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Association Between Green Space Exposure and Depressive Symptoms in Adolescents: A Systematic Review

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Abstract. Adolescent depression has become a growing global public health problem. Although existing research suggests that urban green spaces have a positive effect on mental health, most studies have been conducted with adults or older adults. As a vulnerable group at a critical developmental stage, adolescents may exhibit different psychological responses to green space exposure in their residential environments, necessitating in-depth exploration. Focusing on the relationship between green space exposure and depressive symptoms among adolescents aged 13-19 years, this review synthesizes cohort studies, cross-sectional surveys, and systematic reviews published between January 2019 and July 2025, analyzing the effects of variables including green space distribution, accessibility, and frequency of use. Findings suggest that greater access to green spaces in adolescents is generally associated with reduced depressive symptoms, an effect that may be realized through stress moderation and enhanced social support. However, existing studies differ in design, measurement tools, and control of confounders, limiting the generalizability of findings. Notably, the dose-response relationship between green space exposure and depressive symptoms remains largely unexplored. Future studies should standardize green space exposure assessments, explore dose-response relationships, and focus on cultural and socioeconomic factors to guide mental health interventions and urban greening planning.

Keywords: Adolescent mental health, Green space exposure, Depressive symptoms, Environmental intervention, Social determinants of health

1. Introduction

In recent years, the mental health of adolescents has become a global public health priority. Depressive symptoms, one of the most common psychological problems among adolescents, have shown a continuous upward trend, particularly during the COVID-19 pandemic, when the global prevalence of depressive symptoms for adolescents reached 23.8%, seriously affecting their academic performance, interpersonal relationships and overall well-being [1]. Existing studies have confirmed that environmental factors, especially natural elements in urban living environments such as green spaces and parks, play an important role in promoting mental health [2]. However, most current research focuses on adults or older adults, with few studies specifically targeting adolescents aged 13–19 years through multidimensional green space metrics [3]. This research gap is

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particularly important because adolescents are at a critical stage in their development when they are more emotionally sensitive and more susceptible to environmental influences.

Moreover, existing studies predominantly rely on unidimensional measures of green space exposure (e.g., coverage or area), with insufficient attention to key indicators like quality, perceived accessibility, and actual usage frequency [4]. Meanwhile, differences in study design, measurement tools and cultural contexts, as well as insufficient control for socio-economic confounders, limit the comparability and generalizability of findings [3,4]. The present study aimed to fill these gaps by exploring the relationship between green space exposure and depressive symptoms among adolescents aged 13-19 years. A systematic review approach was used to synthesize and analyze cohort studies, cross-sectional surveys, and systematic reviews published over the past six years to assess the associations between multidimensional indicators of green space exposure and depressive symptoms in adolescents. This review examines not only green space quantity but also accessibility, usage frequency, and subjective perceptions, aiming to facilitate a shift from quantity-oriented to quality-focused environmental interventions. The findings will support an interdisciplinary research framework for adolescent mental health promotion and inform urban planning and public health policymaking that prioritizes mental health.

2. Methods

2.1. Literature search strategy

This systematic review followed PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency and reproducibility. Literature searches were conducted in July 2025 across four databases: PubMed, Web of Science, Scopus, and PsycINFO, covering studies published between January 2019 and July 2025. This time frame was selected to capture recent research developments following increased attention to adolescent mental health and urban environmental interventions, especially in the context of post-COVID-19 recovery. The following combination of keywords was applied: (adolescent OR teenager OR youth) AND (green space OR urban green OR park OR natural environment) AND (depression OR depressive symptoms OR mental health). After removing duplicates, a total of 147 articles were identified. These underwent a two-phase screening process: title/abstract review followed by full-text assessment. Ultimately, 10 studies met the eligibility criteria and were included in the final analysis. As shown in Figure 1, the PRISMA flow diagram illustrates the literature selection process, including the number of studies identified, screened, assessed for eligibility, and ultimately included in the systematic review.

2.2. Inclusion and exclusion criteria

Inclusion criteria:

• Study population aged 13–19 years. While the WHO defines adolescence as the period from 10 to 19 years, this review focuses on individuals aged 13–19 years, corresponding to mid-to-late adolescence, when depressive symptoms are more prevalent and more frequently studied in the literature;

• Examined green space exposure (e.g., NDVI, coverage ratio, proximity, accessibility, quality, usage frequency, or subjective perception) as the independent variable;

• Reported depressive symptoms or related mental health outcomes as dependent variables.

• Used cohort, cross-sectional, or systematic review designs;

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• Published in peer-reviewed English-language journals. Gray literature (e.g., dissertations, theses, and government reports) was excluded to ensure methodological rigor and peer-review standards, though this may introduce potential publication bias;

Exclusion criteria:

• Studies not including adolescents or unable to extract separate adolescent data;

• Intervention studies focusing only on indoor nature exposure (e.g., house plants);

• Did not report depression or mental health outcomes;

• Studies that did not adequately control for key confounding variables, such as baseline depression levels, socioeconomic status, or parental mental health, which may significantly bias the relationship between green space exposure and depressive outcomes;

2.3. Screening and data extraction

All retrieved records were imported into Zotero for deduplication. The reviewer independently screened titles and abstracts against inclusion criteria. Full texts were reviewed for final inclusion.

Data extraction included:

• Author(s), publication year, country/region;

• Study design, sample size, participant age range;

• Green space exposure measurement method (e.g., NDVI, coverage ratio, distance, accessibility, quality, usage frequency);

• Depression assessment tool (e.g., CES-D, adolescent PHQ-9);

• Controlled confounders (e.g., household income, parental education, ethnicity);

• Main findings and conclusions;

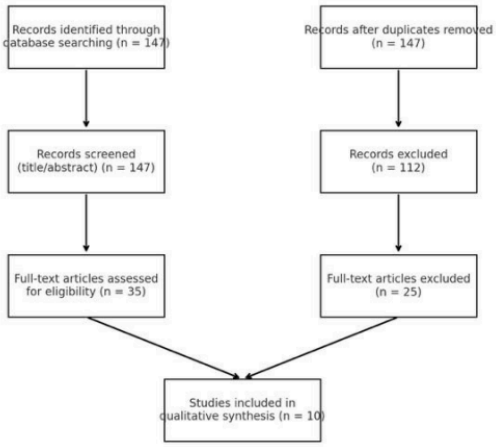

Figure 1. PRISMA flow diagram showing the selection process of studies included in the review

3. Green space exposure: dimensions and measurement approaches

3.1. Spatial distribution

Common measurement methods included NDVI (Normalized Difference Vegetation Index), green space coverage ratio, and proximity-based metrics (e.g., distance to nearest park). Geospatial analyses frequently examined neighborhood green space distribution in relation to mental health outcomes. However, the definition of “nearby” varied widely across studies and countries, ranging from 300 meters to 1 kilometer, affecting comparability and introducing systematic bias due to

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differing urban densities [2,3,4]. For example, a 500-meter buffer may include many parks in suburban areas but little greenery in dense cities, leading to inconsistent estimates of green space benefits across regions. This lack of standardization complicates interpretation, particularly when generalizing findings to diverse socio-ecological contexts. NDVI is valuable as it offers objective and quantifiable statistics regarding green space coverage. These methodologies are particularly advantageous for extensive or cross-regional studies, as they enable researchers to evaluate vegetation levels across diverse areas utilizing uniform data. Nonetheless, a significant disadvantage is that various research defines "nearby" green space in disparate manners. Some utilize 300 meters, while others employ 500 meters or even 1 kilometer. The varied distance standards hinder the comparability of outcomes among investigations. The impact of green space on mental health outcomes, such as depression, may vary in strength based on the definition of "nearby."

3.2. Accessibility and availability

Accessibility was typically evaluated using walking or cycling distances, transportation availability, and built environment connectivity. Neighborhood safety concerns, restrictive gender norms, and parental supervision frequently constrained adolescents' utilization of accessible green spaces. Furthermore, equity issues were prominent, as adolescents from lower socioeconomic backgrounds faced restricted access to quality green spaces, exacerbating health disparities [5-7]. In addition to structural indicators, social barriers, such as neighborhood safety concerns, restrictive gender norms, and parental supervision, frequently constrained adolescents' actual use of green spaces. Thus, although spatial accessibility metrics effectively identify physical disparities, they may overestimate real access unless social and psychological barriers are considered.

3.3. Usage frequency and perception

In addition to accessibility, actual frequency of use and subjective perception are key dimensions in determining the health benefits of green spaces. Green space use was generally measured through self-reported frequency and duration. Crucially, perceived quality factors, such as presence of activity facilities, safety, and cleanliness, strongly influenced actual usage [8]. There was often a mismatch between objective availability and subjective perception; green spaces might exist nearby but remain underutilized due to negative perceptions or social barriers [4,8]. However, reliance on self-reported data introduces recall bias and social desirability bias, especially among adolescents. Recall bias may arise when participants inaccurately remember how often or how long they used green space. Social desirability bias may prompt adolescents to overreport usage to conform to perceived researcher or peer expectations. The diversity of measurement instruments and inconsistent definitions of “use” further hinder cross study comparisons.

4. Measuring adolescent depression and associated risks

Assessment Tools for Depressive Symptoms: Common scales included the CES-D and adolescent versions of PHQ-9. Cross-sectional studies tended to employ brief screening tools for depressive symptoms prevalence, while cohort studies used more rigorous diagnostic criteria or repeated measures to examine changes over time [4-6]. These tools are widely adopted for their simplicity, cost-effectiveness, and robust psychometric properties, making them particularly suitable for large-scale surveys and population-level screening.". Self-report questionnaires are subject to recall bias

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and social desirability bias, particularly among adolescents. Brief screeners may not capture the full spectrum of depressive symptoms or account for fluctuations over time.

Social Determinants and Confounder Control: Beyond measurement issues, the influence of social determinants must be rigorously accounted for to isolate the effect of green space on depression. Key confounders included household income, parental education, ethnicity, and cultural background. Other influential factors were social support networks, school-related stress, and residential environmental quality [5,7,9]. However, literature review revealed inconsistent control of these variables, complicating causal inference and potentially biasing effect estimates [4-6].

5. Synthesis of current evidence on green space and adolescent depression

5.1. Findings from cross-sectional studies

Cross-sectional studies consistently report inverse associations between adolescent green space exposure and depressive symptoms, suggesting potential mental health benefits. For example, one systematic review of 14 observational studies found that higher residential greenness, measured via NDVI, was associated with lower levels of stress, fewer depressive symptoms, and improved emotional well-being in youth [4].

Notably, the strength of this association varied by region and cultural context. European studies generally reported stronger benefits, potentially due to higher baseline access to public parks and green infrastructure, while North American findings showed more heterogeneity, possibly reflecting socioeconomic disparities and urban design differences [4,10]. In many Asian and Latin American urban environments, where dense urban layouts limit green coverage, adolescents cited perceived safety and inadequate maintenance as major barriers, suggesting that objective availability does not always translate to perceived usability [4,10]. However, cross-sectional designs inherently limit causal inferences. Reverse causality remains a concern; adolescents with depressive symptoms may avoid green spaces, potentially attenuating observed exposure levels. Moreover, inconsistent cultural definitions of “green space,” such as informal green corridors, schoolyard greenery, or private gardens, hinder cross-study comparability and obscure localized interpretations of accessibility and benefit.

5.2. Evidence from cohort studies and systematic reviews

Cohort studies provide stronger causal evidence, indicating green space exposure may buffer depressive symptom onset and progression. In one U.S. prospective cohort, higher residential greenness during adolescence predicted significantly lower incidence of depressive symptoms in later adolescence, even after adjusting for socioeconomic and family factors [11]. Gender-stratified analyses indicated that the protective effect was especially pronounced among girls, potentially due to greater social use of neighborhood spaces.

Another recent cohort study in the United States, using NDVI within 300–800 m residential buffers, found that adolescents with moderate to high-quality greenness had a 15–20% reduced risk of new-onset depression over two years [5]. Systematic reviews have synthesized these findings, highlighting consistent evidence of reduced depressive symptoms and improved well-being among adolescents with higher green space exposure across contexts [4,12]. A crucial limitation remains methodological heterogeneity—differences in how greenness is quantified, variation in follow-up durations (ranging from 1 to 5 years), and inconsistent adjustment for key confounding variables.

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These factors preclude strong causal claims, though emerging narrative evidence supports a buffering or preventative role of green spaces in adolescent mental health.

6. Implications for public health and urban planning

6.1. A public health-oriented perspective in urban design

The findings highlight the imperative to integrate mental health promotion into urban planning through the development of safe, inclusive, and socially engaging green spaces tailored for adolescents. Designing environments that integrate nature access within adolescents' daily routines can foster resilience and emotional well-being [2]. In addition to behavioral effects, green space exposure may benefit mental health through biological pathways. Studies suggest it reduces stress-related brain activity, lowers cortisol levels via HPA axis regulation, and improves immune balance. Green environments have also been linked to better sleep and reduced inflammation, all contributing to lower risks of depression and anxiety [13,14].

6.2. Policy recommendations for adolescent-focused interventions

Key policy interventions should prioritize green space infrastructure within 300–500 meters of schools, an evidence-based threshold proven to enhance youth accessibility and utilization frequency [7]. Additionally, integrating nature-based healing and therapeutic activities into community youth mental health programs can enhance psychological well-being. It is also essential to prioritize equitable access to quality green spaces for vulnerable groups, addressing socioeconomic and neighborhood disparities to reduce health inequities.

A recent systematic review found that school-led greenspace interventions, such as outdoor classrooms, green schoolyards, and campus gardening projects, had positive impacts on adolescents' emotional well-being, peer interactions, and levels of physical activity [15]. Notably, programs that actively involved students in the design, planning, and ongoing use of green spaces were more effective, suggesting that youth engagement is a key component of successful interventions. Future research must establish standardized metrics for green space exposure, incorporating operationalized definitions of both spatial proximity and qualitative attributes. Employing longitudinal and experimental designs will strengthen causal inference, while cross-cultural validation studies can improve generalizability. Additionally, incorporating equity-focused analyses is essential to address structural determinants of health disparities.

7. Conclusion

This systematic review examined the relationship between green space exposure and depressive symptoms among adolescents. Overall, findings indicate that greater exposure to green spaces is associated with better mental health outcomes, particularly through mechanisms such as stress reduction, emotional regulation, and enhanced social interactions. Dimensions including accessibility, frequency of use, and subjective perception significantly influenced depressive symptoms in youth populations. However, the current literature is limited by a lack of standardized tools to measure green space exposure, inconsistent control of confounding variables such as family income and neighborhood safety, and a disconnection between objective green space indicators and adolescents' subjective experiences. Future research should employ longitudinal and mixed methods designs to enhance causal inference and contextual comprehension, so addressing these constraints. Creating standardized instruments to evaluate the quality and utilization of green spaces among

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communities is crucial. Furthermore, cross-cultural studies are essential to assess generalizability across varied socioeconomic and geographic contexts. Examining how teenagers' subjective experiences, including their perceptions of safety and belonging, connect with the utilization of green spaces will elucidate the underlying mechanisms. Translating these findings into implementable urban design techniques is essential for developing adolescent-friendly environments that enhance mental health and well-being.

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