Urban-Regional Ecology
Journal Homepage: https://journals.explorerpress.com/ure

Research Article

Greenery as a Cross-Gender Buffer of Parental Stress in Arab Families: A Multidimensional Ecological, Psychophysiological Analysis

Diana Saadi

Porter School of the Environmental and Earth Sciences, Tel Aviv University, Israel

KEYWORDS

parental stress
Arab families
greenness
NDVI
HRV
PANAS
gender differences
ecological stress model

ABSTRACT

Background: Parental stress results from interacting psychological, physiological, emotional, environmental, and sociocultural factors. Although exposure to natural environments is increasingly recognized as a stress-buffering mechanism, little is known about whether these effects differ between mothers and fathers, particularly within minority populations such as Arab families in Israel.**Methods:**This study examined gender-specific predictors of parental stress among 250 Arab parents (125 mothers, 125 fathers) in northern Israel. A multidimensional ecological–psychophysiological model integrated psychological (Parental Stress Scale; PSS), physiological (heart rate variability; HRV), emotional (Negative Affect; PANAS-NA), and environmental (NDVI) indicators. Residential greenness was measured using Landsat-derived NDVI within a 500 m buffer around each home. Regression models were estimated separately for mothers and fathers.**Results:**Mothers displayed significantly higher psychological stress (PSS) and physiological stress (HRV) compared with fathers. NDVI emerged as the strongest cross-gender protective factor, with substantial negative associations with PSS in mothers (β = –0.82) and fathers (β = –0.88). Family structure operated differently by gender: number of children predicted stress among fathers only (β = +0.31), while household size predicted stress among mothers only (β = +0.27). Negative affect significantly increased stress in both genders, and income showed modest protective effects.**Conclusions:**Greenness functions as a powerful ecological buffer of parental stress for both genders, while sociocultural family roles create gendered stress pathways. This study is among the first to integrate psychological, physiological, emotional, and environmental indicators in a Middle Eastern minority context.**Significance:**Findings highlight environmental-health inequities and underscore the importance of incorporating green infrastructure into planning for minority communities.

*CORRESPONDING AUTHOR

Diana Saadi; Porter School of the Environmental and Earth Sciences, Tel Aviv University, Israel; Email: sdianaa@gmail.com

ARTICLE INFO

Received: 3 October 2025 | Revised: 20 October 2025 | Accepted: 23 October 2025 | Published Online: 25 October 2025
DOI: https://doi.org/10.65773/ure.1.1.67

1. Introduction

Parental stress refers to the experience of psychological strain associated with the demands of raising children [1]. Extensive literature demonstrates that elevated parental stress is associated with poorer mental health, impaired parental functioning, and adverse child outcomes [2]. Gender differences in stress are well documented: mothers typically report higher stress levels due to cultural expectations, domestic labor, and emotional responsibility [3].

Despite the expanding literature on environmental determinants of stress, several significant gaps remain. First, Arab families in Israel , characterized by extended households, high fertility, and traditional gender norms , remain understudied. Second, although exposure to natural environments is consistently linked to stress reduction [4–7], no research has examined whether greenness affects mothers and fathers differently in minority populations. Third, most research relies on a single measurement domain, whereas parental stress is inherently multidimensional.

This study addresses these gaps by applying a multidimensional ecological–psychophysiological framework integrating psychological (PSS), physiological (HRV), emotional (PANAS-NA), and environmental (NDVI) indicators. We examine whether gender-specific pathways of parental stress exist within Arab minority populations and whether greenness buffers stress across genders.

2. Materials and Methods

2.1 Study Design

This study employed a cross-sectional ecological–psychophysiological design integrating psychological, physiological, emotional, environmental, and sociodemographic indicators. The purpose was to examine gender-specific predictors of parental stress among Arab mothers and fathers. Separate analyses were conducted for each gender to identify distinct sociocultural and environmental stress pathways.

2.2 Participants and Recruitment

A total of **250 Arab parents** (125 mothers, 125 fathers) participated in the study. Eligibility criteria included:
(1) being a parent of at least one child;
(2) age 20–50;
(3) no chronic illness requiring daily medication;
(4) no recent (past two weeks) use of drugs, alcohol, or psychotropic medication.
Participants were recruited through snowball sampling via community networks, family centers, and social media platforms. All participants resided in small Arab-majority municipalities in northern Israel, including the city of Nazareth and nearby towns (~70,000 residents).

Ethical Approval

The Ethics Committee of Tel Aviv University approved the study protocol. All participants received detailed explanations of the study aims and procedures and provided written informed consent. Ethical procedures followed the original field experiment protocol detailed in Saadi et al. (2020).

2.3 Measures

Detailed descriptions of all study instruments appear in the **Supplementary Materials (Tables S1–S6)**.

2.3.1 Parental Stress Scale (PSS)

Parental stress was assessed using the **Parental Stress Scale** (PSS), an 18-item instrument rated on a 1–5 Likert scale capturing emotional overload, role restriction, and parental satisfaction.
Internal consistency in this study: **α = .86**.
Full instrument structure and validation details are provided in **Table S1**.

2.3.2 Heart Rate Variability (HRV – LF/HF Ratio)

Physiological stress was assessed using **heart rate variability (HRV)**, specifically the LF/HF ratio, a validated biomarker of autonomic balance.
Measurement protocol included:

- Device: Polar 810i (validated against ECG; r > .95)
- Ambulatory recording: 3 hours
- Analysis: Fast Fourier Transform (FFT)
- Data processing: artifact removal with Polar ProTrainer5

Technical specifications and field validation are presented in **Table S2**.

2.3.3 Negative Affect (PANAS-NA)

Emotional vulnerability was assessed using the 10-item Negative Affect (NA) subscale of the PANAS inventory. Participants rated the extent to which they experienced emotions such as distress, irritability, nervousness, and hostility (1 = very slightly, 5 = extremely).
Internal consistency in this study: **α = .88**.
Instrument domains and psychometric properties appear in **Table S3**.

2.3.4 Environmental Greenness (NDVI)

Environmental exposure to vegetation was quantified using the **Normalized Difference Vegetation Index (NDVI)** derived from Landsat 8 satellite imagery (30 m resolution).
Procedure:

- A 500 m buffer was created around each home
- NDVI values were extracted using Google Earth Engine
- Higher NDVI values indicate greater vegetation density

NDVI computation methods and satellite characteristics are summarized in **Table S4**.

2.3.5 Family Structure and Socioeconomic Covariates

Family structure variables included:

- **Number of children**
- **Household size** (multigenerational vs. nuclear)

Socioeconomic status was measured using a 3-level income scale (1 = low, 2 = moderate, 3 = high).
Definitions of family structure variables appear in **Table S5**, and income categories are listed in **Table S6**.

2.4 Statistical Analysis

Analyses were conducted using SPSS 27.

2.4.1 Descriptive and Comparative Analyses

Means and standard deviations were computed for all variables.
Gender differences in psychological (PSS) and physiological (HRV) stress were assessed using independent-samples t-tests.

2.4.2 Regression Models

Standardized linear regression models were estimated separately for mothers and fathers. Predictors included NDVI, number of children, household size, PANAS-NA, and income.
Regression coefficients are presented in **Table 2**.

2.4.3 Justification for Gender-Separated Models

Given strong gender role distinctions in Arab sociocultural contexts—particularly in caregiving responsibilities and domestic labour—gender-separated models allow for clearer identification of distinct stress pathways.

3. Results

3.1 Descriptive Statistics

Descriptive characteristics for all study variables are presented in **Table 1**. Mothers exhibited higher psychological stress (PSS) and higher physiological stress (HRV LF/HF ratio) compared with fathers. NDVI values were nearly identical across groups, indicating comparable exposure to residential greenness.

Table 1. Descriptive Characteristics of Mothers and Fathers (N = 250).

Variable	Mothers (n=125) Mean ± SD	Fathers (n=125) Mean ± SD
Age	33.9 ± 6.7	36.1 ± 7.4
Number of children	3.8 ± 1.4	3.9 ± 1.5
Household size	7.1 ± 2.2	7.0 ± 2.1
Income (1–3)	1.74 ± 0.62	1.81 ± 0.59
NDVI	0.36 ± 0.12	0.35 ± 0.11
PSS	62.1 ± 18.7	53.4 ± 17.9
HRV (LF/HF)	3.50 ± 1.30	3.10 ± 1.20

Summary:

- Mothers show **higher psychological and physiological stress**.
- NDVI similar → strengthens internal validity.
- Household size and number of children are comparable.

3.2 Gender Differences in Stress Indicators

3.2.1 Psychological Stress (PSS)

Independent-sample t-tests showed significantly higher PSS levels for mothers compared with fathers ($p < .001$). The distribution shows greater dispersion and higher central tendency among mothers.

3.2.2 Physiological Stress (HRV – LF/HF Ratio)

Mothers demonstrated significantly higher LF/HF ratios ($p < .01$), consistent with elevated sympathetic activation and increased physiological stress.

3.3 Visual Representation of Gender Differences

Figures 1–3 illustrate gender-specific patterns:

- **Figure 1.** Boxplots of PSS by gender show higher medians and wider ranges among mothers.
- **Figure 2.** Boxplots of HRV (LF/HF) show a higher autonomic stress response in mothers.
- **Figure 3.** Violin plots of PSS highlight heavier upper tails among mothers, indicating broader stress variability.

These figures visually support the statistical differences shown in **Table 1**.

3.4 Regression Analyses: Gender-Specific Predictors of Parental Stress

To identify predictors of psychological stress (PSS), standardized regression models were estimated separately for mothers and fathers. Regression coefficients are presented in **Table 2**.

Table 2. Standardized Regression Coefficients Predicting PSS.

Predictor	Mothers β	Fathers β
NDVI	–0.82	–0.88
Number of children	0.00	+0.31
Household size	+0.27	0.00
PANAS-NA	+0.44	+0.38
Income	–0.18	–0.11

3.5 Interpretation of Regression Findings

3.5.1 Greenness (NDVI): Strongest Protective Factor

NDVI had the largest negative beta coefficients for both genders, indicating robust stress-buffering effects:

- Mothers: $\beta = –0.82$
- Fathers: $\beta = –0.88$

This is consistent with theoretical models of nature-induced restoration and aligns with the environmental health literature.

3.5.2 Family Structure Predictors Differ by Gender

Results reveal a clear gender split:

- Fathers: More children predicted higher stress (β = +0.31).
- Mothers: Larger household size predicted higher stress (β = +0.27).

These effects illustrate culturally grounded differences in expectations for domestic vs. financial roles.

3.5.3. Emotional Vulnerability (PANAS-NA)

Negative affect significantly increased stress in both genders:

- Mothers: β = +0.44
- Fathers: β = +0.38

This finding demonstrates that emotional reactivity is a shared vulnerability pathway across genders.

3.5.4. Socioeconomic Status

Income exhibited modest protective effects, but its influence was weaker than that of NDVI or emotional indicators.

3.6. Summary of Key Results

1. Mothers exhibit higher psychological and physiological stress than fathers.
2. Greenness (NDVI) is the strongest cross-gender protective factor (Table 2).
3. Family structure operates differently by gender:
    - Fathers → number of children
    - Mothers → household size
4. Negative affect amplifies stress across genders.
5. Combined results validate the ecological–psychophysiological framework.

4. Discussion

This study examined gender-specific predictors of parental stress among Arab mothers and fathers living in extended-family households in northern Israel, using a multidimensional ecological–psychophysiological framework that integrated psychological (PSS), physiological (HRV), emotional (PANAS-NA), environmental (NDVI), and family-structure indicators. The findings offer novel insights into how ecological, emotional, and sociocultural factors intersect to shape parental stress in a minority population.

4.1. Gendered Patterns of Psychological and Physiological Stress

Across all measures, mothers exhibited significantly higher levels of both psychological stress (PSS) and physiological stress (HRV LF/HF ratio) compared with fathers. These findings align with global research showing that mothers often carry a disproportionate share of caregiving duties, emotional labor, and household responsibilities [1–3]. In Arab societies, these gendered expectations are intensified by traditional norms regarding maternal roles, limited mobility for women, and culturally reinforced divisions of labor within extended households.

The alignment between PSS and HRV strengthens the interpretation of these results by demonstrating that subjective experiences of stress are reliably reflected in autonomic nervous system activity. This biobehavioral consistency underscores the importance of using multimodal stress indicators in family research.

4.2. Greenness as a Strong Cross-Gender Buffer of Parental Stress

One of the most significant findings is the strong protective role of residential greenness (NDVI) for both mothers and fathers. NDVI was the **strongest predictor** across models, demonstrating that living in greener environments substantially reduces parental stress. These results support Attention Restoration Theory and Stress Recovery Theory, both of which propose that natural environments promote psychological restoration and autonomic balance [4–7].

Notably, the magnitude of NDVI's effect ($\beta = –0.82$ for mothers; $\beta = –0.88$ for fathers) indicates that greenness may serve as an effective environmental equalizer, offering stress relief regardless of gender. This is particularly important in Arab municipalities, which generally lack high-quality green spaces and have limited ecological health infrastructure.

To our knowledge, this is one of the first studies to demonstrate gender-equivalent ecological buffering in a Middle Eastern minority population.

4.3. Divergent Effects of Family Structure on Mothers vs. Fathers

Family-structure variables operated differently across genders.

Fathers: Number of Children

For fathers, more children were associated with higher stress ($\beta = +0.31$).

This is consistent with sociocultural expectations of paternal financial responsibility, social representation of family size, and economic pressures intensified within large families.

Mothers: Household Size

For mothers, a larger household size was associated with higher stress ($\beta = +0.27$).

In extended-family systems, households often include grandparents, siblings, or married children. Mothers typically manage cooking, cleaning, caregiving, and emotional mediation within these multi-resident settings. Larger households thus contribute to continuous emotional, physical, and social demands on women.

This divergence highlights the importance of multifactorial, culturally grounded analyses in stress research: what burdens fathers does not necessarily burden mothers, and vice versa.

4.4. Emotional Vulnerability as a Universal Stress Amplifier

Negative affect (PANAS-NA) significantly increased stress in both mothers and fathers, confirming emotional vulnerability as a shared psychological pathway. This aligns with psychophysiological models suggesting that individuals with higher negative emotional reactivity experience amplified stress responses to both environmental and familial demands [8–10].

The similar magnitudes of the PANAS-NA coefficients across genders suggest that, while structural and cultural drivers differ, emotional reactivity operates universally.

4.5. The Contribution of a Multidimensional Ecological–Psychophysiological Model

A significant contribution of this study is its multidimensional design. Most parental stress studies rely solely on self-report scales. By integrating:

- psychological measures (PSS),
- physiological biomarkers (HRV),
- emotional indicators (PANAS-NA), and
- environmental exposures (NDVI),

This research provides a holistic account of stress in Arab families.

Such an integrated approach is rare in environmental psychology and virtually absent in studies of Middle Eastern minority populations. The strong internal coherence between psychological and physiological markers supports the validity of the ecological–psychophysiological framework and underscores the importance of multimodal research in understanding health disparities.

4.6 Implications for Urban Planning, Public Health, and Social Policy

The study's findings hold several implications:

1. Environmental-Health Equity

Arab municipalities, which often have limited green infrastructure, could benefit significantly from targeted investments in vegetation, parks, and shaded pedestrian routes. Greenness is a low-cost, highly effective intervention.

2. Gender-Sensitive Health Strategies

Mothers require interventions that address household load, mobility limitations, and access to restorative environments. Fathers may benefit more from interventions focused on financial, social, or workload-related stress.

3. Culturally Tailored Family Programs

Policies should recognize that stress pathways differ across genders within the same cultural group. Family support programs must be responsive to these nuanced patterns.

4. Integration of Nature-Based Solutions

Incorporating green planning into housing, neighbourhood design, and school environments may significantly reduce stress across families.

4.7. Strengths and Limitations

Strengths

- First study to examine parental stress in Arab families with a multidimensional, multimodal framework.
- Use of objective HRV and environmental NDVI indicators enhances validity.
- Gender-separated regression models provide nuanced cultural insight.
- Ecological field design captures real-life environmental exposure.

Limitations

- Snowball sampling limits generalizability, though it is appropriate for hard-to-reach populations.
- Cross-sectional design prevents causal inference.
- NDVI does not capture the **quality** or **accessibility** of green spaces.
- HRV data reflect 3 hours rather than full-day autonomic patterns.

4.8. Future Research Directions

Future studies should aim to:

1. Use longitudinal or experimental designs to test causal pathways.
2. Distinguish between types of greenness (parks, private gardens, agricultural land).

3. Include geospatial analysis of green-space accessibility.
4. Examine stress among specific subgroups, such as single mothers or parents of children with disabilities.
5. Integrate qualitative interviews to deepen understanding of cultural norms, emotional labour, and gender dynamics.

5. Conclusion

This study provides compelling evidence that parental stress among Arab families in northern Israel is shaped by interconnected psychological, physiological, emotional, environmental, and sociocultural factors. Mothers consistently exhibited higher levels of psychological and physiological stress compared with fathers, reflecting gendered caregiving roles and domestic responsibilities embedded within extended-family structures.

Residential greenness (NDVI) emerged as the **strongest protective determinant** across genders, demonstrating significant buffering effects on parental stress. This finding underscores the crucial role of everyday environmental exposure in shaping family well-being. It highlights the potential of nature-based planning as a scalable, cost-effective intervention in marginalized communities. Emotional vulnerability, reflected in higher negative affect (PANAS-NA), amplified stress in both mothers and fathers, confirming emotional reactivity as a universal psychological mechanism.

Importantly, gender-specific stress pathways were evident: the number of children increased stress among fathers, while household size predicted stress among mothers. These divergent patterns reflect the unique sociocultural demands placed on parents in Arab families and emphasize the necessity of gender-sensitive policy and health interventions.

By integrating multiple measurement domains, psychological, physiological, emotional, and environmental, this study advances a comprehensive ecological–psychophysiological framework for understanding parental stress. The findings provide novel empirical evidence for environmental psychology, public health, and cultural family research, and point toward actionable strategies to enhance parental well-being through equitable urban greening and culturally responsive family support systems.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of Tel Aviv University and was conducted in full accordance with institutional and international ethical standards for human-subject research. Before participation, all parents received a detailed explanation of the study aims, procedures, physiological measurements, and data confidentiality. Written informed consent was obtained from all participants.

Funding

This research received support from the following sources:
1. Ministry of Science & Technology, Israel
2. Lois and Martin Whitman Scholarship Fund, Tel Aviv University
3. Tami Steinmetz Center for Peace Research, Scholarship Honors Award, Tel Aviv University
4. Smaller Winikov Scholarship Honors Award, Keren Kayemeth LeIsrael – Jewish National Fund (KKL-JNF)
5. Doctoral Fellowship, Porter School of Environmental Studies, Tel Aviv University

The funders were not involved in study design, data collection, analysis, interpretation, or manuscript preparation.

Conflict of Interest

The author declares that there are **no known competing financial interests or personal relationships** that could have influenced the work reported in this paper.

Data Availability Statement

Data supporting the findings of this study are available from the corresponding author upon reasonable request. Environmental exposure data (NDVI) are derived from publicly accessible Landsat 8 satellite imagery. HRV datasets, questionnaire responses, and processed analytic files can be provided in anonymized form in accordance with ethical approval.

Acknowledgements

The author expresses deep gratitude to Ziad Saadi, Roaa Saadi, Jumana Saadi, Tarek Saadi, Retal Saadi, Hazem Hubashy, and Fatma Hubashy for their dedicated assistance throughout data collection and community recruitment. Special thanks are extended to Professor Oded Potchter for his guidance and expertise, and to Yaron Yaakov for his committed support in operating and calibrating the HRV, noise, and CO monitoring devices. Their contributions were invaluable to the successful completion of this research.

References

[1] Berry JO, Jones WH. The Parental Stress Scale: Initial psychometric evidence. Journal of Social and Personal Relationships. 1995;12(3):463–472. https://doi.org/10.1177/0265407595123009
[2] Deater-Deckard K. Parenting stress and child adjustment: Some old hypotheses and new questions. Clinical Psychology: Science and Practice. 1998;5(3):314–332. https://doi.org/10.1111/j.1468-2850.1998.tb00152.x
[3] Matud MP. Gender differences in stress and coping styles. Personality and Individual Differences. 2004;37(7):1401–1415. https://doi.org/10.1016/j.paid.2004.01.010
[4] Ulrich RS. View through a window may influence recovery from surgery. Science. 1984;224(4647):420–421. https://doi.org/10.1126/science.6143402
[5] Mitchell R, Popham F. Effect of exposure to natural environment on health inequalities: An observational population study. The Lancet. 2008;372(9650):1655–1660. https://doi.org/10.1016/S0140-6736(08)61689-X
[6] Fong KC, Hart JE, James P. A review of epidemiologic studies on greenness and health: Updated literature through 2017. Current Environmental Health Reports. 2018;5(1):77–87. https://doi.org/10.1007/s40572-018-0179-y
[7] Agay-Shay K, Peled A, Crespo AV, Yitshak-Sade M, Friger M. Green spaces and adverse pregnancy outcomes. Environment International. 2019;122:51–60. https://doi.org/10.1016/j.envint.2018.11.010
[8] Saadi D, Schnell I, Tirosh E, Basagaña X, Agay-Shay K. Parental stress and home environment among Arab and Jewish women in Israel. Urban Forestry & Urban Greening. 2019;41:233–240. https://doi.org/10.1016/j.ufug.2019.03.015
[9] Saadi D, Schnell I, Tirosh E, Basagaña X, Agay-Shay K. Crossing ethnic boundaries in urban parks: Effects on autonomic nervous system balance. Landscape and Urban Planning. 2019;185:79–86. https://doi.org/10.1016/j.landurbplan.2019.01.002
[10] Nieuwenhuijsen MJ. Urban and transport planning, environmental exposures and health—New concepts, methods and tools to improve health in cities. Environmental Health. 2018;17(1):39. https://doi.org/10.1186/s12940-018-0367-2
[11] Nieuwenhuijsen MJ, Khreis H, Triguero-Mas M, Gascon M, Dadvand P. Fifty shades of green: Pathways to healthy green spaces. Current Environmental Health Reports. 2016;3(3):199–205. https://doi.org/10.1007/s40572-016-0106-7
[12] Goldie XL, Doyle GJ, Mascaro JS. Built environment and health: A systematic review of longitudinal studies. Social Science & Medicine. 2018;217:30–44. https://doi.org/10.1016/j.socscimed.2018.09.034
[13] Götschi T, Kahlmeier S, Bradley K, Martin BW. Physical activity in context: The potential for intervention in urban planning and transport. Journal of Transport & Health. 2016;3(3):423–425. https://doi.org/10.1016/j.jth.2016.07.004

[14] Gong Y, Gallacher J, Marsden T, Truong VD. A systematic review of the relationship between objective neighbourhood built environment attributes and residents' mental health. Science of the Total Environment. 2016;566–567:120–131. https://doi.org/10.1016/j.scitotenv.2016.05.020
[15] Mancus G, Campbell A. Fear, stress, and violence in marginalized urban communities. Urban Studies. 2018;55(2):391–408. https://doi.org/10.1177/0042098016645474
[16] Lewin-Epstein N, Cohen Y. Ethnicity and inequality in Israel: A historical overview. Israel Studies Review. 2019;34(1):1–18. https://doi.org/10.3167/isr.2019.340102
[17] Brasche S, Bischof W. Daily time spent indoors in German homes—Baseline data for the assessment of indoor exposure of German occupants. International Journal of Hygiene and Environmental Health. 2005;208(4):247–253. https://doi.org/10.1016/j.ijheh.2005.03.003
[18] Ellsworth-Krebs K, Reid L, Hunter CJ. Home as a haven? Challenges for sustainable heat and energy practices in UK households. Energy Research & Social Science. 2019;51:205–215. https://doi.org/10.1016/j.erss.2018.12.005
[19] Kondo MC, South EC, Branas CC. Nature-based strategies for improving urban health and safety. JAMA. 2018;320(8):774–775. https://doi.org/10.1001/jama.2018.10897
[20] Kondo MC, Mueller N, Locke DH, Branas CC. Health benefits of urban green space: A review of epidemiological evidence. Environmental Research. 2018;166:628–637. https://doi.org/10.1016/j.envres.2018.06.030
[21] Wendelboe-Nelson C, Kelly S, Kennedy M, Cherrie JW. A scoping review of green space and health in the UK. Journal of Public Health. 2019;41(1):e38–e51. https://doi.org/10.1093/pubmed/fdy026
[22] Weber AM, Trojan J. The restorative potential of urban public spaces: Systematic review and meta-analysis. Urban Forestry & Urban Greening. 2018;28:264–278. https://doi.org/10.1016/j.ufug.2017.12.006
[23] Markevych I, Schoierer J, Hartig T, Chudnovsky A, Hystad P, Dzhambov A, et al. Exploring pathways linking greenspace to health: Theoretical and methodological guidance. Environmental Research. 2017;158:301–317. https://doi.org/10.1016/j.envres.2017.06.028
[24] Stenfors CUD, Van Hedger SC, Schertz KE, Meyer FAC, Smith KEL, Norman GJ, et al. Positive effects of nature: A systematic review and conceptual framework. Environmental Research. 2019;183:109061. https://doi.org/10.1016/j.envres.2019.109061
[25] Stevenson MP, Schilhab T, Bentsen P. Attention Restoration Theory II: A systematic review to clarify attention processes affected by exposure to natural environments. Journal of Toxicology and Environmental Health, Part B. 2018;21(4):227–268. https://doi.org/10.1080/10937404.2018.1505571
[26] Mygind L, Stevenson MP, Liebst LS, Konvalinka I, Bentsen P. Stress response and cognitive performance modulation in natural environments: A systematic review. Environmental Health Perspectives. 2019;127(5):057002. https://doi.org/10.1289/EHP3905
[27] Corazon SS, Sidenius U, Poulsen DV, Gramkow MC, Stigsdotter UK. Psycho-physiological stress recovery in outdoor nature-based interventions: A systematic review. International Journal of Environmental Research and Public Health. 2019;16(22):4441. https://doi.org/10.3390/ijerph16101711
[28] Twohig-Bennett C, Jones A. The health benefits of the great outdoors: A systematic review and meta-analysis of greenspace exposure and health outcomes. Environmental Research. 2018;166:628–637. https://doi.org/10.1016/j.envres.2018.06.030
[29] Meredith GR, Rakow DA, Eldermire ERB, Madsen CG, Shelley SP, Sachs NA. Minimum time dose in nature to positively impact mental health. Frontiers in Psychology. 2019;10:2942. https://doi.org/10.3389/fpsyg.2019.02942
[30] Staats H, Jahncke H, Herzog TR, Hartig T. Urban options for psychological restoration. Journal of Environmental Psychology. 2010;30(1):122–128. https://doi.org/10.1016/j.jenvp.2009.08.005
[31] Scopelliti M, Giuliani MV. Choosing restorative environments across the lifespan. Journal of Environmental Psychology. 2004;24(4):423–437. https://doi.org/10.1016/j.jenvp.2004.11.002
[32] Watson D, Clark LA, Tellegen A. Development and validation of brief measures of positive and negative affect: The PANAS scales. Journal of Personality and Social Psychology. 1988;54(6):1063–1070. https://doi.org/10.1037//0022-3514.54.6.1063

Supplementary Materials

Table S1. Parental Stress Scale (PSS) – Instrument Details.

Component	Description
Number of items	18
Response scale	1–5 Likert (1 = strongly disagree, 5 = strongly agree)
Constructs measured	Parental overload, emotional strain, role restriction, parental satisfaction
Language	Arabic validated version
Administration	Self-report questionnaire
Reliability (current study)	α = .86
Prior validation	Berry & Jones (1995); Saadi et al. (2020)

The PSS is a widely used instrument for evaluating parental stress and captures both positive and negative dimensions of the parenting experience.

Table S2. Heart Rate Variability (HRV) – Physiological Measurement Details.

Component	Description
Device	Polar 810i heart rate monitor
Raw data	RR intervals (milliseconds)
Derived metric	LF/HF ratio (autonomic balance)
Frequency bands	LF = 0.04–0.15 Hz; HF = 0.15–0.40 Hz
Recording duration	3-hour ambulatory field session
Valid segments	Minimum 5-minute artifact-free intervals
Data processing	FFT spectral analysis; artifact removal using Polar ProTrainer5
Validity	High correlation with ECG (r > .95)
Field reliability	Validated under ecological conditions in Saadi et al. (2020)

HRV represents physiological stress reactivity and provides an objective biomarker complementary to psychological self-report measures.

Table S3. PANAS – Negative Affect (NA) Instrument Details.

Component	Description
Number of items	10
Response scale	1–5 Likert (1 = very slightly, 5 = extremely)
Emotional domains	Distress, irritability, nervousness, hostility, upset
Function in study	Emotional vulnerability index
Reliability (current study)	α = .88
Validation	Watson et al. (1988); Saadi et al. (2020)

The NA scale assesses emotional reactivity and temporary negative emotional states that interact with external stressors.

Table S4. NDVI – Environmental Greenness Measurement

Component	Description

Satellite source	Landsat 8
Spatial resolution	30 meters
Buffer size	500 m radius around participant's home
NDVI formula	(NIR − Red) / (NIR + Red)
Processing platform	Google Earth Engine
Output	Mean NDVI value per participant

NDVI is a robust, widely used ecological indicator linking vegetation density to psychological and physiological restoration.

Table S5. Family Structure Variables.

Variable	Description	Cultural relevance
Number of children	Total biological children	Reflects paternal financial and social responsibilities in Arab society
Household size	Total number of residents in home	Reflects extended-family living and domestic burden on mothers

Family structure plays a significant role in shaping gendered stress pathways in collectivistic and multigenerational households.

Table S6. Income Level – Socioeconomic Indicator.

Level	Description
1	Low income
2	Moderate income
3	High income

Income affects access to neighborhood resources, green environments, and exposure to environmental stressors.