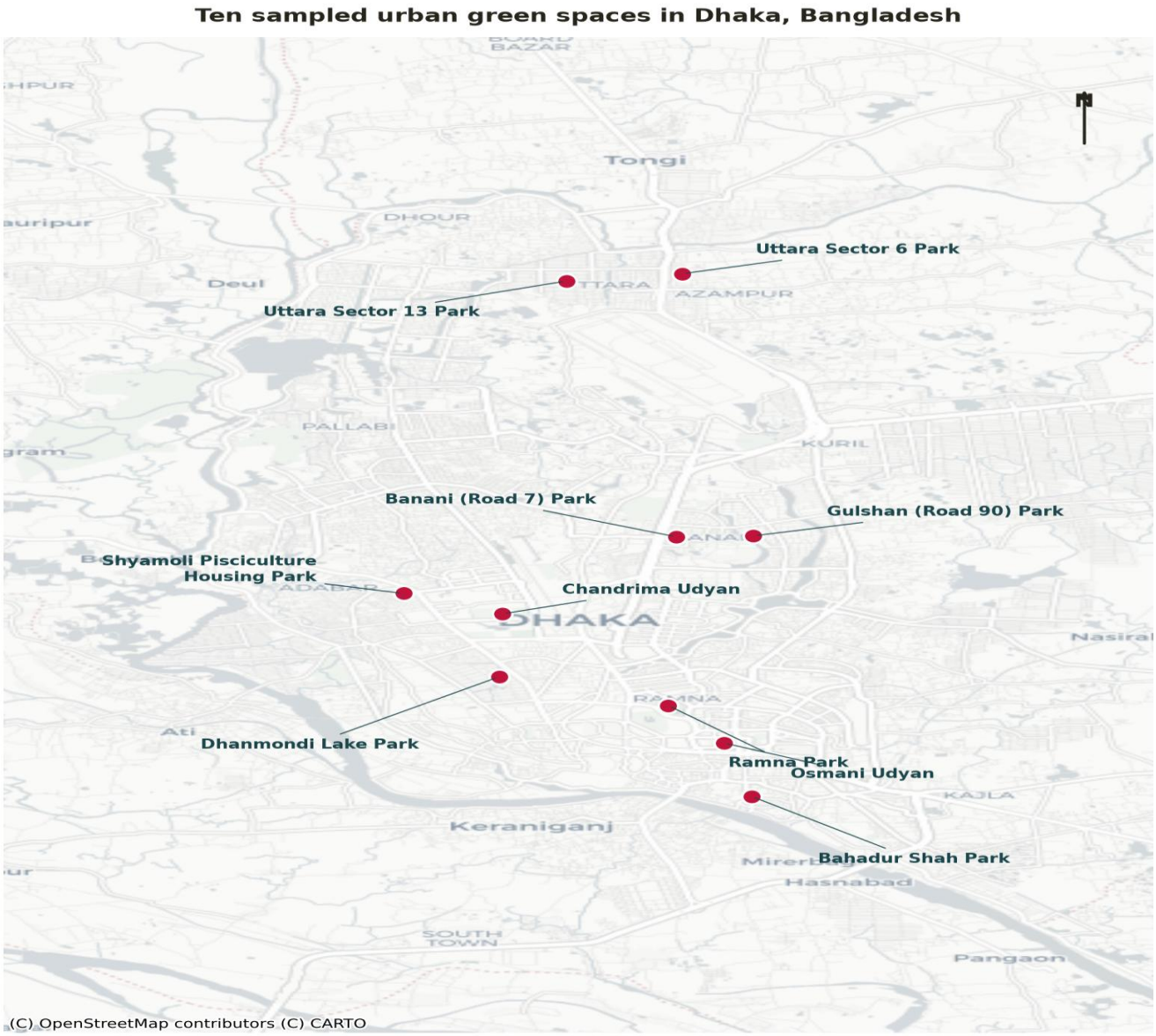
The study was carried out across ten public parks and green spaces distributed across the central, northern, and historic parts of Dhaka: Chandrima Udyan, Ramna Park, Dhanmondi Lake Park, Osmani Udyan, Gulshan (Road 90) Park, Banani (Road 7) Park, Shyamoli Pisciculture Housing Park, Uttara Sector 6 Park, Uttara Sector 13 Park, and Bahadur Shah Park (Figure 1). These sites range from large metropolitan parks with lakes and extensive vegetation Chandrima Udyan beside Crescent Lake and the National Parliament complex; Ramna Park, a historic approximately 68-acre park organised around a central lake and often described as one of the "lungs of Dhaka"; Dhanmondi Lake Park, a linear lakeside park within a dense residential area; and Osmani Udyan, a large central-city green space near the old commercial core to medium-sized neighbourhood parks in higher-income planned districts (Gulshan Road 90 Park and Banani Road 7 Park), a community-scale green space in a mixed residential area (Shyamoli Pisciculture Housing Park), two parks embedded within the

planned Uttara neighbourhood (Sector 6 and Sector 13), and a small, historically significant park in Old Dhaka (Bahadur Shah Park, formerly Victoria Park, in Laxmibazar).

This set of sites was selected to capture variation in park size, lake-front versus non-lake settings, planning era (colonial-era, post-independence, and modern neighbourhood parks), and surrounding socio-economic context, so that the sample would reflect the diversity of Dhaka's public green spaces rather than the profile of a single flagship park.

Figure 1. Map of the ten sampled urban green spaces in Dhaka, Bangladesh.

Park locations are approximate, based on publicly available geocoding sources (OpenStreetMap/Mapcarta), and are shown for illustrative purposes.



Sampling and participants

A total of 397 valid responses were retained for analysis after data screening. This sample size is consistent with comparable published studies in this design space, including n = 276 in Dhaka [12], n = 444 in Malaysia [28], n = 384 in Pakistan [29], and n = 493 in Albania [30]. Eligible participants were adults aged 18 years or older residing in the study area. No cases required exclusion for missing composite-scale data, and no IPAQ-SF cases exceeded the 960-minutes/week implausibility threshold requiring removal.

Measures and instruments

Socio-demographics and health behaviours

Age, gender, marital status, education, monthly household income, occupation, and years of urban residence were recorded, alongside self-reported NCD diagnosis, tobacco use, alcohol use, unhealthy-diet frequency, and family NCD history. Body mass index (BMI) was computed from self-reported height and weight and categorised as underweight, normal, overweight, or obese.

Urban green space use, access, and perceived quality

Participants reported visit frequency, typical visit duration, and activities undertaken in green spaces. UGS use intensity was computed as the product of visit frequency and visit duration. Perceived satisfaction, safety, accessibility, and health-benefit ratings were summed to form a perceived access quality composite (Green_perception, range 4–20). The Perceived Benefits of Urban Green Space (PBUGS) scale (6 items, 5-point Likert) captured perceived psychological, social, and physical benefits. The Perceptions of Urban Green Spaces Scale (10 items) captured broader adequacy/equity perceptions of UGS provision; five negatively worded items (items 1, 5, 7, 9, and 10) were reverse-scored prior to summation, following standard practice for mixed-worded batteries.

Physical activity

Physical activity was measured with the IPAQ short form (IPAQ-SF) [6], scored exactly per the IPAQ Research Committee's [31] official processing protocol: walking, moderate, and vigorous activity times were converted to minutes, truncated at 180 minutes/day per category, and multiplied by their respective MET values (walking = 3.3, moderate = 4.0, vigorous = 8.0 METs) and reported days/week, then summed to yield Total

MET-minutes/week. Participants were also classified into Low, Moderate, and High activity categories using official IPAQ cut-points. Because MET-minutes/week is characteristically right-skewed, median and interquartile range are reported alongside the mean. Activity enjoyment was measured with an adapted 5-item, agreement-format short form of the Physical Activity Enjoyment Scale (PACES), adapted from Chen et al. [32].

Psychological well-being and perceived restorativeness

Psychological well-being was measured with the WHO-5 Well-Being Index [33], using the previously validated Bangla translation (α = .754, one-factor structure confirmed in a Dhaka sample). Raw scores (0–25) were multiplied by 4 to yield a 0–100 scale, with scores below 50 classified as indicating poor well-being. Perceived restorativeness was assessed with a 4-item battery adapted from Hartig et al.'s [5] Perceived Restorativeness Scale, covering mental refreshment, effortless attention/fascination, activity–environment compatibility, and connectedness to living things; as this battery is a short, context-adapted selection rather than the full PRS or its validated PRS-11 short form, it is reported here as "a PRS-derived short battery" with its own psychometric evaluation, consistent with recommended practice for adapted instruments.

Park prescription (ParkRx) awareness

A single item assessed prior awareness of park-prescription or nature-prescription programmes, alongside items on self-rated importance of green space for well-being and perceived need for more green space in the local area.

Ethical statement

This research was conducted in full accordance with the ethical principles governing human subjects research, including the Declaration of Helsinki, the Belmont Report's principles of respect for persons, beneficence, and justice, and the institutional ethical guidelines of Noakhali Science and Technology University (NSTU). Ethical approval for the study was obtained from the Ethical Committee of Noakhali Science and Technology University (NSTU) before the commencement of data collection (Reference No: NSTU/SCI/EC/2025/454).

All participation was entirely voluntary. Potential participants were approached by trained research assistants who explained the study's purpose, procedures, risks, and benefits clearly in Bengali before soliciting participation. Participants were explicitly informed that declining to participate or withdrawing at any point

would result in no negative consequences and that their access to park facilities would be unaffected. Written informed consent was obtained from all survey participants. No personally identifying information (name, contact details, or precise address) was collected or linked to survey responses. Questionnaire data were coded using alphanumeric identifiers and stored in password-protected digital files accessible only to the researchers.

Statistical analysis

Analyses were conducted in Python (SciPy, statsmodels, pingouin, factor_analyzer). Internal consistency of each multi-item scale was assessed with Cronbach's alpha, item-total correlations, and alpha-if-item-deleted diagnostics. Exploratory factor analysis (principal-axis extraction, with Kaiser–Meyer–Olkin [KMO] sampling adequacy and Bartlett's test of sphericity) examined the dimensionality of the two researcher-adapted scales (PBUGS and the UGS Perceptions Scale). Bivariate associations among continuous composites were assessed with Pearson correlations; group differences were assessed with independent-samples t-tests, one-way ANOVA, and chi-square tests of independence as appropriate.

The primary inferential model was a four-block hierarchical multiple regression predicting WHO-5 well-being score: Block 1 entered socio-demographic and health-behaviour covariates (age, gender, education, income, BMI, NCD status, tobacco use, alcohol use, unhealthy diet); Block 2 added UGS use intensity and perceived access quality; Block 3 added the PBUGS and UGS Perceptions Scale composites; Block 4 added the candidate mediators (total MET-minutes/week, PACES enjoyment, and perceived restorativeness). Standardised β coefficients, ΔR^2 per block, and variance inflation factors (VIF) for multicollinearity diagnosis are reported for the final model.

Parallel mediation analyses (pingouin.mediation_analysis, bias-corrected bootstrap, n = 5,000 resamples, seed = 42) tested total MET-minutes/week and perceived restorativeness as simultaneous mediators of three predictor–outcome relationships: (Model A) UGS use intensity → WHO-5; (Model B) perceived access quality → WHO-5; and (Model C) perceived benefits (PBUGS) → WHO-5. All mediation models adjusted for age, gender, education, income, BMI, NCD status, tobacco use, alcohol use, and unhealthy diet. Moderation analysis tested whether perceived safety and perceived accessibility (entered separately, mean-centred, with their product terms) moderated the association between UGS use intensity and total MET-minutes/week.

Results

Sample characteristics

The final analytic sample comprised 397 adults (mean age 30.7 ± 12.3 years, range 18–70), of whom 61.7% were male. Table 2 summarises the full socio-demographic and health-behaviour profile of the sample. Nearly one in five participants (30.7%) fell in the lowest UGS-use-intensity tertile, and 37.5% reported a diagnosed non-communicable disease (NCD).

Table 2. Sample demographic and health characteristics

Characteristic	Category	n	%
Gender	Male	245	61.7%
	Female	152	38.3%
Marital status	Single	233	58.7%
	Married	144	36.3%
	Divorced/Separated	8	2.0%
	Widowed	12	3.0%
Education	SSC	84	21.2%
	HSC	92	23.2%
	Bachelor's	108	27.2%
	Master's	109	27.5%
	PhD or higher	4	1.0%
Monthly income (BDT)	< 20000	64	16.1%
	20001–40000	119	30.0%
	40001–60000	108	27.2%
	60001–80000	31	7.8%
	80001–100000	43	10.8%
	> 100000	32	8.1%
Occupation	Student	168	42.3%
	Government employee	36	9.1%
	Private employee	86	21.7%
	Business	51	12.8%
	Homemaker	12	3.0%
	Unemployed	36	9.1%
	Other	8	2.0%
BMI category	Underweight	52	13.1%
	Normal	123	31.0%

Characteristic	Category	n	%
	Overweight	159	40.1%
	Obese	63	15.9%
NCD diagnosis	Yes	149	37.5%
	No	248	62.5%
Tobacco use	Yes	97	24.4%
	No	300	75.6%
Alcohol use	Yes	53	13.4%
	No	344	86.6%
Unhealthy diet	Yes	185	46.6%
	No	212	53.4%
ParkRx awareness	Yes	217	54.7%
	No	180	45.3%

N = 397. Continuous age: M = 30.7, SD = 12.3, range 18–70.

Descriptive statistics of composite scales

Descriptive statistics for the seven study composite scales are presented in Table 3.

Table 3. Descriptive statistics for study composite scales

Composite scale	Mean	SD	Range
Perceived Benefits of UGS (PBUGS, mean, 1–5)	4.09	0.54	2.83–5.00
UGS Perceptions Scale (total, 10–50)	26.22	5.52	13–41
Perceived access quality (Green_perception, 4–20)	14.79	2.67	8–20
Total physical activity (MET-min/week)	2340.6 (median 1215.0, IQR 438.0–2733.0)	3207.9	right-skewed
Activity enjoyment (PACES, mean, 1–5)	3.85	0.64	1.00–5.00
Perceived restorativeness (mean, 1–5)	3.88	0.66	1.75–5.00
WHO-5 well-being score (0–100)	55.63	21.70	8–100

N = 397. Physical activity level (IPAQ categories): Low 30.5% (n = 121), Moderate 48.4% (n = 192), High 21.2% (n = 84). WHO-5 status: poor well-being (score < 50) 34.8% (n = 138), good well-being 65.2% (n = 259).

Scale reliability and factor structure

All five multi-item scales showed acceptable-to-excellent internal consistency (Table 4). The PBUGS scale (6 items) yielded a unidimensional exploratory factor analysis (EFA) solution (KMO = .806, Bartlett's $\chi^2 = 695.6$, $p < .001$; one factor by Kaiser criterion, 41.2% variance explained; loadings |.427–.746|), supporting its use as a single composite. In contrast, the 10-item UGS Perceptions Scale showed only marginal sampling adequacy (KMO = .690) and resolved into four factors (cumulative 53.3% variance: 18.3%, 12.0%, 11.5%, 11.5%), with

its weakest reverse-coded item (ugs7_r) showing a low item-total correlation (r = .187). This scale is therefore reported and interpreted as a summed total score with an acknowledged multidimensionality limitation rather than a confirmed unidimensional construct (see Section 4.4).

Table 4. Internal consistency reliability of study scales

Scale	Items	Cronbach's α	95% CI	Item-total r range
Perceived Benefits of UGS (PBUGS)	6	.792	[.759, .823]	.388–.644
UGS Perceptions Scale	10	.737	[.697, .774]	.187 (weakest item) – .59
Activity enjoyment (PACES)	5	.882	[.863, .899]	—
WHO-5 Well-Being Index	5	.916	[.903, .929]	—
Perceived restorativeness battery	4	.827	[.798, .853]	—

N = 397. CI, confidence interval; UGS, urban green space.

Bivariate associations

Bivariate associations among the key study composites are summarised in the correlation matrix in Figure 2.

Figure 2. Correlations among key study composites

Pearson correlation matrix. All green-space-related composites correlate positively with WHO-5 well-being (r range .14–.48). Visit frequency and urban green space use intensity are strongly correlated (r = .82), as expected because the latter is derived from the former.



WHO-5 well-being differed significantly by physical activity level (Low M = 50.98, Moderate M = 54.73, High M = 64.38; $F(2,394) = 10.24$, $p < .001$) and by UGS-use-intensity group (Low M = 1990.3, Moderate M = 1529.9, High M = 4548.9 MET-min/week; $F(2,394) = 31.84$, $p < .001$), and by monthly income (six groups; $F(5,391) = 12.35$, $p < .001$), though the income pattern was non-monotonic (group means 60.75, 47.97, 53.19, 49.03, 70.14, 69.00). Perceived restorativeness increased monotonically with perceived-greenness category (M = 3.17, 3.86, 3.94; $F(2,394) = 8.13$, $p < .001$). WHO-5 did not differ significantly by gender (male M = 57.29, SD = 19.5 vs. female M = 52.95, SD = 24.68; $t(395) = 1.84$, $p = .067$, marginal) or by NCD status ($t(395) = -0.84$, $p = .399$). ParkRx awareness was significantly associated with NCD status ($\chi^2(1) = 23.05$, $p < .001$; 70.5% of NCD-positive respondents were ParkRx-aware, versus 45.2% of NCD-negative respondents) and with visit-frequency category ($\chi^2(2) = 10.83$, $p = .004$), but showed no association with perceived need for more green

space ($\chi^2(1) = 0.0$, $p = 1.0$) a null result attributable to a ceiling effect, as the large majority of respondents endorsed needing more green space regardless of ParkRx awareness, leaving little variance to explain.

Hierarchical regression predicting WHO-5 well-being

A four-block hierarchical multiple regression tested the incremental contribution of green-space exposure and candidate mediators to WHO-5 well-being, over and above socio-demographic and health-behaviour covariates (Table 5). Block 1 (covariates only) explained 17.7% of variance (adjusted $R^2 = .158$, $F(9,387) = 9.24$, $p < .001$). Adding UGS use intensity and perceived access quality in Block 2 produced a large increment ($\Delta R^2 = .201$, $p < .001$), nearly doubling explained variance ($R^2 = .378$). Block 3 added the PBUGS and UGS Perceptions Scale composites ($\Delta R^2 = .023$, $p < .001$). The final model (Block 4), adding total MET-minutes/week, PACES enjoyment, and perceived restorativeness, explained 43.9% of variance (adjusted $R^2 = .415$, $F(16,380) = 18.57$, $p < .001$; $\Delta R^2 = .038$, $p < .001$ for the final block).

In the final model, the strongest standardised predictors of WHO-5 were perceived access quality ($\beta = .321$, $p < .001$) and perceived restorativeness ($\beta = .242$, $p < .001$), followed by BMI ($\beta = .171$, $p < .001$), education ($\beta = -.147$, $p = .001$), income ($\beta = .146$, $p = .002$), unhealthy diet ($\beta = -.128$, $p = .005$), and alcohol use ($\beta = .114$, $p = .031$). UGS use intensity was only marginally significant in the final model ($\beta = .096$, $p = .054$), and PBUGS, UGS Perceptions total, total MET-minutes/week, and PACES enjoyment were not significant unique predictors once perceived access quality and restorativeness were included, consistent with their operating primarily as antecedents/mediators rather than independent predictors. Notably, the tobacco-use effect, significant and negative in Block 1 ($\beta = -.237$, $p < .001$), was substantially attenuated after green-space variables entered the model (Block 4: $\beta = -.055$, $p = .339$), suggesting the socio-demographic profile of tobacco users partly overlaps with lower green-space access/perception. All variance inflation factors in the final model were below 2.3 (Table 6), indicating no problematic multicollinearity.

Table 5. Hierarchical regression predicting WHO-5 well-being

Predictor	Block 1 β	Block 2 β	Block 3 β	Block 4 β
Panel A. Standardised coefficients				
Age (years)	-0.002	-0.080	-0.075	-0.046
Gender (female)	-0.147**	0.005	-0.033	-0.047
Education level	-0.184***	-0.128**	-0.150***	-0.147***
Household income	0.212***	0.218***	0.193***	0.146**

Predictor	Block 1 β	Block 2 β	Block 3 β	Block 4 β
BMI	0.122*	0.144**	0.152**	0.171***
NCD diagnosis (yes)	-0.042	-0.046	-0.047	-0.036
Tobacco use (yes)	-0.237***	-0.082	-0.059	-0.055
Alcohol use (yes)	0.139*	0.117*	0.127*	0.114*
Unhealthy diet (yes)	-0.237***	-0.192***	-0.183***	-0.128**
UGS use intensity (freq. × duration)	—	0.168***	0.123*	0.096
Perceived access quality (satisfaction+safety+accessibility+benefit)	—	0.380***	0.336***	0.321***
Perceived Benefits of UGS (PBUGS, mean)	—	—	0.181***	0.037
UGS Perceptions Scale (total)	—	—	-0.014	-0.013
Total physical activity (MET-min/week)	—	—	—	0.004
Activity enjoyment (PACES, mean)	—	—	—	0.059
Perceived restorativeness (mean)	—	—	—	0.242***
Panel B. Model summary				
Model summary	Block 1	Block 2	Block 3	Block 4
R^2	0.177	0.378	0.401	0.439
ΔR^2	0.177	0.201	0.023	0.038
Adjusted R^2	0.158	0.360	0.380	0.415
F	9.24	21.25	19.69	18.57

N = 397. Panel A reports standardised β coefficients; —, variable not yet entered at that block. *p < .05, **p < .01, ***p < .001.

Block 4: R^2 = .439, adjusted R^2 = .415, F(16,380) = 18.57, p < .001.

Table 6. Variance inflation factors for the final model

Predictor	VIF (Block 4)
Age (years)	1.55
Gender (female)	1.69
Education level	1.26
Household income	1.53
BMI	1.45
NCD diagnosis (yes)	1.15
Tobacco use (yes)	2.25
Alcohol use (yes)	1.87
Unhealthy diet (yes)	1.39
UGS use intensity (freq. × duration)	1.68
Perceived access quality (satisfaction+safety+accessibility+benefit)	2.11
Perceived Benefits of UGS (PBUGS, mean)	2.18
UGS Perceptions Scale (total)	1.54
Total physical activity (MET-min/week)	1.35
Activity enjoyment (PACES, mean)	1.81
Perceived restorativeness (mean)	2.09

All values were < 2.3, indicating no multicollinearity concern. VIF, variance inflation factor.

Parallel mediation analysis

Three bootstrapped (n = 5,000 resamples) parallel mediation models tested total MET-minutes/week (physical activity) and perceived restorativeness as simultaneous mediators of the relationship between

green-space exposure and WHO-5 well-being, adjusting for age, gender, education, income, BMI, NCD status, tobacco use, alcohol use, and unhealthy diet (Table 7). Across all three models, perceived restorativeness was a robust, statistically significant mediator (all indirect-effect 95% confidence intervals excluded zero, all $p < .001$). Physical activity (total MET-minutes/week) mediated the relationship only in Model C, where perceived benefits (PBUGS) was the predictor (indirect effect = 0.988, 95% CI [0.274, 2.044], $p = .016$); its indirect effects were not significant when UGS use intensity (Model A) or perceived access quality (Model B) were the predictors. This pattern offers nuanced, partial support for H2–H4: the two mediators operate as parallel but not equally weighted pathways, with restorativeness consistently dominant a pattern consistent with the mixed physical-activity-mediation evidence reported by Zhang et al. [23].

Table 7. Parallel mediation results for green space and well-being

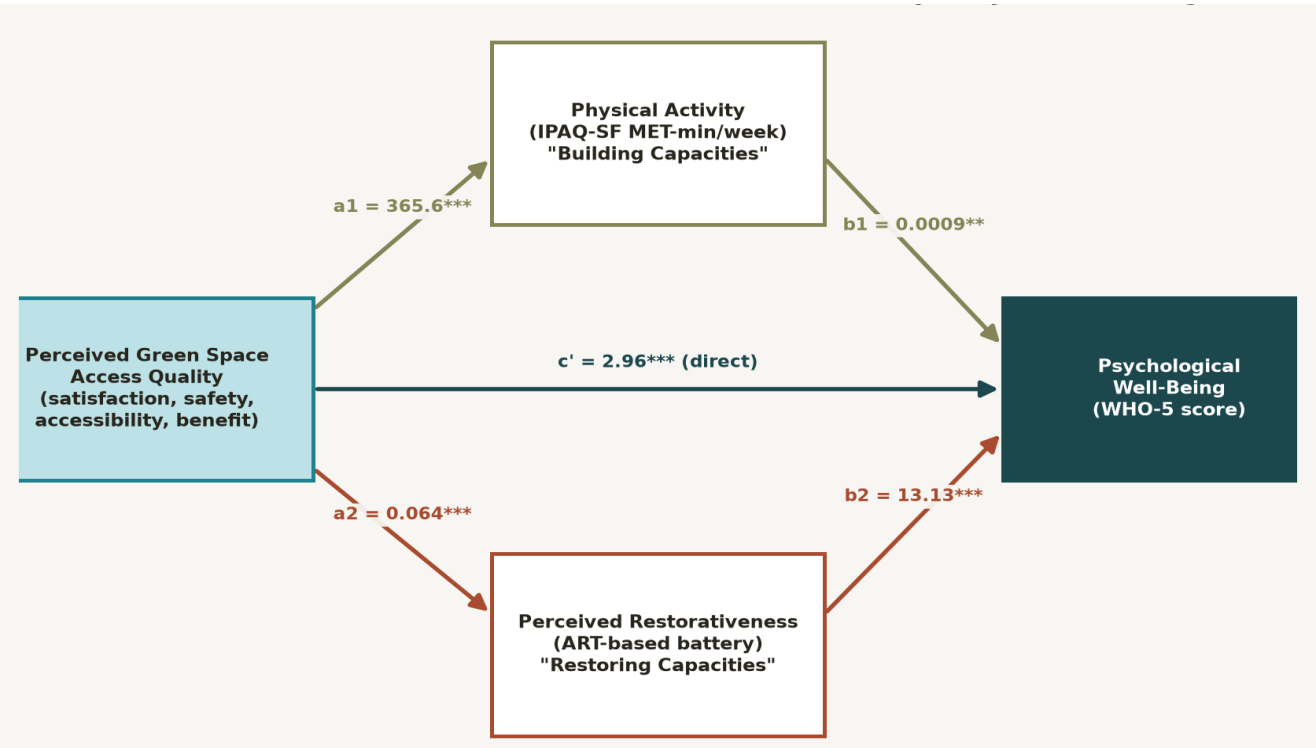
Model (predictor → WHO-5)	Mediator	Indirect effect	95% CI (bootstrap)	Significance
A: UGS use intensity	Total MET-min/week	0.083	[−0.008, 0.178]	n.s.
	Perceived restorativeness	0.355	[0.230, 0.508]	$p < .001$
B: Perceived access quality	Total MET-min/week	0.065	[−0.142, 0.266]	n.s.
	Perceived restorativeness	0.642	[0.374, 0.967]	$p < .001$
C: Perceived benefits (PBUGS)	Total MET-min/week	0.988	[0.274, 2.044]	$p = .016$
	Perceived restorativeness	6.825	[4.559, 9.310]	$p < .001$

Indirect effects of green space exposure on WHO-5 well-being through total physical activity and perceived restorativeness. Bias-corrected bootstrap with 5000 resamples; covariates: age, gender, education, income, BMI, NCD status, tobacco use, alcohol use, and unhealthy diet. CI, confidence interval; n.s., not significant.

For illustration, Model B (perceived access quality as predictor) is depicted as a path diagram in Figure 3. The total effect of perceived access quality on WHO-5 ($c = 3.664$, $p < .001$) was only partially explained by the two mediators (direct effect $c' = 2.957$, $p < .001$), with the restorativeness pathway ($a2 = 0.064$, $p < .001$; $b2 = 13.13$, $p < .001$) contributing the larger share of the indirect effect relative to the physical-activity pathway ($a1 = 365.6$, $p < .001$; $b1 = 0.0009$, $p = .003$).

Figure 3. Parallel mediation model for perceived access quality

Model B shows perceived access quality predicting WHO-5 well-being through total physical activity and perceived restorativeness. Path coefficients are unstandardised; ***p < .001, **p < .01. Brackets show the 95% bootstrap confidence interval for each indirect effect.



Moderation analysis

A moderated-regression analysis tested whether perceived safety and perceived accessibility moderated the relationship between UGS use intensity and total MET-minutes/week (Table 8, testing H5). Perceived accessibility significantly strengthened this relationship (interaction b = 0.191, p < .001; model R^2 = .152), such that residents who both used green space more intensively and perceived it as more accessible reported disproportionately higher physical activity. Perceived safety did not significantly moderate the relationship (interaction b = 0.080, p = .081, marginal; model R^2 = .124), offering only partial support for H5.

Table 8. Moderation of green space use and physical activity

Moderator	b (UGS use intensity)	b (moderator)	b (interaction)	Model R^2
Perceived safety	0.274 (p < .001)	0.122 (p = .013)	0.080 (p = .081, n.s.)	.124
Perceived accessibility	0.170 (p = .003)	0.188 (p < .001)	0.191 (p < .001)	.152

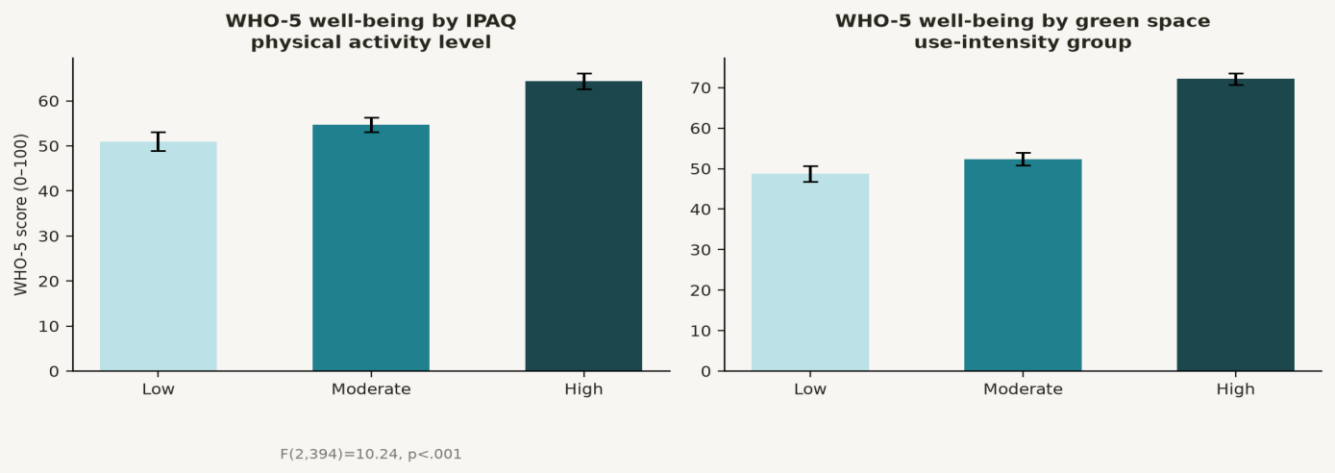
Separate models used mean-centred predictors. UGS, urban green space.

Group comparisons: well-being by activity level and UGS-use group

Group differences in WHO-5 well-being by physical activity level and urban green space use intensity are illustrated in Figure 4.

Figure 4. Well-being by physical activity and green space use

Mean WHO-5 well-being score by IPAQ physical activity level (left; $F(2,394) = 10.24$, $p < .001$) and by urban green space use intensity group (right). Error bars show standard error of the mean.



Discussion

This study is, to our knowledge, the first in Bangladesh and among the first in South Asia to test a formal parallel-mediation model of the urban green space (UGS)–well-being relationship using validated IPAQ-SF physical activity, WHO-5 well-being, and ART-derived restorativeness measures in the same sample. Three findings stand out. First, green-space exposure variables (use intensity, perceived access quality, perceived benefits) accounted for a substantial increment in explained WHO-5 variance beyond socio-demographic and behavioural covariates ($\Delta R^2 = .201$, Block 2), confirming H1 and underscoring that UGS is not a marginal correlate of well-being even in a setting of extreme green-space scarcity. Second, and central to the study's novelty, perceived restorativeness was the dominant, consistently significant mediating pathway across all three predictor specifications, while physical activity mediated the relationship in only one of three models. This directly supports H3 and offers only partial support for H2 and H4: the two "building capacities" and "restoring capacities" pathways of the Markevych et al. [4] framework are not equally weighted in this population — psychological restoration appears to matter more than exercise volume. Third, perceived accessibility, but not perceived safety, significantly amplified the UGS-use–physical-activity relationship (partial support for H5), suggesting that removing practical barriers to reaching green space may do more to promote activity than safety-focused interventions alone in this context.

The restorativeness-dominant mediation pattern found here diverges from the most direct regional benchmark, Ahmad, Du and Rashid's [12] study of 276 Dhaka residents, which reported physical activity and social cohesion (not restorativeness, which was not measured) as significant mediators of the UGS accessibility–SWEMWBS well-being relationship. The present results are more consonant with the broader restoration-theory literature: Li et al. [34], in a sample of 668 Chinese adults, found that perceived restorativeness mediated the green-space–depression relationship more strongly than did physical activity, and Baceviciene and Jankauskiene's [35] Lithuanian study similarly found psychological restoration to be a stronger pathway than exercise behaviour. Zhang, Zhang and Rhodes' [23] systematic review characterised the physical-activity-mediation evidence base as genuinely mixed across 26 studies, attributing inconsistency partly to measurement heterogeneity a critique the present study addresses by using the standardised IPAQ-SF protocol rather than ad hoc activity counts. This restoration-dominant pattern also aligns with the broader international evidence base linking green space exposure to health outcomes more generally: a systematic review and meta-analysis synthesising more than 140 observational studies and nearly 300 million participants found that greater greenness exposure was consistently associated with reduced all-cause and cardiovascular mortality, lower type 2 diabetes incidence, lower blood pressure and cortisol, and improved mental health outcomes [36], a pattern corroborated by cohort-based meta-analytic evidence on mortality specifically [37] and by a further systematic review documenting consistent inverse associations between green-space exposure and cardiovascular disease [38]. Mechanistic support for the restorative pathway itself comes from research in deprived UK communities, where greater green-space exposure was associated with lower salivary cortisol, providing physiological corroboration for the psychological restoration process central to the present study's mediation findings [39]. Other work has additionally identified social interaction within green spaces as a third pathway partially mediating mental health benefits, a mechanism not directly measured here but broadly consistent with a multi-pathway framing of the green space–health relationship [40], and neighbourhood-greenness research has similarly linked physical and mental health outcomes to walking, social coherence, and local social interaction operating as parallel explanatory pathways, consistent with the present study's parallel-mediation approach [41]. Our finding that physical activity mediation emerged only for the perceived-benefits (PBUGS) predictor, not for use intensity or perceived access, is a novel

nuance: it suggests physical activity may be more tightly coupled to a belief that green space is beneficial than to accessibility or use frequency per se, a distinction not previously reported in the reviewed literature.

The extremely low per-capita green space available in Dhaka (0.039 ha/1000 residents) [11] provides an important contextual qualifier: even under this scarcity, use intensity, perceived quality, and perceived benefits all showed substantial associations with well-being, echoing Labib et al.'s [11] finding that green-space use was associated with lower prevalence of several NCDs among 169 Dhaka adults despite similarly constrained supply. This is consistent with an emerging "scarcity premium" hypothesis in LMIC green-space research that the marginal well-being value of accessible green space may be higher, not lower, where supply is scarce, though this remains speculative pending direct comparative testing [8]. This scarcity-premium reasoning is broadly consistent with population-level evidence that exposure to natural environments can narrow socioeconomic health inequalities, which reinforces the present study's emphasis on the perceived quality and accessibility of existing green space, rather than green-space quantity alone, as a lever for well-being [42].

Theoretically, these findings lend empirical weight to Attention Restoration Theory and Stress Reduction Theory as complementary but non-redundant explanations for green space–well-being associations, and support Markevych et al.'s [4] call to model "restoring" and "building" pathways in parallel rather than treating physical activity as a proxy for all green-space benefit. This framing is consistent with global reviews of city planning and population health, which identify equitable green-infrastructure provision as a central lever for addressing the health challenges of rapidly urbanising low- and middle-income megacities such as Dhaka [43].

Practically, the dominance of the restorativeness and perceived-access-quality pathways over raw use intensity or physical activity volume suggests that urban planning and public health interventions in Dhaka and comparable South Asian megacities may achieve greater well-being returns by improving the perceived quality, safety-independent accessibility, and psychological restorativeness of existing green spaces (shade, quiet zones, maintenance, reduced crowding and noise) than by solely promoting exercise-focused park programming. This safety-independent emphasis is notable given evidence from urban-park research that perceived safety in green space is systematically gender-differentiated, a consideration relevant to interpreting why perceived safety, unlike perceived accessibility, did not significantly moderate the UGS-use–physical-activity relationship in the present study's moderation analysis [44]. The moderate but non-trivial ParkRx

awareness rate (54.7%) and its significant association with NCD status suggest an opportunity: nature-prescription-style interventions, hitherto studied almost exclusively in high-income countries [25,26], could be piloted in Dhaka's existing primary care–NCD management pathway, building on demonstrated feasibility in a comparable Southeast Asian urban RCT context [45] (Singapore).

Strengths and limitations

Cross-sectional design precludes causal inference; reverse causality (e.g., psychologically well individuals may be more inclined to visit and rate green space favourably) cannot be excluded. IPAQ-SF relies on self-report and is subject to social-desirability and recall bias; no accelerometer validation was available. No validated Bangla-language version of the IPAQ-SF currently exists; the instrument was administered using the original English/adapted item wording, a limitation shared with most South Asian applications of the tool. The PBUGS and Perceived Restorativeness battery are researcher-adapted rather than independently pre-validated in Bangladesh; the restorativeness battery, in particular, is a short 4-item selection derived from the Perceived Restorativeness Scale [5] rather than its full or validated short (PRS-11) form. The 10-item UGS Perceptions Scale showed a multidimensional (4-factor) exploratory structure rather than the assumed unidimensional structure, indicating the summed total score should be interpreted with caution pending confirmatory validation. Sampling combined park-intercept and community-based recruitment across ten parks in Dhaka, which may not be fully representative of the city's general adult population. Common-method bias is possible given single-source, single-occasion self-report for both predictors and outcome. Strengths include the use of internationally validated core instruments (IPAQ-SF, WHO-5 with prior Bangla validation), a comparatively large sample (N = 397) relative to comparable regional studies, bootstrapped rather than Sobel-based mediation estimation, explicit multicollinearity diagnostics, and a hierarchical modelling strategy that isolates the incremental contribution of green-space variables from established socio-demographic and behavioural determinants of well-being.

Conclusions

Among 397 adults using public urban green spaces in Dhaka, Bangladesh, a setting with among the lowest documented per-capita urban green space use globally, perceived access quality, and perceived benefits were

all substantively associated with WHO-5 psychological well-being, together with socio-demographic and behavioural covariates explaining 43.9% of total variance. Perceived restorativeness, not physical activity volume, was the consistent, dominant mediating pathway linking green-space exposure to well-being across three complementary model specifications, and perceived accessibility (but not safety) significantly strengthened the link between green-space use and physical activity. These findings suggest that in resource-constrained, green-space-scarce urban contexts, interventions that enhance the psychological restorativeness and perceived accessibility of existing UGS not only its physical activity affordances may offer a high-value, low-cost lever for improving population mental health. Future longitudinal and intervention research, ideally paired with objective UGS exposure measures (e.g., NDVI) and a validated Bangla IPAQ, is needed to test the causal and generalisable status of this restorativeness-dominant pathway across other South Asian urban settings.

List of abbreviations

ART, Attention Restoration Theory;

BMI, body mass index;

CI, confidence interval;

EFA, exploratory factor analysis;

IPAQ-SF, International Physical Activity Questionnaire—Short Form;

KMO, Kaiser–Meyer–Olkin; LMIC, low- and middle-income country;

MET, metabolic equivalent of task;

NCD, non-communicable disease;

NDVI, normalized difference vegetation index;

PACES, Physical Activity Enjoyment Scale;

ParkRx, park prescription;

PBUGS, Perceived Benefits of Urban Green Space;

PRS, Perceived Restorativeness Scale;

SRT, Stress Reduction Theory;

SWEMWBS, Short Warwick–Edinburgh Mental Well-being Scale;

UGS, urban green space;

VIF, variance inflation factor;

WHO-5, World Health Organization Five Well-Being Index.

Data availability statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Author Contributions

M.A.M.R. conceptualized the study, designed the methodology, conducted data curation, performed formal analysis, and contributed to writing, reviewing, and editing the manuscript. M.R.S. contributed to the formal study, wrote the original draft, and participated in reviewing and editing the manuscript. Both authors (M.A.M.R. and M.R.S.) reviewed and approved the final manuscript for submission.

Conflict of interest

The authors do not have any conflicts of interest.

Clinical Trial Number

Not applicable.

Declarations

Ethics statement

The authors affirm their unwavering commitment to ethical standards, ensuring that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2013. The study protocol was approved by the Ethical Committee of Noakhali Science and Technology University (Reference no: NSTU/SCI/EC/2025/454).

Consent to Participate

Informed consent was obtained from all individual participants included in the study, reaffirming the Authors' commitment to transparency and ethical conduct.

Consent to publish

Not applicable.

References

1. WHO Regional Office for Europe. Urban green spaces: a brief for action. Copenhagen: World Health Organization; 2017. https://iris.who.int/bitstream/handle/10665/344116/9789289052498-eng.pdf
2. Kaplan S. The restorative benefits of nature: toward an integrative framework. J Environ Psychol. 1995;15(3):169–182. https://www.sciencedirect.com/science/article/pii/0272494495900012
3. Ulrich RS, Simons RF, Losito BD, Fiorito E, Miles MA, Zelson M. Stress recovery during exposure to natural and urban environments. J Environ Psychol. 1991;11(3):201–230. https://explore.openaire.eu/search/result?pid=10.1016/s0272-4944(05)80184-7
4. Markevych I, Schoierer J, Hartig T, Chudnovsky A, Hystad P, Dzhambov AM, et al. Exploring pathways linking greenspace to health: theoretical and methodological guidance. Environ Res. 2017;158:301–317. https://pubmed.ncbi.nlm.nih.gov/28672128/

5. Hartig T, Korpela K, Evans GW, Gärling T. A measure of restorative quality in environments. Scand Hous Plan Res. 1997;14(4):175–194. https://blogs.ubc.ca/2017wufor200/files/2017/02/Perceived-Restorativeness-Scale-Hartig-et-al-1997.pdf

6. Craig CL, Marshall AL, Sjöström M, Bauman AE, Booth ML, Ainsworth BE, et al. International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc. 2003;35(8):1381–1395. https://pubmed.ncbi.nlm.nih.gov/12900694/

7. Byomkesh T, Nakagoshi N, Dewan AM. Urbanization and green space dynamics in Greater Dhaka, Bangladesh. Landsc Ecol Eng. 2012;8:45-58.

8. Nawrath M, Guenat S, Elsey H, Dallimer M. Exploring uncharted territory: do urban greenspaces support mental health in low- and middle-income countries? Environ Res. 2021;194:110625. https://pubmed.ncbi.nlm.nih.gov/33338487/

9. Nawar N, Sorker R, Chowdhury FJ, Mostafizur Rahman M. Present status and historical changes of urban green space in Dhaka city, Bangladesh: a remote sensing driven approach. Environ Challenges. 2022;6:100425. https://doi.org/10.1016/j.envc.2021.100425

10. Khan MW, Hossain MS, Alam M. GIS-based analysis to identify the distribution and accessibility of urban green space in Dhaka Metropolitan City, Bangladesh. J Geogr Inf Syst. 2023;15:35-52.

11. Labib SM, Shuvo FK, Browning MHEM, Rigolon A. Noncommunicable diseases, park prescriptions, and urban green space use patterns in a Global South context: the case of Dhaka, Bangladesh. Int J Environ Res Public Health. 2020;17(11):3900. https://pmc.ncbi.nlm.nih.gov/articles/PMC7313456/

12. Ahmad M, Du J, Rashid MJ. Urban green space and mental health: mediating roles of physical activity and social cohesion. Am J Health Promot. 2026;40(4):459–470. https://pubmed.ncbi.nlm.nih.gov/41922936/

13. Bangladesh Bureau of Statistics. Population and Housing Census 2022. Dhaka: BBS; 2022.

14. United Nations Department of Economic and Social Affairs. World Urbanization Prospects 2025: Summary of Results. New York: UN DESA; 2025. https://population.un.org/wup/

15. Shammi M, Reza F, Sarker AC, Sakib AA. Prospects and challenges of achieving sustainable urban green-spaces: a case study of urban greening in Dhaka North City Corporation (DNCC), Bangladesh. PLOS Sustain Transform. 2023. https://doi.org/10.1371/journal.pstr.0000061

16. World Health Organization Bangladesh. Bangladesh moves to integrate NCD and mental health care into emergency preparedness [Internet]. Geneva: WHO; [cited 2026 Apr 6]. https://www.who.int/bangladesh/news/feature-stories/item/bangladesh-moves-to-integrate-ncd-and-mental-health-care-into-emergency-preparedness
17. National Institute of Preventive and Social Medicine. National STEPS Survey for Non-Communicable Diseases Risk Factors in Bangladesh 2018. Dhaka: NIPSOM; 2018.
18. International Diabetes Federation. Diabetes in Bangladesh — IDF Diabetes Atlas [Internet]. Brussels: IDF; [cited 2026 Apr 6]. https://diabetesatlas.org/data-by-location/country/bangladesh/
19. World Health Organization Bangladesh. Minister of Health releases first findings of National Mental Health Survey [Internet]. Geneva: WHO; 2019 [cited 2026 Apr 6]. https://www.who.int/bangladesh/news/detail/27-11-2019-minister-of-health-releases-first-findings-of-national-mental-health-survey
20. Alam MF, Ahmed HU, Alam MT, Sarkar M, Khan NM, Uddin MJ, Sarkar AA. Community prevalence of psychiatric disorders: findings from a nationwide survey in Bangladesh. Asian J Psychiatr. 2024;92:103897.
21. Hasan MZ, Rabbani MG, Ahmed MW, Mehdi GG, Tisha KI, Reidpath DD, Hanifi SMA, Mahmood SS. Assessment of socioeconomic and health vulnerability among urban slum dwellers in Bangladesh: a cross-sectional study. BMC Public Health. 2024;24:2946.
22. Debnath S, Das PK. Green space and the risk of non-communicable diseases: a study of urban residents in Dhaka City. Eur J Dev Stud. 2023;3:37-45.
23. Zhang R, Zhang CQ, Rhodes RE. The pathways linking objectively measured greenspace exposure and mental health: a systematic review of observational studies. Environ Res. 2021;198:111233. https://pubmed.ncbi.nlm.nih.gov/33933490/
24. Faruk MO, Alam F, Chowdhury KUA, Soron TR. Validation of the Bangla WHO-5 Well-being Index. BJPsych Open. 2021;7(5):e159. https://pmc.ncbi.nlm.nih.gov/articles/PMC8318837/
25. Kondo MC, Oyekanmi KO, Gibson A, South EC, Bocarro J, Hipp JA. Nature prescriptions for health: a review of evidence and research opportunities. Int J Environ Res Public Health. 2020;17(12):4213. https://pmc.ncbi.nlm.nih.gov/articles/PMC7344564/

26. Nguyen PY, Astell-Burt T, Rahimi-Ardabili H, Feng X. Effect of nature prescriptions on cardiometabolic and mental health, and physical activity: a systematic review. Lancet Planet Health. 2023. https://www.thelancet.com/journals/lanplh/article/piis2542-5196(23)00025-6/fulltext
27. Saha B, Atiqul Haq SM. Perception of urban green space among university students in Bangladesh. PLoS One. 2024;19:e0311033.
28. Malekinezhad F, Courtney P, Lamit H, Vigani M. Investigating the mental health impacts of university campus green space through perceived sensory dimensions and the mediation effects of perceived restorativeness on restoration experience. Front Public Health. 2020;8:578241. https://eprints.glos.ac.uk/9240/8/9240-Courtney-(2020)-Investigating-the-mental-health-impacts.pdf
29. Niazi Z, Khan MA. Urban green space usage behaviours and self-perceived mental health benefits. Cities Health. 2024. https://www.tandfonline.com/doi/abs/10.1080/23748834.2024.2348296
30. Kruja D, Braçe O, Garrido-Cumbrera M, Kokthi E. Green space, physical activity and well-being: evidence from the AUGS survey in Tirana, Albania. Landscape Online. 2024;99:1126. https://landscape-online.org/index.php/lo/article/download/LO.2024.1126/LO.2024.1126/3184
31. IPAQ Research Committee. Guidelines for data processing and analysis of the International Physical Activity Questionnaire (IPAQ): short and long forms. 2005. https://biobank.ctsu.ox.ac.uk/ukb/ukb/docs/ipaq_analysis.pdf
32. Chen C, Weyland S, Fritsch J, Woll A, Niessner C, Burchartz A, et al. A short version of the Physical Activity Enjoyment Scale: development and psychometric properties. Int J Environ Res Public Health. 2021;18(21):11035. https://pmc.ncbi.nlm.nih.gov/articles/PMC8582913/
33. Topp CW, Østergaard SD, Søndergaard S, Bech P. The WHO-5 Well-Being Index: a systematic review of the literature. Psychother Psychosom. 2015;84(3):167–176. https://pubmed.ncbi.nlm.nih.gov/25831962/
34. Li H, Li Y, Wang Z, Zhang G. Green physical activity for leisure connects perceived residential greenspace and mental well-being. Front Public Health. 2023;11:1254185. https://www.frontiersin.org/journals/public-health/articles/10.3389/fpubh.2023.1254185/full
35. Baceviciene M, Jankauskiene R. Associations between quality of life and nature exposure, nature restorativeness, and stress: a mediation model. Int J Environ Res Public Health. 2022;19(4):2098. https://pmc.ncbi.nlm.nih.gov/articles/PMC8871825/

36. Twohig-Bennett C, Jones A. The health benefits of the great outdoors: a systematic review and meta-analysis of greenspace exposure and health outcomes. Environ Res. 2018;166:628-637.
37. Rojas-Rueda D, Nieuwenhuijsen MJ, Gascon M, Perez-Leon D, Mudu P. Green spaces and mortality: a systematic review and meta-analysis of cohort studies. Lancet Planet Health. 2019;3:e469-e477.
38. Liu XX, Ma XL, Huang WZ, et al. Green space and cardiovascular disease: a systematic review with meta-analysis. Environ Pollut. 2022. https://doi.org/10.1016/j.envpol.2022.118990
39. Ward Thompson C, Roe J, Aspinall P, Mitchell R, Clow A, Miller D. More green space is linked to less stress in deprived communities: evidence from salivary cortisol patterns. Landsc Urban Plan. 2012;105:221-229.
40. Wood L, Hooper P, Foster S, Bull F. Public green spaces and positive mental health - investigating the relationship between access, quantity and types of parks and mental wellbeing. Health Place. 2017;48:63-71.
41. Sugiyama T, Leslie E, Giles-Corti B, Owen N. Associations of neighbourhood greenness with physical and mental health: do walking, social coherence and local social interaction explain the relationships? J Epidemiol Community Health. 2008. https://doi.org/10.1136/jech.2007.064287
42. Mitchell R, Popham F. Effect of exposure to natural environment on health inequalities: an observational population study. Lancet. 2008;372:1655-1660.
43. Giles-Corti B, Vernez-Moudon A, Reis R, et al. City planning and population health: a global challenge. Lancet. 2016;388:2912-2924.
44. Polko P, Kimic K. Gender as a factor differentiating the perceptions of safety in urban parks. Ain Shams Eng J. 2022;13:101608.
45. Müller-Riemenschneider F, Petrunoff N, Yao J, Ng A, Sia A, Ramiah A, et al. Effectiveness of prescribing physical activity in parks to improve health and wellbeing: the park prescription randomized controlled trial. Int J Behav Nutr Phys Act. 2020;17:42. https://pmc.ncbi.nlm.nih.gov/articles/PMC7079356/