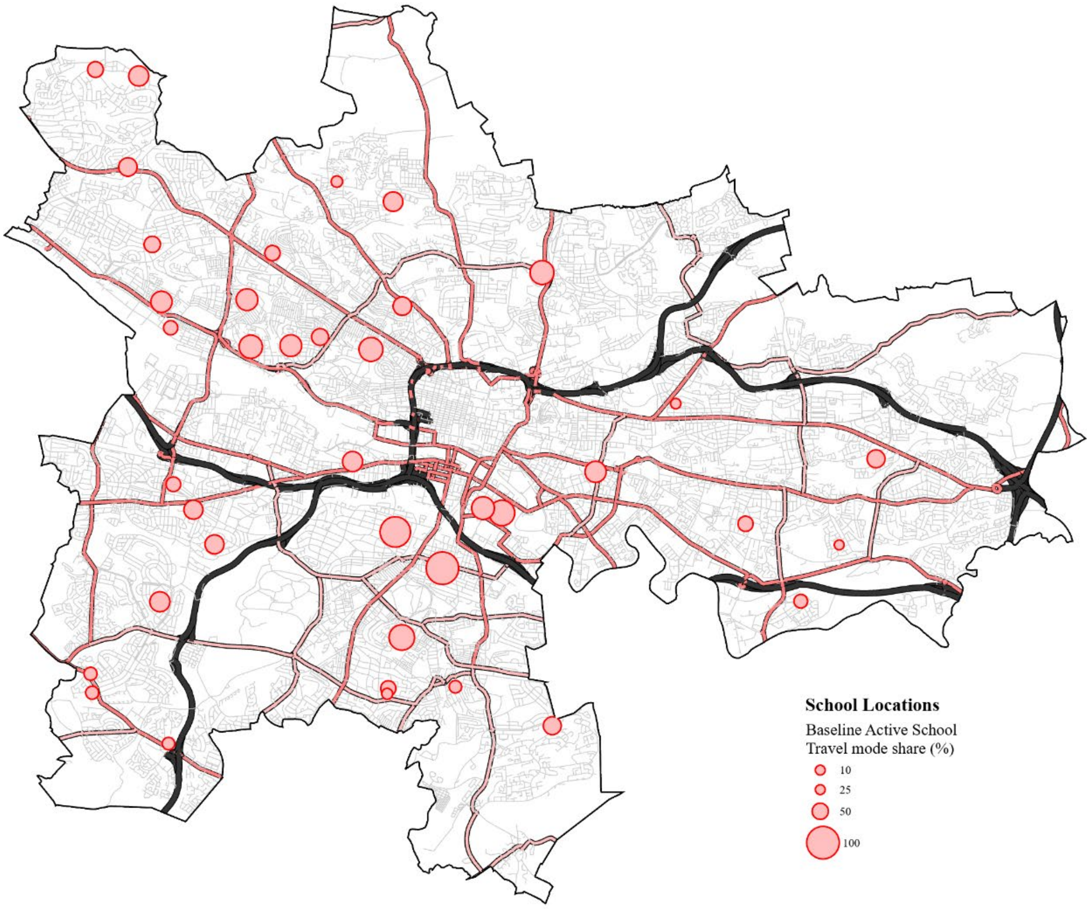

RECLAIMING STREET SPACE:

Glasgow's Schools Streets, the Built Environment and Lessons from International Best Practice

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TPS Membership Number: 93781592
Word Count: 4998

Table of Contents

1. Introduction

The number of children walking or cycling to school has been decreasing in countries around the world despite increasing active school travel (AST) campaigns and research (Wangzom et al., 2023). Instead, more and more parents opt for the car – where recent decades have seen a rise in prominence of parents 'chauffeuring' their children around in the back seat (Timperio et al., 2004).

It is important that children can travel actively to school for a number of reasons, for example, the benefits to cardiovascular health, and the role of physical activity in aiding mental and social development (Muller et al., 2020; Schoeppe et al., 2013; Stark et al., 2019). It is also important in terms of developing a future generation who do not view the car as the only means of urban mobility. Previous research has shown the importance of developing healthy lifestyle traits during childhood – which is correlated to the increased likelihood that these can be sustained into later life (Tudor-Locke et al., 2001; Janssen & Leblanc, 2010).

However increasing AST is a challenge in cities designed around the car. By viewing 'car infrastructure' (including parking) as public space - just in the same way that greenspace or playgrounds are - a large percentage of the public space is inaccessible to a significant share of the resident population – and all children. This idea is central to Gehl (2010), who is credited with helping transform Copenhagen into one of the most liveable cities in the world. The spatial sprawl of car-centricity – which Baty (2013) coins one of the 20th century's most impactful tragedies - creates an exclusionary dynamic, where alternative modes such as walking or cycling are marginalised. For children, this means either that those who travel actively often have to put up with an unsafe or unsuitable environment for active travel, or active travel is not considered an option – where parents perceive the built environment to be too dangerous (Christian et al., 2015).

To overcome the dominance of the car within our society, there is a need to reclaim space Gössling (2020). Doyle (1996) argues that if children are allowed to play on the streets, roam within their own neighbourhood and get to know their own city, then into adulthood they may be less inclined to defend the levels of motorised traffic which are limiting children's access to their environments. Through this lens, creating safer environments for children to be active is an important domain of research as a means of encouraging active modes as viable alternatives to the private car in the long run.

School Streets are a relativity new type of intervention aimed at encouraging AST through temporary space-reclamation. The principal behind most School Streets is simple: at the start and end of the school day, the road adjacent to a school is closed to vehicles, allowing children and parents to walk, wheel or cycle the final portion of the journey to school traffic free. Traffic Regulation Orders allow for a restriction in cars entering the streets, and are usually enforced with road signs, temporary bollards, through marshalling, or more recently, Automatic Number Plate Recognition (ANPR) cameras (Sustrans, 2022). Through these measures, School Streets can be viewed as a redefinition of the space on a [usually] temporary basis, turning a space of exclusion and danger into one of leisure and play.

The rise in popularity of School Streets was accelerated by the COVID-19 Pandemic (TfL, 2021), and the greater emphasis on space for social distancing. However 'the compounding crises' of road safety, health, and air quality have encouraged authorities to embrace School Streets as a solution to make cities more humancentric (Clean Cities Campaign, 2022).

The benefits of School Streets can be broken down into two broad groups:

1. The benefits of removing vehicles from the space – including better, cleaner air quality around the school & a less dangerous environment overall.
2. The benefits of promoting active alternatives to the car – encouraging independent mobility amongst young people, and an overall healthy lifestyle.

Both aspects are appealing to present-day decision makers looking both to increase physical activity among young people and transition urban areas away from car dominance.

2. Aims and objectives

The overall aim of this research is to – through spatial analysis - improve clarity on School Street interventions, and which contexts they are most likely to yield the greatest increases in AST. To achieve this aim, the following research goals were set:

1. To investigate the impact of Glasgow's School Streets at primary schools with varying levels of AST baseline.
2. To investigate the built environment characteristics (BECs) of school neighbourhoods that have seen the biggest uptake in AST since School Street implementation.
3. Identify what can be learnt from international best practice to support the growth of School Streets initiatives, and how these lessons can be applied to cities such as Glasgow.

3. Literature Review

3.1 School Streets

Whilst School Streets have exploded in popularity in recent years, there is a lack of research quantifying mode shift, and less still looking to explain the reasons behind these observations. Davis (2020), in a review of the impacts of 16 School Streets initiatives, concluded with 'medium strength' that active travel levels increased at all schools with street closures reported on by local authorities. A technical report by Sustrans (2022) investigating the effects of School Streets on traffic displacement also concluded that there is an overall fall in the volume of traffic around these schools.

The City of Edinburgh Council released an evaluation of their pilot School Streets in 2016, showing a 6% decrease in children being driven to/from school, with smaller increases to both walking and park and stride mode share. Contrastingly, Thomas (2022) found that in London, despite significant reductions in motor vehicle usage both during and outside of the restricted hours, this did not translate to a significant increase in active travel use. A TfL report (2021) concluded that the way children travel was 'relatively unchanged' – however survey questions were asked with the respect to pre and post pandemic behaviour, rather than specifically isolating School Streets. By their own admission, it is extremely difficult in their case to disentangle the impact of School Streets from the influence of the COVID-19 pandemic (*ibid*).

It should not be a surprise that there are differences in performance across School Streets; for the decision of how a child travels to school is inherently complex (Larouche, 2015). This paper will look to build on this shallow body of literature, to improve clarity on the impact of School Streets and the influence of the built environment - to help inform which school and neighbourhood types should be targeted to maximise impact from interventions.

3.2 The impact of the Built Environment and Perceptions

There are a wide range of factors within the built environment that can influence children's active travel. Infrastructure to assist active travel is often associated with increased AST (Aldred, 2015; Helbich et al., 2016), which is particularly important for children, who don't have the ability to process complex traffic interactions (Wangzom et al., 2023). Land use mix has also been associated with increased AST (Ding et al., 2011), where more destinations tend to be within a short distance of the home – which encourage a greater proportion of journeys to be completed by active modes. This extends to park routes and neighbourhood greenspace - which provide a safe traffic-free environment in which parents are usually more comfortable allowing their children to roam (Wolch et al., 2011). There are many further aspects of the built environment that influence travel mode choice – such as both personal and road safety, urban form and aesthetics. A full list of BECs and the rationale for inclusion can be found in **Appendix 2.**

Curtis et al. (2015) found that whilst BECs are important, a decisive role lies within the 'combination of preferences and licences' – where parental preferences and perceptions are the primary indicator of how a child travels to school. Similarly, Christian et al. 2015 found that parents who perceive the neighbourhood environment as unsafe for children to move around independently are less likely to grant their children licenses to travel independently to a number of different local destinations.

Loh et al. (2024) outline the need for multilevel interventions taregtting both the environment and perceived safety to promote AST. School Streets sit within this criteria, and this is where they can become a particularly interesting concept. Whilst the intervention only represents a small-scale change to the physical environment, there may be a much larger potential benefit in their power to change perceptions of safety – particularly among parents.

3.3 Variation in approach

The UK, and particularly London, is a global leader in terms of the number of School Streets, largely following the temporary enforcement pattern outlined above. However in light of the pandemic, there are interesting developments on the concept that move beyond a narrower definition of School Streets, expanding in terms of either time or space. These can still be viewed as School Streets to Clarke (2022), who argues that temporality is not the defining characteristic of a School Street, but rather a "car-free space outside schools to support clean air, active travel, social connections and improved wellbeing."

In 2020, the *'Protegim Les Escoles'* programme was launched in Barcelona – which has transformed 217 school zones into safer, healthier spaces. Permanent changes were made to the built environment, talking space away from cars, repurposing it for socialising and play among children. As a result, the perception of medium or high road safety went from 56% to 68% among parents (Agència de Salut Pública de Barcelona, 2023).

Launched in 2019, Paris' *'rues aux écoles'* scheme has expanded to over 150 streets, many of which are now formalised as pedestrian-only areas. There has been a strong focus on complementing the School Streets with greening measures, as part of the broader '*Embellir votre quartier' ('Embellish your neighbourhood').* In the Albanian capital Tirana, whilst not traffic free, School Streets are wide, segregated pedestrian spaces with a single narrow one-way lane for vehicles. The following quote from Anuela Ristani, the Deputy Mayor of Tirana illustrates how priorities in the city have shifted.

> *"When we decided to take kids seriously in this city, schools were the logical place to start… Our School Streets show loud and clear what we sacrifice by choosing to store cars on the street instead of using that precious public space for people"* – via Weedy (2024)

Design has centred around involving the children, which "invites the collective imagination about the potentials of a street" (Quendra Marrëdhënie, 2024): a powerful means of fostering a connection to the reclaimed space. In these examples School Streets are not purely aimed at the journey to school; rather their permanent nature looks to contribute to the wider concept of a child-friendly city. As well as increasing active travel to school in Barcelona, the number of students staying to play or socialise in the space at least 25 minutes after the end of the school day increased from 25% to 56% (Agència de Salut Pública de Barcelona, 2023). The elimination of traffic was seen as a necessary condition for play to occupy the street, but it does not guarantee it on its own (Honey-Rosés et al., 2023). Within their final report recommendations, emphasis was placed on the importance of wider network calming measures, beyond the school street itself (Agència de Salut Pública de Barcelona, 2023). Similarly, a debrief report by 2CV (2022), for TfL, recommended wider environmental enhancement to support behaviour change – where the School Street can become a 'special area', supported by signage designed by children, planters, street furniture, or cycle parking.

Permanent change also means that the transformed public space can benefit the entire community, not just school children at the start and end of the day. In Barcelona, use of the public space tripled – proving popular among both children and the elderly (Honey-Rosés, 2023).

4. Study Area: Glasgow

Active Travel is at the forefront of Glasgow City Council's vision, which is evident both through its active travel polices (Glasgow City Council, 2016; Glasgow City Council, 2022) but also its drive to host major events and develop world class facilities in doing so.

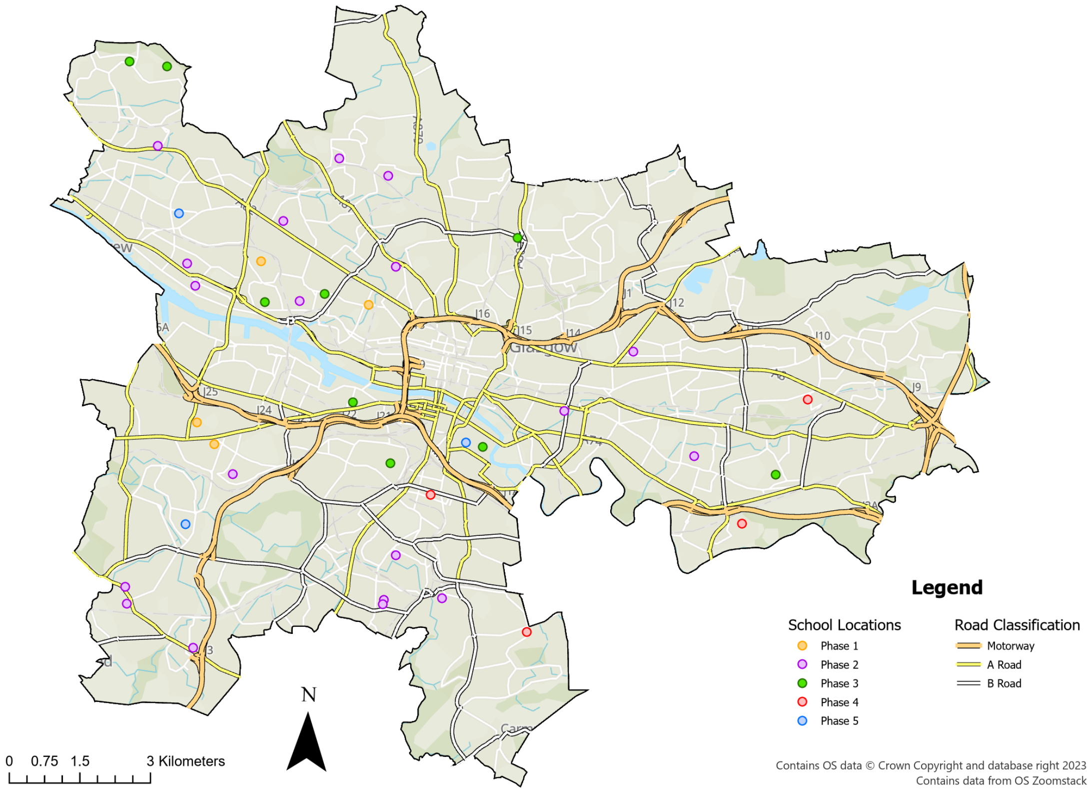

Figure 4-1: Glasgow City study area and school locations

Despite these efforts, car use still dominates in Glasgow – a city characterised by its motorway running through the heart of the city. This extends to the school run – where over 30% of school journeys are completed by car (Glasgow City Council, 2024). This set of circumstances make Glasgow, a city invested in moving beyond its dependence on the car, a strong benchmark for this study.

Glasgow City Council first introduced their School Streets programme in 2019, where experimental TROs were introduced on streets outside six schools – comprising Phase 1. Over 40 primary schools have since had School Streets made permanent - the latest of which, Phase 5, went live in August 2022.

5. Methodology

The Sustrans Hands Up Scotland Survey (HUSS) is a yearly gauge of school travel mode-share, where each September, children are asked ‘how do you normally travel to school?’ Glasgow City data was acquired from Sustrans from 2019 through to 2023, allowing for a baseline dataset to be established and compared to the most recent figures. Active travel mode share data was calculated as the sum of children walking, cycling, scootering or skateboarding. To establish the baseline dataset, for each phase of the School Streets programme, the latest available dataset before the school street Traffic Regulation Order went live was used. A leeway of one year from the start date was applied, where if data was not available the school was excluded. A total of 39 primary schools had sufficient data available for analysis.

To spatially assess the influence of the built environment on AST, BECs (for example, the length of cycleways) were calculated both within an 800m circular buffer around the school location and at school catchment level – and the average score taken. **Appendix 1** sets out the rationale behind this approach to calculation of BECs (illustrated through **Figure 0-1**), based on findings from previous research.

This study aligns with the framework set out by Panter et al. (2008) to ensure coverage of all aspects of the built environment, and controlling for other necessary indicators (i.e. socioeconomic factors). Indicators included aim to measure both the impacts of both the built environment and perceptions of it. **Appendix 2** lists the 13 BECs, the method of spatial quantification and the rationale for inclusion within the study.

5.1 Statistical analysis

With the GIS-measured BECs around each school, multiple regression was used to gauge the ability of BECs to predict variation in baseline active travel mode share (before the school street intervention), controlling for the external factors, individual factors and moderators (further detailed in **Appendix 2**). Standardised coefficients were used to interpret the variation in impact across BECs to identify the strongest predictors of AST.

To address the key aims of this study – which schools see the greatest benefits from School Streets and which BECs are associated with them - two sets of hypotheses tests were conducted. Firstly, to understand the impact of School Streets at different baseline levels of active travel mode share, schools were split into two samples: where baseline AST was either above or below the 2019 mean of 54.1%. Hypotheses tests were conducted to examine differences in the GIS-measured BECs between schools that already feature above-average levels of AST compared to below-average AST schools.

The second set of hypotheses tests focused on the schools showing increases in AST. An increase of greater than 2% in AST was set as the threshold, where higher increase schools were separated from those displaying more neutral, or negative changes in AST. Hypotheses tests were conducted to examine differences in the GIS-measured BECs between the schools showing significant increases in AST versus schools displaying small or no increase since the implementation of School Streets.

Depending on normality, independent samples t-tests or Mann-Whitney U-tests were used. Jamovi v2.3 and Microsoft Excel were used for statistical analysis.

6. Results and Discussion

The fitted regression model was statistically significant (Adjusted $R^2 = 0.648$, $F (9, 16) = 6.11$, $p < .001$) when controlled for median household income, car ownership, school catchment area and the availability of Bikeability training at the school. This would suggest that BECs are a significant predictor of active school travel in Glasgow - before the School Street interventions.

Built environment characteristic	Standard Estimate	Control	Standard Estimate
Cycleway length	0.3029	Household income	0.6606
Pedestrianised length	0.0458	Car ownership	0.7895
Land use mix	0.1738	School catchment area	-0.1191
Greenspace	0.1710	Bikeability training	0.0661
Street connectivity	-0.1687		

Table 6-1: Standardised regression coefficients

Standardised coefficient estimates for variables included in the fitted model are shown in **Table 6-1**. Cycling infrastructure was the strongest built environment predictor of AST, showing the highest standard coefficient - which aligns with previous research on the importance of infrastructure that assists active travel (Wangzom et al., 2023; Ikeda et al., 2018; Aldred, 2015). Whilst finding that both walking and cycling infrastructure were associated with AST, Ikeda et al. (2018) discuss a 'socio-economic gradient', in that more advantaged communities were more likely to benefit from infrastructure improvements. In Glasgow, median household income showed a high standard estimate within the model of 0.66 – which may indicate a similar dynamic, in which wealthier neighbourhoods benefit from increased infrastructure provision as well as overall AST mode share. The percentage of households without access to a vehicle was also a significant predictor of AST, which also agrees with the findings of Ikeda et al. (2018).

Whilst remaining significant ($F (9,16) = 4.24$, $p < .01$) the regression model returns an Adjusted $R^2 = 0.539$ when switching from the baseline to the 2023 AST mode share as the dependent variable. This suggests that BECs could account for approximately 11% more of the variation in AST before the School Streets intervention. To better understand which schools were seeing improvements in AST, a series of hypotheses tests were conducted, where first schools were split either side of the mean active travel mode share at baseline (54.1% in 2019). High baseline schools showed higher neighbourhood shares of travelling to work by active modes, and lower shares of driving to work - in line with previous research highlighting the importance of parental perceptions and their own travel habits (Christian et al., 2015). The below-average baseline group also showed significantly larger school catchment areas, aligning with previous research that has highlighted distance to school as a key moderator of AST (Curtis et al., 2015; Mitra & Buliung 2012; Wangzom, 2023). Greenspace, major roads, road safety incidents, street lighting, trees, land use mix and residential density all showed insignificant differences between the two groups.

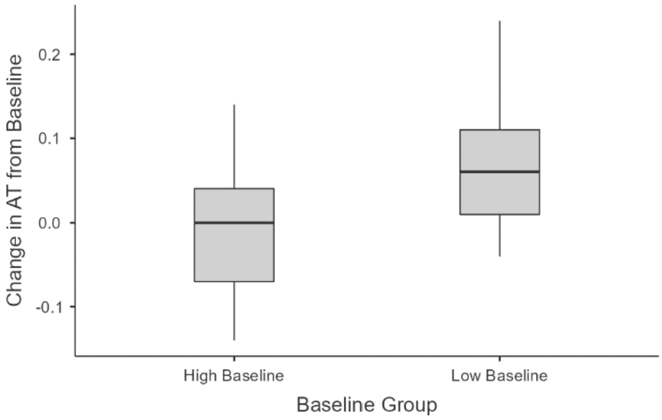

Figure 6-1: Increase in active travel (AT) for high and low baseline groups

A significantly higher increase in active travel was observed in the below-average baseline group of schools. In these schools, an average increase in active travel of 7.14% was observed between the baseline and 2023 mode share (**Figure 6-1**). In contrast, the above-average baseline group saw a 0.97% decline in active travel, despite showing largely better GIS-measured BECs for AST (**Table 6-2**) – with a significantly higher number of crossings and provision of cycleways. The mixed increases in AST disagrees with Davis (2020), who reported an increase in active travel across all participating schools; but agrees with findings in London – that change in AST was mixed across intervention schools (Tfl, 2021; Thomas, 2022). The differences between low and high active travel baselines may suggest that School Streets are a more effective concept when targeting areas of low active travel or high car use.

	Active travel baseline			Change from baseline		
Built environment characteristic	**<54.1%**	**>54.1%**		**<2%**	**>2%**	
Percentage of Non-Residential Land Use	35.84	39.02		38.26	37.04	
Greenspace (percentage of buffer/catchment)	8.39	12.52		10.61	10.83	
Method of travel to work: Driving a car or van (Percentage, Census 2022)	0.39	0.32	*	0.31	0.39	
Method of travel to work: Walking or cycling (Percentage, Census 2022)	0.09	0.13	*	0.13	0.09	*
Street Lighting Columns (count)	760.45	800.30		813.66	753.74	
Major Road Length (m)	5653.29	7098.07		6502.08	6436.19	
Road Safety Incidents (count)	50.59	77.24		82.15	49.92	
Residential Density (people/km^2)	2966.78	3964.08		4173.54	2917.38	*
Cycleway Length (m)	1123.91	3153.55	*	3146.87	1450.70	
Pedestrianised Length (including park routes)	413.23	812.47		818.94	403.82	*
Crossings (count)	15.26	30.80	*	30.46	17.91	*
Street connectivity (density)	135.47	145.88		149.29	133.79	*
Trees (count)	90.69	133.39		117.94	111.77	
Control variable						
School catchment area (km^2)	2.79	1.89	*	2.26	2.30	
Bikeability Training (binary 1/0)	0.41	0.55		0.42	0.55	
Median Household Income per week (£)	534.38	557.50		530.93	563.09	
Percentage of households with no car access	44.59	49.45		53.11	41.86	*

Table 6-2: Hypotheses tests conducted to examine differences in the GIS-measured BECs between school groups (mean values). *Significant p ≤ 0.05

A second set of hypotheses tests were conducted (**Table 6-2**) to further understand the built environment conditions around schools displaying the largest increases in AST. Schools showing at least a 2% increase in AST displayed significantly less pedestrianised infrastructure, cycleways, number of crossings and displayed lower residential density than the schools showing less than a 2% increase. Whilst appearing contradictory, this finding may indicate the impact of the School Streets in overcoming other negative neighbourhood BECs. There were also significant differences in car ownership between the groups – suggesting that in Glasgow, School Streets have been more effective in areas of higher car use, where previously AST levels were lower.

Overall, a key finding is that there are significant differences in the built environment characteristics between the schools with the highest overall levels of AST, and the schools seeing the greatest increase in AST. Schools with high overall AST showed associations more commonly reported within AST research (such as greater provision of infrastructure to assist AST or higher residential density), whereas schools showing the greatest increase in AST showed significantly poorer GIS-measured built environment conditions for AST.

There have been no studies to date researching the direct influence of the built environment on School Streets, making these findings important in improving clarity around School Street interventions. In London – TfL (2021) found that those at intervention schools were more satisfied with the area around schools. In turn, a number of previous studies have highlighted the importance of parental perceptions as a predictor of AST (Curtis et al., 2015; Christian et al., 2015; Panter et al., 2009). If School Streets can be a vessel for improving perceptions of the built environment – where in Barcelona there was a 12% increase the perception of medium or high road safety following the intervention (Agència de Salut Pública de Barcelona, 2023) - they may have significant potential to improve AST, particularly in areas which are perceived as less safe. Furthermore, using neighbourhood travel to work data as a gauge of perceptions, higher increases in AST were observed in neighbourhoods where walking to work was significantly lower, and driving to work was higher. Again, this contradicts the findings of the baseline dataset (**Table 6-2**), further indicating that School Streets may have altered parental perceptions. Due to the quantitative nature of this study, these points can only be hypothesised – and future research should look to examine the causality of this relationship.

School Streets could also be seen as a counterbalance to the 'socioeconomic gradient' discussed by (Ikdea et al., 2018), where in Glasgow, School Streets have yielded the greatest increases in AST in neighbourhoods featuring lower provisions of active travel infrastructure – and therefore could provide a cost-effective solution for mediating active travel benefits. However, Thomas (2023) outlines that in London, School Streets were prioritised where leadership and parent cohorts were in favour of the concept. Therefore reimagining the way in which School Streets are prioritised across a city may allow for a more equal distribution of the benefits.

It is also important to consider why the higher baseline AST group did not observe any significant increase in AST. These areas showed significantly better GIS-measured BECs for AST, and this may be the reason why the baseline active travel levels were high. Therefore the ability for School Streets to overcome poor perceptions of the BE may be lessened, because the majority of children who can travel actively, already are. However, in cases where AST is already high, there is still scope to improve built environment conditions – for which School Streets can be a facilitator. Cities like Barcelona, Paris or Tirana have shown how built environment interventions, permanently redefining the hierarchy of their street spaces beyond the common definition of the School Street, can contribute to a broader child-friendly city. Permanent changes to the built environment, repurposing road space to create spaces for people, that can facilitate increased play, socialising, as well as benefiting the wider community - such as the elderly.

Whilst Barcelona and its superblocks may seem incomparable to a UK-context at first; space-reclamation can be adapted to the local context. An example of this in Glasgow is Hillhead Primary School, which was one of the School Streets in Phase 1. Overall in 2023, 74.8% of children travel actively (a 3.8% increase from the baseline) – considerably higher than the average for the city. **Figure 6-2** displays the school street closure on Otago Street and Westbank Quadrant, however the school benefits from the pedestrianisation of Kelvin Way – initially a COVID-19 measure that has since become permanent. Kelvin Way, a previously busy cut-through Glasgow's West End, represents a significant change in the city's priorities – a shift towards putting people first.

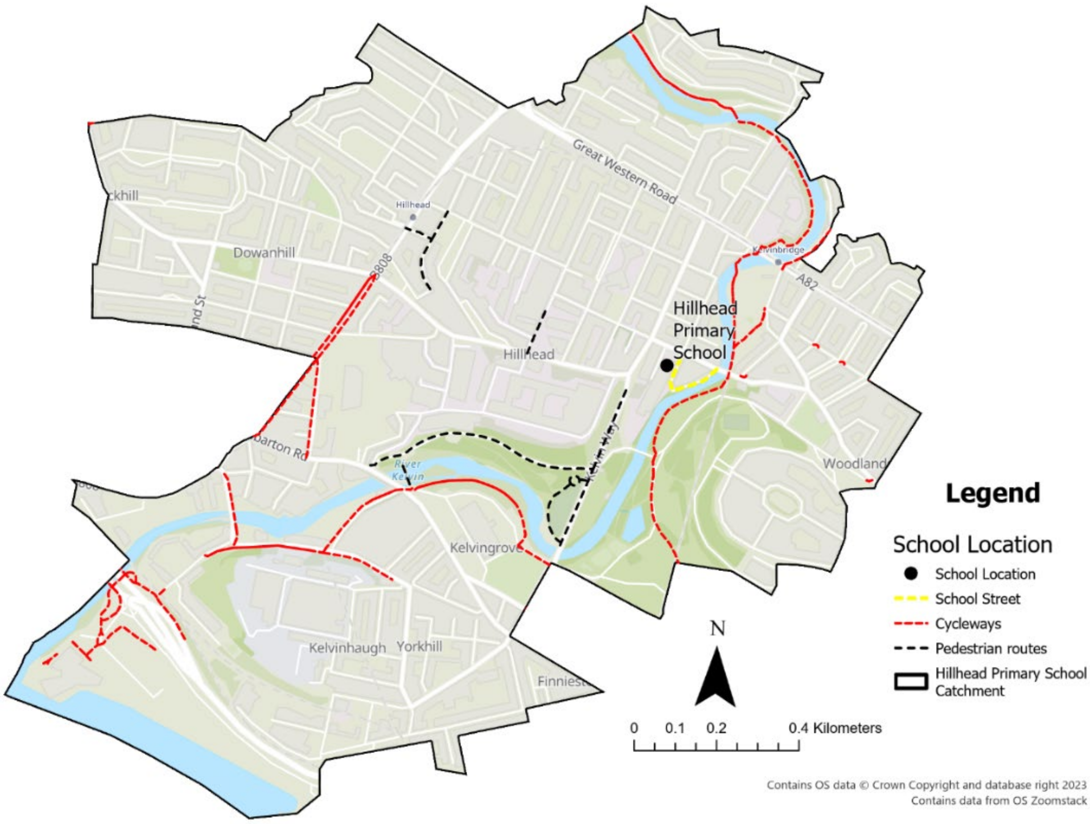

Figure 6-2: Glasgow's West End and Hillhead Primary School

Hillhead Primary School features a larger than average catchment area, at 2.60km^2, where not all pupils will live within walking distance. Notably, there are very high levels of cycling (16.7%) and children who scooter/skateboard (7.0%) – which could be attributed to high-quality reclaimed space in the neighbourhood. These are journeys that may be done by private car in an alternative scenario where the environment is not tailored to support children's mobility - and highlights the wider benefits of space-reclamation.

Learning from the successes of space-reclamation efforts both internationally and closer to home, permanent interventions can help create environments that foster children's independent mobility. In any case, these interventions should be supported by facilities such as planters, benches, context-specific play equipment or cycle parking (Agència de Salut Pública de Barcelona, 2023; 2CV, 2022) – to maximise the utility and collective benefit of the space. Involving children in design, for example signage (2CV, 2022) or play equipment (Quendra Marrëdhënie, 2024), can help develop a connection to the reclaimed space.

Our cities may not have the plazas and open space in the same way that Barcelona and its Superblocks do; but that should not limit ambition. The Hillhead Primary School example illustrates how bold changes to the built environment can be executed to provide widespread benefits beyond the conventional School Street. Core to this, is reimagining who public space serves. If cities such as Glasgow want to best influence the private car, and encourage active modes as viable alternatives - high-quality, reclaimed space should be a priority. Providing space for our future generation of adults to be active and develop healthy habits whilst young may hold immense transformative potential.

7. Conclusions

In conclusion, this study has addressed previous gaps in the literature, improving clarity on the performance and impact of School Street interventions on the uptake of active school travel. A multiple regression model was used to identify key predictors of AST in Glasgow, and two sets of hypothesis tests were conducted to examine the differences in the GIS-measured BECs of different school groups. A key finding of this study: in Glasgow, School Streets have been significantly more effective where baseline active travel levels were below-average – showing a 7.14% increase in AST. In contrast, the above-average baseline group saw a 0.97% decline in active travel.

Significant differences were observed in the built environment characteristics between the schools with the highest overall levels of AST, and the schools seeing the greatest increase in AST. Schools displaying increases in AST of greater than 2% mode share showed significantly less pedestrianised infrastructure, cycleway length, number of crossings and displayed lower residential density than schools showing less than a 2% increase. Although appearing contradictory, a possible explanation is that School Street interventions were a facilitator of these increases, overcoming poorer built environment conditions and perceptions. This is an area that would benefit from further research, however could be an important finding for maximising the impact of future interventions.

It is concluded that School Street interventions can be an effective means of influencing the private car, enabling greater uptake in active travel by young people – which is immensely important in developing cities that are capable of overcoming the dominance of the car. While temporary solutions can be powerful; international best practice illustrates new variations on the concept. Key to these approaches, is the focus on permanent change – understanding the value in devoting precious public space to people, rather than cars. Leading cities such as Barcelona or Tirana have not just encouraged AST through their interventions, but created neighbourhood spaces where children can roam, play and socialise – contributing to broader child-friendly cities. Reimagining the hierarchy of public space through reclamation from cars, these examples also highlight the importance of supporting measures and involving children in design to foster a connection between the community and the reclaimed space. This study has highlighted how similar space-reclamation is achievable, and has already been successfully executed in Glasgow, transforming a previously busy corridor into a space for people. To continue to grow School Streets initiatives, cities like Glasgow should take a bold, strategic approach to space-reclamation, whilst allowing input from children in design. By focusing on wider, permanent reclaimed neighbourhood spaces, cities like Glasgow could aim not just to encourage AST, but create spaces to facilitate increased play, socialising, and encourage children to be independently mobile – to help foster a future generation who can think beyond the private car.

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Appendix 1: Approach to quantifying Built Environment Characteristics, and spatial data aggregation.

BECs were quantified using a mix of Glasgow City Council spatial datasets and OpenStreetMap data (via Overpass Turbo), all accessed in November 2024. Additionally, Scottish Census 2022 data was used for socioeconomic (control) variables and the HUSS mode share data was joined to a Scottish Government school locations dataset to interpret results spatially. Data processing was done in FME Workbench 2023.0.0.3, and all mapped outputs were created in ArcGIS Pro v3.2.1.

BECs were calculated both as an 800m circular buffer around the school location and at school catchment level – and the average score taken. This is illustrated in **Figure 0-1.** School catchment metrics were standardised to avoid skew from differences in area.

Previous research has outlined the issues of similar AST studies and the Modifiable Areial Unit Problem (MAUP), where the changes in boundary or buffer size around target locations (in this case, schools) can vastly impact upon how the results are interpreted. Whilst no single buffer distance or approach will be optimal in all scenarios (Mitra and Buliung, 2012), the approach to data aggregation should take into account the local context of the study. A single circular buffer around the school location alone can exagerate the impact when aggregating data, and also neglect the areas of the catchment that do not sit within the circular buffer, as can be seen in both examples illustraed in **Figure 0-1**. In Glasgow, there are significant variations in catchment size due to the high number of Roman Catholic schools, which feature larger catchment areas than the non-denominational schools. In this case, when values are calculated, there may be too little emphasis on the area directly around the school because of the inflated catchment size – which is evident in the second illustrated example in **Figure 0-1**.

The above approach ensures that the entire school neighbourhood is accounted for by using catchments, but also highlights the importance of the direct area surrounding schools, understanding that some school catchments extend long beyond where the majority of the population reside.

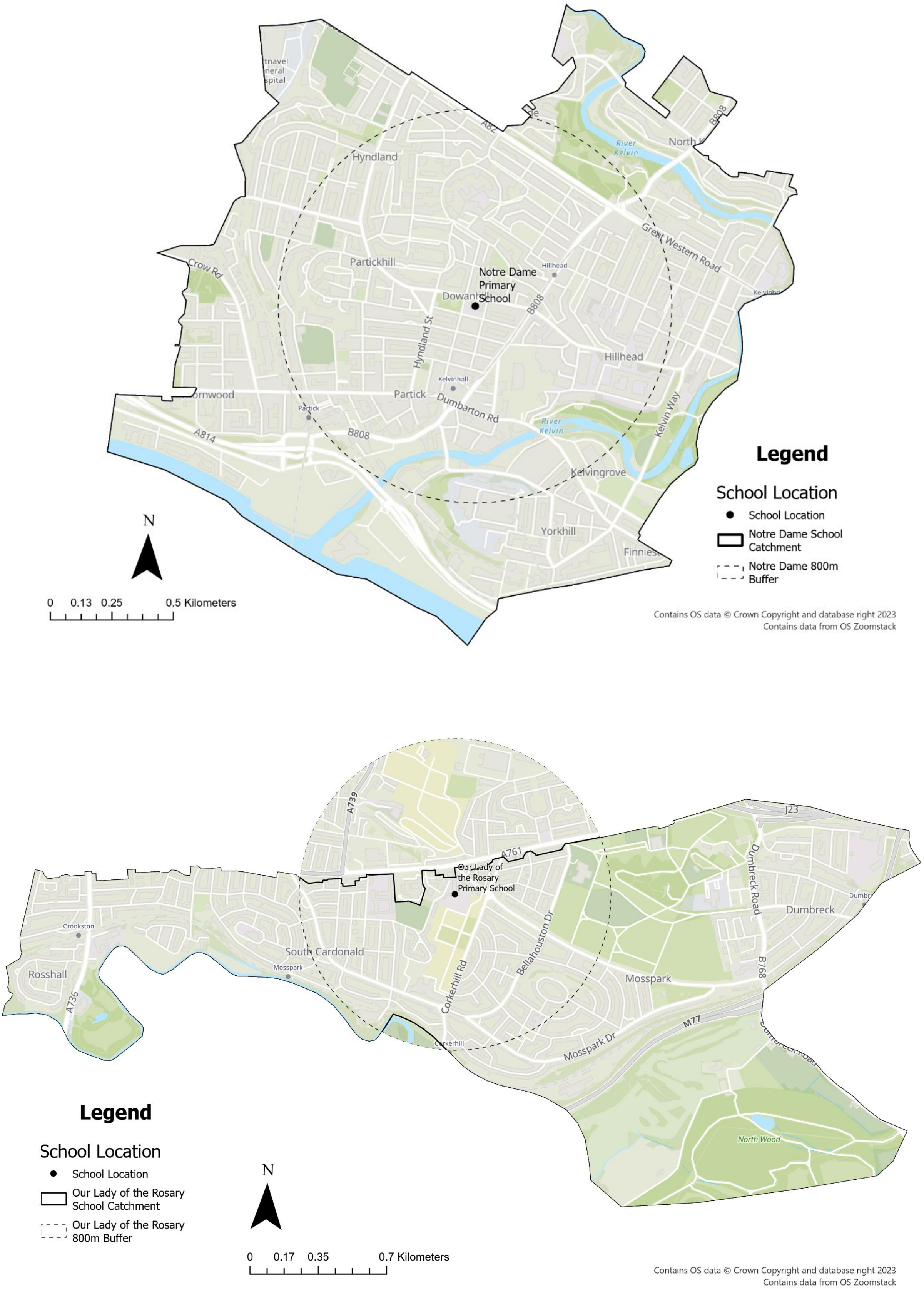

Figure 0-1: Influence of using school catchment compared to an 800m circular buffer around the school location as a means of data aggregation

Appendix 2: Built environment characteristics included in the analysis, method of spatial quantification and rationale for inclusion.

*Calculated area refers to the combined 800m buffer + school catchment approach to quantification (see **Appendix 1**).

Domain	Built environment characteristic	Method of GIS quantification	Rationale
Provision of facilities	Land use mix	Percentage of land use that is non-residential within the calculated area.	Land use mix has been associated with increased AST (Ding et al., 2011), where more destinations tend to be within a short distance of the home – which encourage a greater proportion of journeys to be completed by active modes. Wangzom et al. (2023) also argue this association can be attributed to the 'eyes on the street' – streets with greater land use mix encourage pedestrian presence, in turn improving [perceptions of] safety.
	Availability of greenspace	Percentage of land use that is greenspace within calculated area.	Park routes and presence of neighbourhood green space has been shown to be positively associated with children's AST (Pont et al., 2008; Timperio et al., 2004). Green space provides a safe traffic-free environment where parents are usually more comfortable allowing their children to roam (Wolch et al., 2011).
Safety (including perceptions of)	Parents current travel habits	Percentage of journeys to work done by walking or cycling (Census 2022).	Parents own travel habits are a strong predictor of their perceptions of the built environment. Christian et al. (2015) found that parents who perceive the neighbourhood environment as unsafe for children to move around independently are less likely to grant their children licenses to independently travel to a number of different local destinations.
		Percentage of journeys to work done by private car or van (Census 2022).	
	Lighting	Number of street lighting columns within calculated area.	A built environment that is not maintained well and has a run-down appearance, including improper street lighting, is perceived as unsafe (Loukaitou-Sideris, 2006).
Road safety	Major roads	Length of major road network (A and B road) within calculated area.	When focusing on children, evidence suggests that presence of major roads reduces the ability to cycle (Broberg & Sarjala, 2015; Villanueva et al., 2012; Giles-Corti et al., 2011), however evidence is less clear for active travel more generally. Kullman (2010) found that lower traffic levels and lower speeds improve safety and comfort for AST.
	Road safety accidents	Number of road safety accidents within calculated area (Glasgow City Council).	Areas where accidents are frequent may represent unsafe built environment characteristics, but accidents can also significantly alter parental perceptions of safety – leading to lower uptake in AST (Mehdizadeha et al., 2017). However, Rothman et al. (2015) found that the perception of traffic safety did not always align with the real traffic risks and there was no significant association between the perception of risk along a route and the road accidents.

Social interactions	Residential density	Population density (population / area) of the datazone of the school location.	Increased social interactions have been shown to have an association to AST (Ikeda et al., 2018) – attributed to enhanced perceptions of safety and sense of community, thus potentially facilitating children's active travel (Ikeda et al., 2018). The use of residential density assumes that areas of high density provide more opportunity for social interactions on the route to school.
Infrastructure to assist active travel	Segregated cycle infrastructure	Length of cycle infrastructure within calculated area.	Infrastructure away from traffic is of particular importance for children (Aldred, 2015; Helbich et al., 2016), who don't have the ability to process complex traffic interactions (Wangzom et al., 2023).
	Pedestrianised streets / spaces	Length of pedestrianised infrastructure (including park routes) within calculated area.	
	Crossings	Number of crossings within calculated area.	Ikeda et al., 2020 highlight the significance of crossings around school in order to navigate busier roads.
Urban Form and Street Design	Street connectivity (intersection density)	Total number of road network intersections, divided by the calculated area.	High street connectivity is often shown to be associated to children's active travel (Villanueva et al., 2012; Giles-Corti et al., 2011; Chevalier and Charlemagne, 2020; Helbich et al., 2016). Street connectivity may be so often found to improve children's active travel because the easier ability to traverse their neighbourhood gives parents more confidence in granting autonomy to roam (Villanueva et al., 2012) or by providing more possible interaction points to meet schoolmates (Helbich et al., 2016). However a number of studies have also shown null or negative associations. High proportion of four way intersections has been shown to limit active travel (Broberg & Sarjala, 2015; Mitra & Buliung, 2012), which cater more towards cars. Wong et al. (2011) showed that seven of nine included studies investigating intersection density reported null relationships. Krenn et al. (2014) removed street connectivity from their study, arguing that evidence in European cities is not as conclusive as it is in North America regarding the role of well-connected streets.
Aesthetics	Presence of trees adjacent to carriageway.	Number of trees within a 10m buffer of the road network within the calculated area.	There is some AST research evidence that shows that street trees improve parental perception (Wangzom, et al., 2023).

Control variables

Distance to school is commonly shown to have an inverse association with AST (Curtis et al., 2015; Mitra & Buliung 2012; Wangzom, 2023). Due to the nature of the HUSS dataset, distance to school cannot be accounted for directly in the analysis, however school catchment area size has been controlled for in the absence of a distance metric.

Additional control variables were identified for each domain within the framework set out by Panter et al (2008): individual factors (median household income, car ownership), external factors (availability of cycle training at the school) and moderators (school catchment area size).