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Residential Reach and Routine Contact in Youth Greenspace Access: Evidence from Amsterdam, Rotterdam and The Hague

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Abstract

Urban greenspace access measures are often based on residential walking distance despite the fact that children and teenagers interact with their urban environment in school, college, university, and via travel routes. This paper analyzes whether residential reach to public greenspace amenities in Amsterdam, Rotterdam, and The Hague is translated into educational and travel-related contacts for youth. The analysis is based on access quantities for 848 publicly accessible greenspaces including 398 in Amsterdam, 281 in Rotterdam and 169 in The Hague. The data source differentiates children between the ages of 0 and 14 years old and adolescents between the ages of 15 and 24 years old and includes the following categories: residence-based walksheds, education-based walksheds, modeled commute entry, commute-distance exposure, dispersion values, and Spearman rank associations. To investigate the degree to which residential access is translated into contact with greenspaces, we compare three approaches, namely residence proximity, nearby educational institutions, and travel through greenspaces to access educational institutions. The increase of the walking distance from 300 m to 800 m leads to approximately a five-fold increase of mean residential access for residents, children, and adolescents. However, this larger distance does not translate into similar levels of exposure. An 800 m walking distance results in the average greenspace being accessible for 1203.6 children and 937.3 adolescents. On the other hand, there is an average of only 2.0 child-oriented and 1.1 adolescent-oriented educational institutions within 800 m. The modeled commute entry drops to 68.7 children and 34.6 adolescents per greenspace. Adjusting for resident-accessible youth, the commute entry rate for adolescents is 35.33% less than for children. Commute entries of adolescents are also extremely concentrated. Their coefficient of variation is 4.36 and maximum to mean is 66.10. These findings show that residential reach can be successfully applied for the identification of young residents near greenspace amenities, but not for youth exposure, particularly in adolescent learning routes. Monitoring of municipal exposure to greenspaces should separate residential, educational, and route-based exposures.

Keywords: youth greenspace access; residential proximity; school travel; pedestrian networks; activity space; adolescent mobility; Dutch cities

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1. Introduction

Greenspace has emerged as a core feature in health-oriented planning due to its ability to encourage physical activity, provide psychological restorative experience, promote social interaction and create a healthy environment. Youth are a specific audience for whom all these attributes of greenspace are applicable since youth interact with the outdoor environment as part of learning, playing and socially developing processes. Research indicates that there are connections between greenspace access and cognitive abilities among schoolchildren, physical activity, mental health and general youth health status. There is an understanding that the relationship between greenspace and various health indicators depends on how exposure is defined, the age of the individuals, the qualities of greenspaces and the urban setting [1, 3, 5, 20, 24, 27]. As a result, planning for youth needs not just to establish whether a city offers greenspace but also if youth are able to encounter it in the locations and routes they use.

While residential proximity remains the standard metric for greenspace exposure, it has both advantages and drawbacks in the youth setting. Residences are relatively stable parts of urban life and can easily be counted from population grid cells. Moreover, a distance measure is intuitive and can be communicated using simple standards like 300, 500 and 800 m radius. However, residential proximity is unable to represent all the locations where youth interact with their environment. A young individual may live nearby one greenspace, but learn nearby another. An adolescent may live in 800 m pedestrian walking distance from a greenspace but travel daily through routes where the greenspace is unavailable or inaccessible. This problem known as the uncertain geographic context problem implies that the residential environment does not always correspond to actual exposure locations [11]. Activity space analysis reveals the same pattern: the concept that health-related exposure includes not only home but also other regular destinations and routes [9, 17, 18].

This aspect is significant for youth planning, which requires taking into account the contribution of educational institutions into daily movement patterns. While primary schools tend to be more dispersed in residential settings, higher-level schools tend to concentrate into fewer but larger clusters and thus create different reach zones. Thus, while the same greenspace located near a residential cluster will be effective for younger students, an identical greenspace in a different area near a secondary school can be more relevant. According to public health research, multiple channels can connect greenspace and health, ranging from the process of restoration, capacity building to harm prevention [8, 13, 15, 23]. These channels imply contact, and not just proximity measured in terms of buffers. Accessibility studies suggest that accessibility may be estimated based not only on buffer proximity but on the combination of multiple factors including distance, the structure of the street network, entrance options, attractiveness and opportunity for cumulative contact [7, 12, 21, 25].

This study examines the difference between residential proximity and routine greenspace contact in three Dutch cities and aims at establishing whether residential proximity corresponds to education- and movement-related exposure for children and adolescents. The question raised here is important for planning purposes since if residential reach is a sufficient measure for greenspace exposure for youth, this information will allow planners to use a simple standard to monitor greenspace availability. Otherwise, it will mean that residential, educational destination and greenspace route contact need to be evaluated separately.

2. Literature background

2.1. Residential proximity and exposure uncertainty

Access estimation in residential greenspace studies commonly involves the usage of buffers or reachable area measurements. These metrics are convenient when the focus of planning is local availability around the home. However, they do not necessarily describe exposure to greenspace across daily activities in a city. Modifiable areal unit problem demonstrates the importance of proper area definition [16]. The problem of uncertain geographic context expands this approach and questions whether the spatial context chosen by the researcher reflects the one that is relevant to the object under analysis [11]. For youth greenspace planning, the residential context is merely one of the multiple ones.

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The importance of moving away from purely residential context and towards dynamic exposure assessments is also confirmed in literature. Perchoux et al. propose the idea that daily mobility needs to be considered when calculating environmental exposure in health research [17]. Helbich stresses the distortion caused by static residential zones in mental health exposure studies [9]. Roberts and Helbich demonstrate the value of mobile tracking for revealing daily routes as opposed to residential locations [18]. These works call for the reconsideration of residential-centric approach towards estimating greenspace exposure of youth.

2.2. Youth mobility and educational geography

Educational facilities are not mere dots on a map but locations that organize daily life, limit mobility decisions and offer multiple exposure opportunities. Individuals aged 0-14 often go to nearby primary schools, whereas 15-24 individuals need to go farther to secondary schools and higher level of education. This age difference implies that the same greenspace system operates for different age groups in the same way.

Previous literature on greenspace and youth health outcomes supports this idea. Dadvand et al. found an association between greenness and cognitive ability among primary schoolchildren [5]. Almanza et al. used GPS and accelerometer data to evaluate the impact of community greenness on physical activity of children [1]. Several review papers on youth mental health and cognitive development highlight the importance of access, use, quality and age-specific exposure for understanding greenspace effects [20, 24, 27]. All these aspects call for the study that distinguishes residential proximity from education- and mobility-related greenspace contact.

2.3. Pedestrian network and route-based contact

A network approach to measuring access allows considering more accurately the conditions of walking, which are determined by street network, obstacles, and entrances. The comparison of various approaches to the estimation of park access based on GIS shows that choices made by researchers may significantly affect the results [25]. A similar pattern emerges in literature on green-blue spaces and health outcomes [12]. This suggests that there are gaps between greenspaces reachable by foot and ones integrated into actual youth movement.

Such an integration becomes important for analysing greenspaces related to school attendance. Betweenness centrality measures the share of edges lying between pairs of points in a graph [6]. More recent approaches for pedestrian flows modeling take into consideration weighted origins and destinations, distance decay effects and tolerances for detours [14, 19]. Finally, mental health has been shown to positively correlate with active commuting through natural environments [28]. Taken together, these aspects point out to the importance of separating destination access and route contact in youth greenspace planning.

3. Study setting and analytical procedure

3.1. Urban sample and access quantities

The paper uses aggregated access measures for 848 publicly accessible greenspaces of Amsterdam, Rotterdam and The Hague. The numbers of greenspaces per city are 398 for Amsterdam, 281 for Rotterdam and 169 for The Hague [22]. For children, age groups are 0-14 years; for adolescents – 15-24 years. Residential reach is estimated from a grid of 100 m × 100 m cells. Education reach is split into 559 schools of children and 362 institutions for adolescents including secondary schools, colleges and universities. Greenspaces smaller than 0.5 ha are discarded, and connected to the pedestrian network.

Three channels of access are estimated. The first one (residence) estimates people who live in a certain pedestrian radius from the greenspace. The second (education) counts institutions related to the relevant age group and falling within the same pedestrian radius. The last channel (travel) counts number of traversers of the greenspace while travelling from a residential cell to an institution, as well as the total distance covered inside greenspaces while traveling. Walking radii are 300, 500 and 800 m representing different levels of pedestrian reach. Descriptive statistics and rank correlation coefficients are used for analyzing access.

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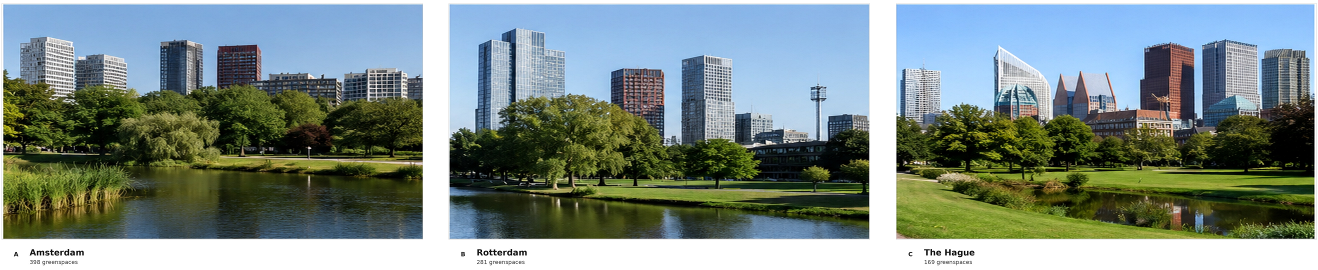

Figure 1. Urban greenspace inventory.

The city inventory in Figure 1 anchors the analysis in the actual metropolitan sample rather than in an abstract accessibility diagram. Amsterdam contributes the largest share of greenspaces, followed by Rotterdam and The Hague. The photographic city views also make clear why the same greenspace can be evaluated through different daily settings: each space sits within a built environment that contains residences, learning destinations and walking corridors.

Table 1. Access record.

Measure	Unit	Radius	Mean	Std. dev.	Maximum
All-age residence	people	300 m	1524.5	1878.7	16605
All-age residence	people	500 m	3498.3	3872.3	31810
All-age residence	people	800 m	7763.3	7635.3	58110
Child residence	people	300 m	240.2	308.6	2240
Child residence	people	500 m	546.0	615.2	4630
Child residence	people	800 m	1203.6	1185.1	9215
Adolescent residence	people	300 m	177.6	251.9	2055
Adolescent residence	people	500 m	418.4	520.8	3730
Adolescent residence	people	800 m	937.3	1030.8	6715
Child education	facilities	300 m	0.4	0.7	4
Child education	facilities	500 m	0.8	1.3	10
Child education	facilities	800 m	2.0	2.3	16
Adolescent education	facilities	300 m	0.2	0.7	7
Adolescent education	facilities	500 m	0.5	1.2	11
Adolescent education	facilities	800 m	1.1	2.1	16
Child commute entry	people entering	800 m	68.7	199.4	2322
Adolescent commute entry	people entering	800 m	34.6	150.8	2287
Child commute-distance	people × metres	800 m	11250.6	33024.6	387594
Adolescent commute-distance	people × metres	800 m	5772.3	25180.7	316204

As shown by the access record presented in Table 1, there are large variations between access values across the three channels in terms of unit and scale. While residential values can go up to hundreds or thousands of people per greenspace, the education values tend to be around 1 or 2 facilities per greenspace at the 800 m radius. The travel values are between the above scales in the entries but large on the commute-distance channel since each traverser will be multiplied by the distance in metres covered in greenspace. Therefore, direct comparison should only be performed after the values have been transformed into age-related yield and concentration metrics.

3.2. Routine contact analysis

In the first step of routine contact analysis, radius enlargement should be calculated using the formula,

$$A_m = \frac{\mu_{m,800}}{\mu_{m,300}}, \tag{1}$$

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where m stands for the type of access channel and μ for the average access value per greenspace. This coefficient measures the strength of the access effect from the enlargement of the walking radius from 300 to 800 m. High values indicate that the enlarged radius covers many people or facilities that would not otherwise be reachable through routine walking activities.

Next, outer-band contribution is estimated using the following formula:

$$B_m = 100 \times \frac{\mu_{m,800} - \mu_{m,500}}{\mu_{m,800} - \mu_{m,300}}. \tag{2}$$

This percentage indicates the relative contribution of areas located farther from the origin of interest. As such, it serves as a proxy for the quality of opportunities within that area since opportunities in outer-bands may formally lie within reach but actually unlikely to be utilized due to inefficient travel routes and low accessibility levels.

The next step involves the scaling of educational and travel access values with respect to the young-resident accessibility levels:

$$Y_{g,e} = 1000\frac{\mu_{g,e}}{\mu_{g,r}}, \qquad Y_{g,c} = 1000\frac{\mu_{g,c}}{\mu_{g,r}}, \qquad Y_{g,d} = \frac{\mu_{g,d}}{\mu_{g,r}}. \tag{3}$$

Here, g stands for an age group (children or adolescents), e – for educational facilities, c – for commute entry, d – for commute-distance exposure and r – for resident accessibility. Both the educational and commute-entry yield will be expressed per thousand people while the commute-distance yield will be expressed per commuter metre.

Lastly, the age-specific routine deficit is expressed as follows:

$$D_s = 100 \times \left(1 - \frac{Y_{A,s}}{Y_{C,s}}\right). \tag{4}$$

Here, A means adolescents, C - children and s - the routine channel. A positive value will mean that adolescents get less routine benefits per accessible young person after taking residential reach into account. However, the result should be interpreted as an aggregated metric rather than an individual's preference regarding the route to use.

3.3. Concentration and residential substitution

Concentration metrics include the coefficient of variation and maximum leverage:

$$CV_m = \frac{s_m}{\mu_m}, \qquad H_m = \frac{b_m}{\mu_m}. \tag{5}$$

Here, s_m represents standard deviation, while b_m stands for the maximum access value per greenspace. Their combination forms the concentration load:

$$C_m = CV_m H_m. \tag{6}$$

Large values of the load indicate uneven distribution of accessibility across different greenspaces and concentration of access opportunities in specific greenspaces. Large concentration load does not necessarily mean that the distribution is undesirable as some cities might feature several major parks or linear corridors that would have many visitors.

Residential substitution is analysed based on Spearman rank association:

$$N_{xy} = 1 - \rho_{xy}^2, \tag{7}$$

where ρ_{xy} stands for the Spearman correlation coefficient and the rank transfer measure N_{xy} lies within the interval $(0, 1)$. Residential substitution load will be calculated as follows:

$$S_{xy} = N_{xy} C_y. \tag{8}$$

It will be largest when residential ranking differs from that of the target channel and the latter is very concentrated. The metric is to be used for evaluating access channels within the scope of this study but cannot be generalized as an absolute threshold.

4. Results

4.1. Radius enlargement effects on access values

Expanding the pedestrian radius from 300 to 800 m dramatically expands the reachability of residential and educational facilities. All-age residence increases from 1524.5 to 7763.3 people per greenspace, making up for a 5.09-fold increase. Child residence expands 5.01-fold from 240.2 to 1203.6 children and adolescent residence 5.28-fold from 177.6 to 937.3 adolescents. Education facilities also expand in comparable scales, namely, child education goes from 0.4 to 2.0 facilities, while adolescent education from 0.2 to 1.1 facilities.

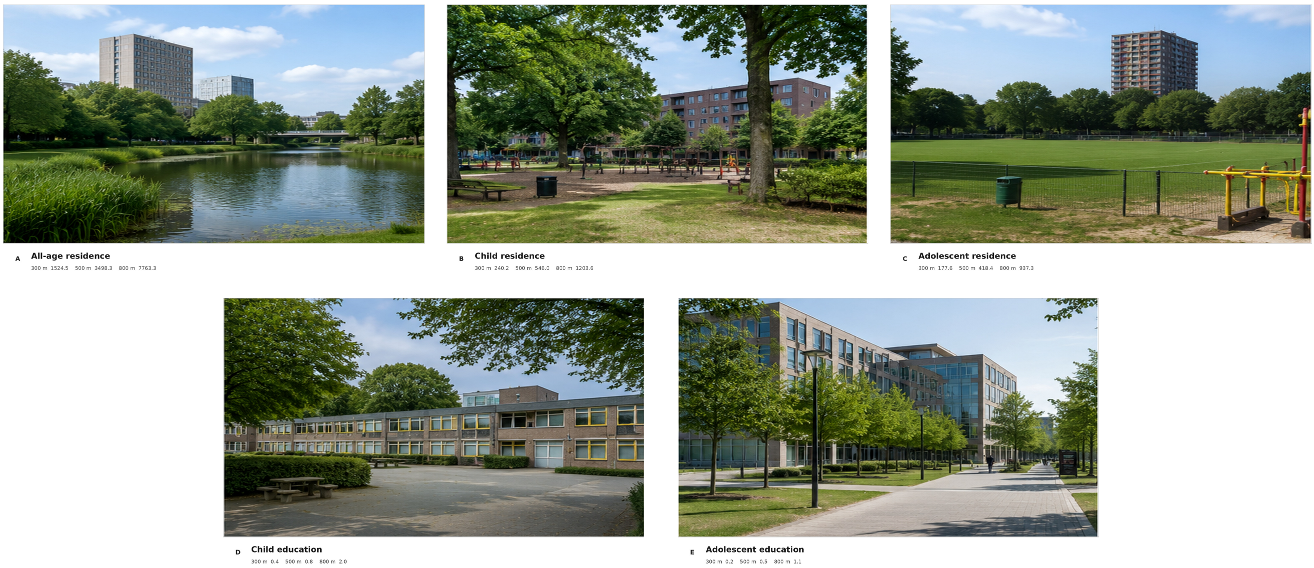

Figure 2. Walking-radius access.

The radius panels in Figure 2 show that the 800 m threshold creates a substantially larger access field than the 300 m threshold for every measured channel. The photographic presentation is deliberately tied to real urban settings: residential lawns, school frontages and campus-like routes can all sit within nominal walking distance, but they do not imply the same kind of daily contact. Growth in a walkshed count therefore cannot be read as proof that the same greenspaces are relevant to education or travel.

Table 2. Radius enlargement.

Measure	μ_{300}	μ_{500}	μ_{800}	A_m	B_m (%)
All-age residence	1524.5	3498.3	7763.3	5.09	68.36
Child residence	240.2	546.0	1203.6	5.01	68.26
Adolescent residence	177.6	418.4	937.3	5.28	68.30
Child education	0.4	0.8	2.0	5.00	75.00
Adolescent education	0.2	0.5	1.1	5.50	66.67

These values demonstrate the significant contribution of the outer band, which provides up to 68% of the increase in the residential catchment area and 75% of the increase in the catchment area of children-educational institutions. Such a finding is critical for youth urban planning since the increase provided by a longer radius may become less effective compared to the increase at a shorter distance when entrances and crossings, the exposure to traffic, and directness are considered. While a longer standard increases the potential, it puts greater emphasis on the outer band walkability.

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4.2. Conversion of nearby residence into routine access

The values of 800 m catchment areas indicate a marked reduction between the residence and education/travel catchment areas. A mean greenspace becomes accessible to 1203.6 children and 937.3 adolescents. The same distance becomes relevant for linking each greenspace to 2.0 child-educational and 1.1 adolescent-educational establishments. Commuter catchment is even narrower, at 68.7 children and 34.6 adolescents per greenspace. Commute-distance exposure amounts to 11250.6 commuter-metres for children and 5772.3 commuter-metres for adolescents.

Table 3. Routine yield.

Quantity	Children	Adolescents	Adolescent deficit
Mean residence access	1203.6	937.3	–
Mean education access	2.0	1.1	–
Mean commute entry	68.7	34.6	–
Mean commute-distance	11250.6	5772.3	–
Educational facilities per 1000 resident-accessible youth	1.66	1.17	29.37%
Commute entries per 1000 resident-accessible youth	57.08	36.91	35.33%
Commuter-metres per resident-accessible youth	9.35	6.16	34.12%

The routine yields in Table 3 show that adolescent disadvantage persists after scaling by the number of adolescents living near greenspace. Adolescents have 29.37% fewer educational facilities per 1000 resident-accessible youth, 35.33% fewer commute entries per 1000 resident-accessible youth and 34.12% fewer commuter-metres per resident-accessible youth. This pattern indicates that the adolescent result is not only a smaller residential population count. It reflects a weaker conversion from residential reach into the educational and travel channels where routine contact occurs.

Figure 3. Residence-to-routine translation.

The translation panels in Figure 3 show the empirical contraction from nearby residence to routine contact. The child panel links a mean 800 m residential reach of 1203.6 children to 1.66 educational facilities per 1000 resident-accessible children and 57.08 commute entries per 1000. The adolescent panel is lower on all comparable routine channels, with 937.3 resident-accessible adolescents, 1.17 facilities per 1000 and 36.91 commute entries per 1000. This comparison is central to the paper because it shows that weaker adolescent contact remains after residential population size has already been considered.

The age-ratio panels in Figure 4 confirm that the adolescent yield is only about two thirds of the child yield for route-based quantities. Education performs slightly better, but the adolescent value still remains below the child value. The consistency across residence, education, commute entry and commute-distance strengthens the

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interpretation that adolescent greenspace contact is constrained by educational location and travel alignment rather than by one measurement unit alone.

Figure 4. Age-specific access ratios.

4.3. Concentration of adolescent travel contact

Dispersion statistics reveal why mean values are insufficient for interpreting travel contact. Residential measures have coefficients of variation close to one and maximum-to-mean ratios close to seven. Educational access is more uneven, especially for adolescents. Travel access is the most selective channel. Child commute entry has a coefficient of variation of 2.90 and a maximum-to-mean ratio of 33.80. Adolescent commute entry has a coefficient of variation of 4.36 and a maximum-to-mean ratio of 66.10.

Table 4. Access concentration.

Measure	Mean	CV_m	H_m	C_m
All-age residence	7763.3	0.98	7.49	7.34
Child residence	1203.6	0.98	7.66	7.51
Adolescent residence	937.3	1.10	7.16	7.88
Child education	2.0	1.15	8.00	9.20
Adolescent education	1.1	1.91	14.55	27.79
Child commute entry	68.7	2.90	33.80	98.02
Adolescent commute entry	34.6	4.36	66.10	288.20
Child commute-distance	11250.6	2.94	34.45	101.28
Adolescent commute-distance	5772.3	4.36	54.78	238.84

The concentration values in Table 4 indicate that adolescent travel contact is not merely lower than child travel contact; it is concentrated in a much smaller part of the greenspace system. The concentration load for adolescent commute entry is 288.20, compared with 98.02 for child commute entry and less than 8 for residential access. Averages therefore mask an important planning fact: many greenspaces contribute little or no adolescent travel contact, while a few spaces account for a large share of the route-based exposure.

The concentration bars in Figure 5 reveal the route-contact issue without collapsing the problem into a bar graph format. Access via residences appears as a more generally broad factor within the greenspace inventory than adolescent commute entry, which shows greater specificity. The selectivity of the latter implies that adolescent planning requires more than the mere addition of residential access greenspaces; rather, it involves identifying the few corridors and edges where such accesses occur, and the many places where they do not.

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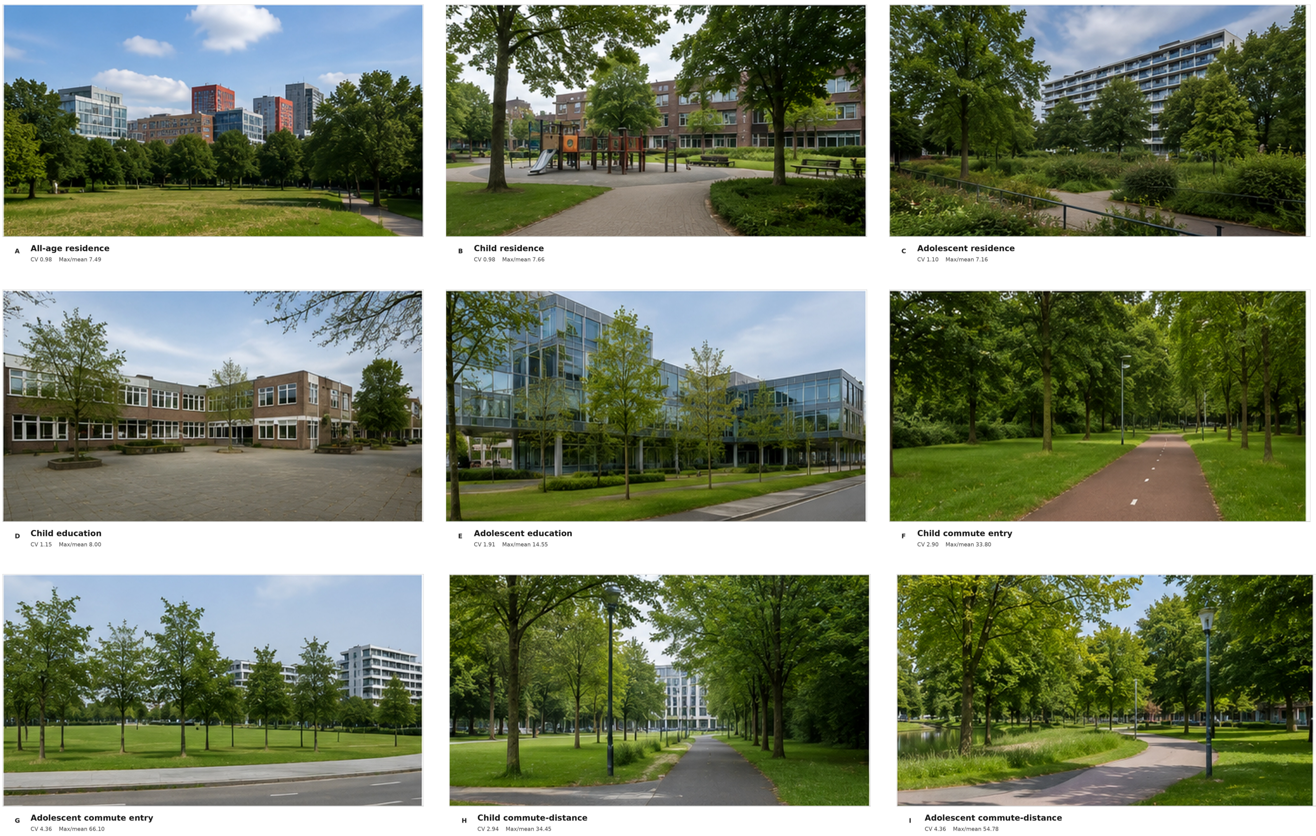

Figure 5. Dispersion and maximum leverage.

4.4. Validity of residential substitutions

The presence of a rank association between two access channels reveals situations where one channel substitutes for the other. Access through all ages ranks greenspaces similarly to access through children and adolescents, with Spearman coefficients of 0.962 and 0.963 respectively. This demonstrates that access through residence can substitute for access through youth at an aggregated rank level fairly reliably. The rank association drops off beyond the residential channel. The Spearman coefficient for all-age access through residences to education is 0.543. To commute entry, it is 0.554.

Table 5. Residential substitution.

Pair	Spearman ρ	N_{xy}	S_{xy}
All-age residence to child residence	0.962	0.074	0.56
All-age residence to adolescent residence	0.963	0.073	0.58
All-age residence to child education	0.865	0.252	2.32
All-age residence to adolescent education	0.543	0.705	19.59
All-age residence to child commute entry	0.743	0.448	43.91
All-age residence to adolescent commute entry	0.554	0.693	199.72
Child residence to child commute entry	0.730	0.467	45.77
Adolescent residence to adolescent commute entry	0.532	0.717	206.64

The substitution values in Table 5 separate two very different uses of residential access. Residential access works well as a substitute for youth residential reach, with loads below 0.60 for both age groups. It performs poorly when used to replace adolescent education or adolescent travel contact. The largest values occur for adolescent commute entry, whether the substitute is all-age residence or adolescent residence. This means that even an adolescent-specific residential measure cannot reliably identify the greenspaces most involved in adolescent home-to-education movement.

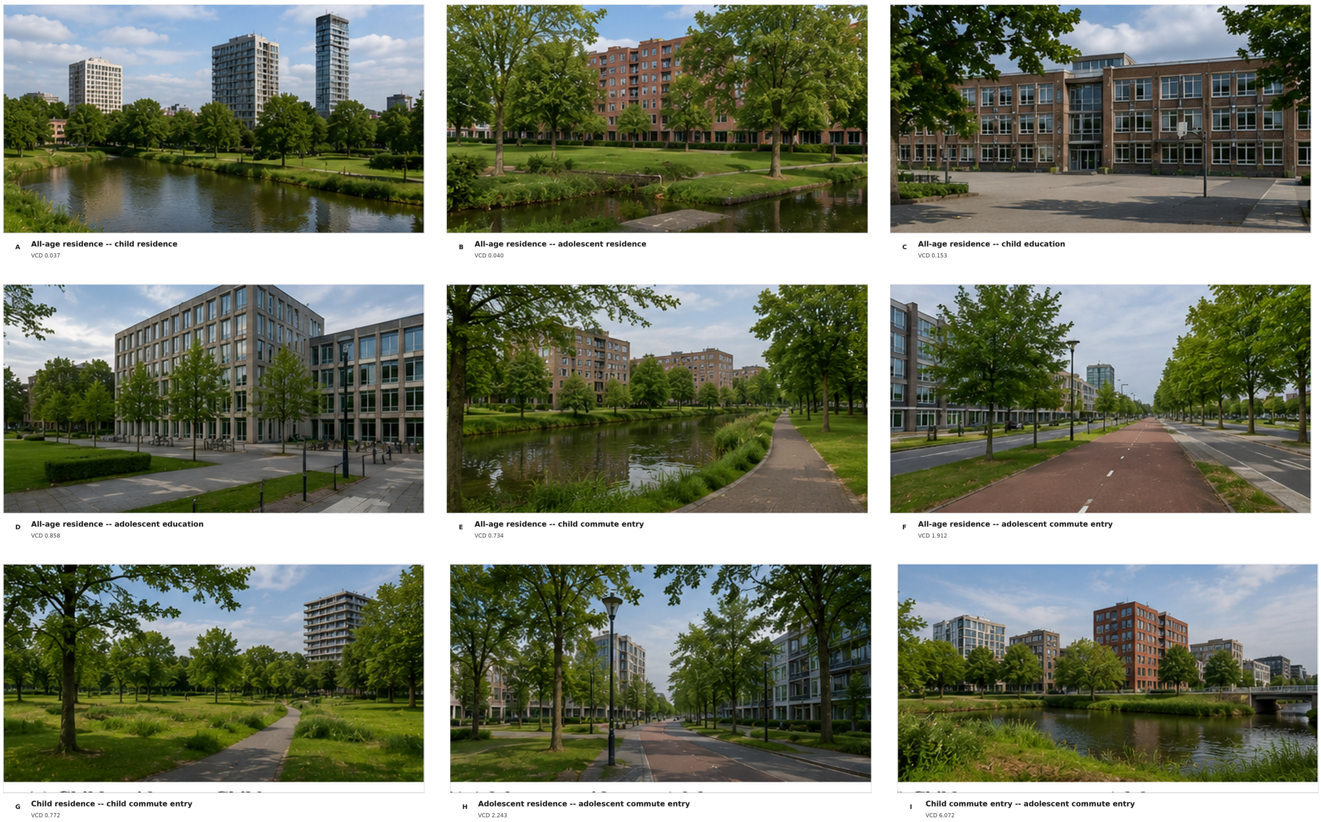

Figure 6. Residential substitution loss.

The proxy-loss panels in Figure 6 show a steep transition from reliable residential substitution to unreliable routine-contact substitution. The residential-to-residential values are almost negligible. Child education remains relatively modest. Adolescent education and travel contact rise sharply, and adolescent commute entry becomes the dominant risk. The result provides a clear ordering for planners: residential indicators can support residence-nearby screening, but adolescent school and travel channels require separate maps and interventions.

Figure 7. Zero and near-zero routine access.

The zero-access panels in Figure 7 indicate that there is a significant amount of greenspace with zero adolescent educational access and nearly zero adolescent commute access. Yet greenspace residential access may still exist for both children and adolescents.

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5. Discussion

5.1. Why residential reach is not exposure sufficiency

The empirical findings show that an 800 m residential reach provides additional opportunities, but does not imply routine greenspace contacts. A higher radius expands the population and educational reach, but does not guarantee proximity to educational destinations or routes. This distinction is important because exposure cannot be estimated merely in terms of radius. It is also necessary to consider institutional location, route alignment, connections, perceived safety and greenspace permeability.

Dutch evidence provides support for a strict interpretation. All-age residentials are a good indicator for youth residentials, given the close correlation of the two rankings. However, the same indicator turns out to be inappropriate for estimating educational access or route exposure. The issue is not about residential reach being incorrect. It is rather its purpose being restricted to residences. Problems start when residential reach serves to prove routine contact with greenspaces for adolescents.

5.2. Age-specific implications for Dutch urban greenspace

The age differences emerge from different levels of residential proximity, educational yield, route contact and spatial clustering. Children have a higher residential reach, a higher educational and a higher commute-entry yield. In addition, child-oriented educational facilities tend to be close to residential areas, as expected for primary schools' locations in neighbourhoods. The child-specific planning approach can rely upon the proximity of small greenspaces, vegetated squares, pocket parks and safe schools' plantings even if the area coverage is moderate.

The adolescent-specific problem involves greater clustering of educational institutions and more pronounced concentration of route contact. The average adolescent commute-entry value amounts to 34.6, while the coefficient of variation reaches 4.36 and the maximum-to-mean ratio – 66.10. This means that there is an excessive share of greenspace contact in a few facilities, making intervention planning focused on the key route segments.

5.3. Destination value and traversal value

One distinction deserves mention here: destination value vs. traversal value. The former relates to whether or not greenspaces can be accessed intentionally. The latter concerns repeated traversal of greenspace along the desired path. Larger greenspaces may well have high destination value in terms of attracting a lot of residential proximity. They might fail, however, in terms of traversal value. In particular, this is true when internal greenspace pathways do not coincide with school routes and are blocked by barriers. On the contrary, small greenspaces situated alongside educational facilities will attract a greater number of traversals.

This distinction explains the difference between residential reach and travel exposure, as both conditions are required for the latter. Residential reach is determined by the surrounding population within the radius. Travelling contact demands greenspace proximity to homes and educational institutions, as well as alignment with school routes, all of which can be neglected with the expansion of radius.

The illustration of park-edge permeability in Figure 8 shows that the difference between destination and traversal values makes sense in practice. Open-through edges are favourable because they ensure routine movements along or through greenspaces. Blocked edges, however, can leave greenspaces isolated from repeated adolescent visits to learning places.

5.4. Implications for monitoring and intervention

It follows that the monitoring of youth greenspace access must consider three independent dimensions: residential reach, educational access and route contact. Municipal departments can continue to report residential reach as it has intuitive appeal. It should, however, be supplemented with information on educational access and travel contact

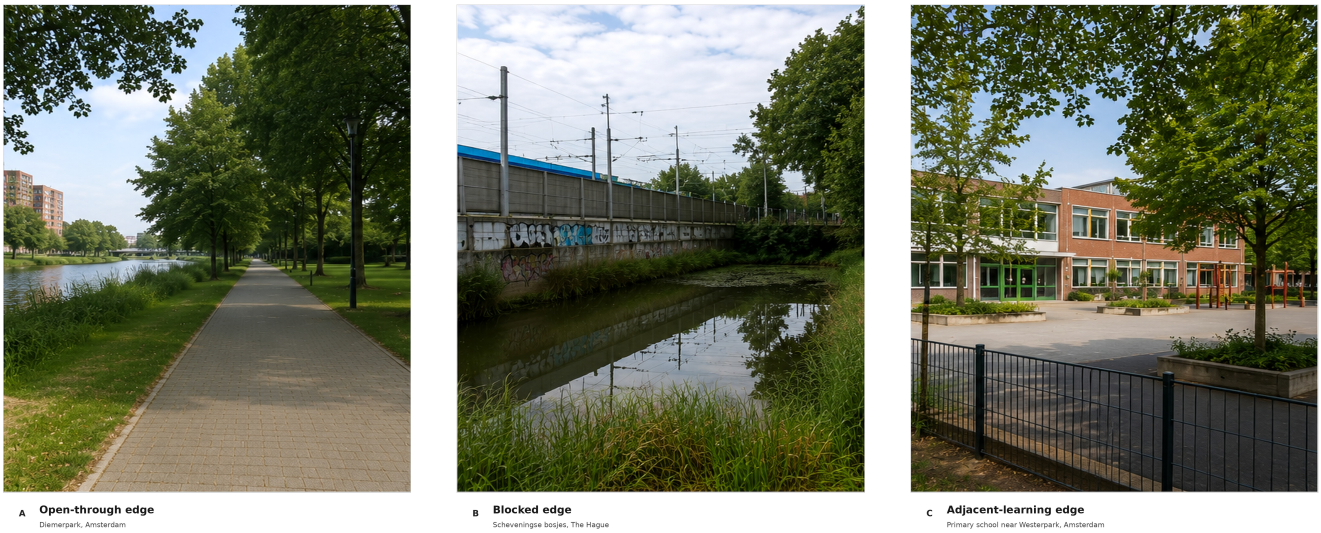

Figure 8. Park-edge permeability.

when this factor has to be included. The three channels should be assessed independently because they are mutually substitutable with high substitution load.

Amsterdam, Rotterdam and The Hague can benefit from focusing on adolescent route contact. Routine monitoring should identify secondary schools, colleges and universities with insufficiently developed greenspaces and map the corridors that join clusters of adolescent residences to these institutions. Potential interventions include the installation of additional or upgraded entrances, safer crosswalks, vegetated pathway segments and edge improvements for increased permeability. The goal would be not just enlarging greenspaces but putting them into repeated use by youth.

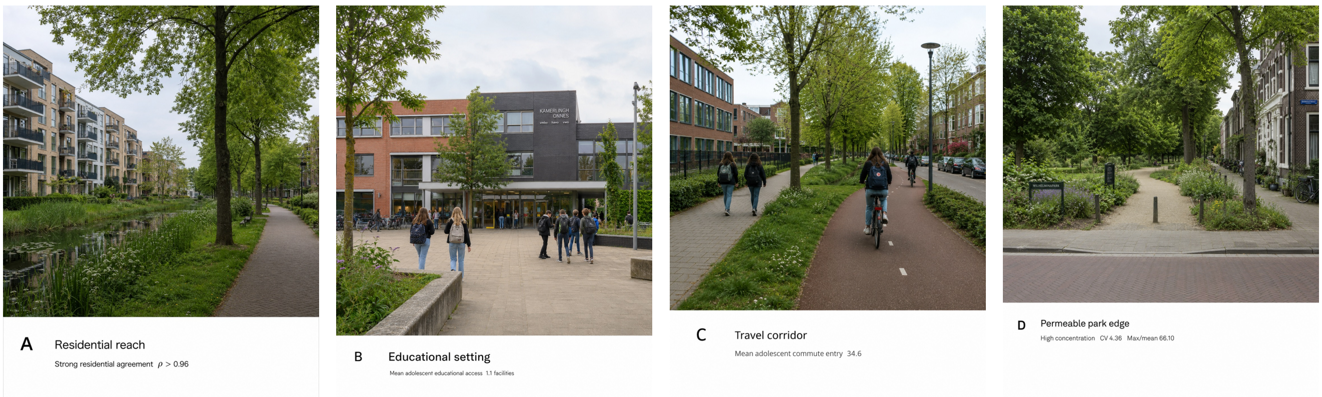

Figure 9. Planning interpretation of routine access.

As shown in Figure 9, there are four practical dimensions to be monitored. Residential reach can be useful in terms of identifying youth population nearby, but adolescent educational and travel access have to be addressed separately. Therefore, the monitoring framework can retain its multi-channel approach rather than switch to residential proximity alone.

6. Conclusions

The aim of this study was to assess the ability of the residential greenspace reach within 800 m to substitute for the actual youth routine access considering their educational destinations and route to school. Based on the data for Amsterdam, Rotterdam and The Hague, the hypothesis was rejected. Residential reach is relevant only to residential identification, but not educational access or route contact for adolescents.

The consistency across scale, yield, concentration and rank association can be seen clearly in the comparison between radii. The 800 m radius is associated with five times more mean access. Still, it does not resolve the divergence of means between the channels. Thus, the mean greenspace allows reaching of 1203.6 children and 937.3 adolescents at residential location, links with 2.0 child-oriented and 1.1 adolescent-oriented educational institutions, and accommodates 68.7 child commuters and 34.6 adolescent commuters. Normalizing by resident-accessible youth yields a 35.33% lower commute entry for the latter.

The most notable result of this paper concerns adolescent route contact. Adolescent commute entry exhibits a coefficient of variation of 4.36, a maximum-to-mean ratio of 66.10 and a resident substitution load of nearly 200 when all-age residentials are used for normalization. These parameters confirm that travel exposure is highly concentrated and cannot be determined based on residential proximity. Planning has to address youth routine access in terms of three channels: residence, education and travel. Children should be provided with small facilities and safe school surroundings. Adolescents, in turn, should receive learning corridors, park-edge permeability, entrance proximity, crossing improvements and vegetated route segments.

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