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# Determinants of children's active travel to school: A case study in Hong Kong

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ABSTRACT

This paper examines the prevalence of active travel to school and the associated determinants for Hong Kong schoolchildren aged 5–12. Data were collected through questionnaire surveys, which provided information relating to children's travel characteristics for their journeys to school and personal/household socio-demographic characteristics. Secondary data of the geography around children's residences were also obtained, to better understand surrounding street environment, public transit, open and green space and recreational facilities. The geographical features within their residence neighbourhoods were mapped and enumerated. Binary logistic regression modelling was conducted to understand the association between the status of children's active travel to school (binary dependent variable of 'active travel' versus 'not active travel') with socio-demographic and geographical factors (independent variables). The results show that network distance from school and other neighbourhood environment variables, such as street block size, public transit facilities and sport/ leisure venues, are highly significant factors associated with active travel to school. A case study was conducted on one selected primary school, where one third of participating children walked to school, with the majority of walkers living within the neighbourhood of the school. Their most direct routes to school were 10–15 min walks involving 1–2 at-grade crossings. Other pedestrian facilities in the area were also qualitatively examined on-site to better understand the local geographical context of the case study area. The findings inform policy direction on what needs to change for children to lead a healthier and more physically active lifestyle, including improvements in the neighbourhood environment.

## 1. Background and review

In recent years, children's active school travel (AST) has been widely studied in the context of Europe (Pojani and Boussauw, 2014; van Goeverden and de Boer, 2013; Shaw et al., 2013), North America (Rothman et al., 2017; McDonald, 2007; Centers for Disease Control and Prevention, 2004) and the Asia-Pacific region (Wen et al., 2008; Booth et al., 2007; Irawan and Sumi, 2011; Garrard, 2009). AST is well-known to be an important contributor to physical health, with a multitude of favourable fitness and activity outcomes (Armstrong, 1993; Santos et al., 2009; Cooper et al., 2003; Lubans et al., 2011; van Sluijs et al., 2009), and has been shown to be positively associated with psychological wellbeing and development (Leung and Loo, 2017; Romero, 2015; Ramanathan et al., 2014). Despite the many advantages of active travel, however, AST has been on the decline around the world over the years. In Australia, Sydney's percentage of children aged 5–9 walking to school fell from 58% in 1971 to 26% at the turn of the century, while the national American rate of AST for school-aged children fell from around 50% in 1969 to under 15% in 2004 (Garrard, 2009; Centers for Disease Control and Prevention, 2004). In England, where the rate of primary schoolchildren walking to school have remained relatively high at over 60% in 2010, this still marks a considerable decrease from the figure of 81% recorded in 1971 (Shaw et al., 2013). In an increasingly urbanised and motorised world, with built surroundings "designed to prioritize cars", the car culture is deeply ingrained into all aspects of daily life, which explains AST's continuing decline (Rothman et al., 2017, p. 320).

Parents, as role models, and their attitudes to travel and road safety together have considerable influence over their children activities and travel behaviour (Lee et al., 2013; Muir et al., 2017). In cities, perceived danger from heavy traffic has led some parents to drive their children to and from school, to be more assured of their children's safety by reducing traffic exposure (Hillman et al., 1990). However, this has been shown to lead to more congestion especially near residential areas and schools, and completes the vicious cycle of further reducing children's AST due to increased traffic (Tsai et al., 2004). The root of this conflict appears to stem from the heightened expectations on a modern-day, 'good' parent, where on the one hand, children need to be protected

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from dangerous people or situations, i.e. automobiles, strangers, etc., but at the same time need to be allowed the freedom to learn to navigate their neighbourhood and become independent (Valentine, 1997a). On addressing this balance, the likeliest outcome has so far been more in favour of safety first, which would translate to the current predicament of parents chauffeuring their children to and from school and other activities, or children being accompanied to and from school and other activities by domestic helpers. This situation is common in Hong Kong, the location of this present study, and in other Asian cities as well (Karsten, 2014; Douglass, 2006).

At the city-level, studies have discussed AST's associations with socio-demographic characteristics, and separately with neighbourhood environment attributes. Various studies have focused on AST's relationship with gender, where boys were generally more likely to make active journeys to school than girls (Leslie et al., 2010; McMillan et al., 2006). Other factors that have been discussed in the literature on children's travel and physical activity literature include age and adult accompaniment (Rissotto and Tonucci, 2002; Karsten, 2014; Hillman et al., 1990; Rothman et al., 2017), household car ownership (Sener et al., 2008; Panter et al., 2008) and presence of siblings (Leung et al., 2019; Allbaugh et al., 2016; Price et al., 2017). Children seem more likely to be physically active in travel and other activities if they are older and require less accompaniment, come from non-car-available households and have siblings. Regarding neighbourhood environment, shorter journey distances, more interconnected streets and higher accessibility to local facilities, like sport and recreation facilities, parks, playgrounds, etc., were associated with a higher likelihood of walking to school (Kerr et al., 2006; Dalton et al., 2011; Panter et al., 2008; Larsen et al., 2009). Parents' perceptions of the quality and safety of the surrounding neighbourhood environment also influence whether a child travels to school actively. A neighbourhood that is perceived to be dangerous and devoid of child-friendly facilities like parks and playgrounds would not likely encourage AST (Timperio et al., 2006; Lee et al., 2013). Few studies in the literature comprehensively include all the above perspectives together in their analysis (perhaps with the exception of Pojani and Boussauw, 2014).

In Hong Kong, education policy broadly encourages attendance of schools situated within children's own residential neighbourhoods through the allocation of public school places according to children's home locations (Loo and Lam, 2015). Attending school closer to home within the neighbourhood catchment area seems to be a straightforward and beneficial decision. It is less of a burden for children because they do not need to travel as far to go to school, and it is also easier for their family members where supervision, if necessary, becomes less time-consuming and more convenient. More affluent families may even move to different neighbourhoods where parents perceive there to be better school quality and provision of facilities and amenities (Lam and Loo, 2014, 2015), although school quality is just one of many possible reasons for moving home to another location (Yu and Zhu, 2015). Alternatively, some parents choose the option of sending their children to private schools, which have larger region-wide and even Hong Kong-wide catchment areas. Despite the high school tuition fees of private schools, the quality of the education is perceived to be better than public schools (Bray and Kwok, 2003). Around one fifth of all Hong Kong primary schools are part of the private sector (Education Bureau, 2013).

With this backdrop in mind, it is important to include both public and private schools for a more comprehensive overview of the status of AST in Hong Kong. In this part of the world, AST has only been discussed as a side note in the investigation of children's independent mobility, via secondary data from a territory-wide travel-diary style survey (Lam and Loo, 2014). The study showed a rate of just over 50% for primary school children walking to school in their sample, based on a snapshot of the travel characteristics of a section of Hong Kong's population, including primary school-age children, in 2002. With more than a decade gone by, there is an imperative need to more comprehensively understand the status of, and factors associated with, AST for Hong Kong primary school children in the present day, inclusive of those in public and private schools. This study aims to provide an extensive scope of study in the Hong Kong context, to better understand, visualise and analyse the association of AST with the relevant personal and household socio-demographic characteristics, as well as neighbourhood environment attributes around their residences. This study is well-positioned to inform international readers about children's AST in the context of Hong Kong in East Asia, with its dense and compact urban form that shapes AST in different ways and draws conclusions different from studies from other locales. Findings complement previous children's mobility literature along individual, household and neighbourhood lines (Lam and Loo, 2014). Three research questions are proposed, as follows:

1) What is the level of AST in Hong Kong children, by age and gender?
2) How does the neighbourhood environment affect rates of AST?
3) What personal and household socio-demographic characteristics are associated with more AST?

This study seeks to provide answers to the above questions and move toward a broader perspective in understanding children's AST in dense and highly motorised cities like Hong Kong. Through the findings, policymakers may better plan for and maintain neighbourhoods that are more walking-friendly, especially for vulnerable groups such as children and the elderly, and also formulate active travel policies that target relevant groups of children and other transport-disadvantaged groups.

## 2. Methodology

The study incorporated questionnaire survey, GIS and on-site field observation data to provide a comprehensive basis for approaching and answering the research questions. The flow of the data collection and analysis process is shown in Table 1. The following sub-sections will detail and elaborate upon each step of the methodology, from data collection to data analysis methods.

**Table 1**
Flow of data collection and analysis process.

| Step | Target | Action |
|---|---|---|
| 1 | Invite primary schools across Hong Kong to participate in school survey | Invitation letters sent by batches and four schools agreed to participate |
| 2 | Collect travel behaviour and socio-demographic data of child participants | Data obtained from parent questionnaires (valid N = 585) |
| 3 | Collect neighbourhood environment data around child participants' residences | Data obtained from government and other sources |
| 4 | Visualise and enumerate neighbourhood environment variables | Transformed neighbourhood environment data into shapefiles and conducted buffer analysis using ESRI ArcMap 10.5 |
| 5 | Analyse determinant variables of children's active travel to school | Conducted binary logistic regression modelling on IBM SPSS Statistics 25 |
| 6 | Conduct case study to further investigate school neighbourhood environment based on analysis findings | Selected one typical neighbourhood school and closely examined neighbourhood environment via field observations on-site |

### 2.1. Data collection

In the first step, invitation letters for survey participation were sent in randomly selected batches of primary schools in Hong Kong (Education Bureau, 2013). Four schools replied positively, three public and one private, corresponding relatively well with the public–private ratio of primary schools in Hong Kong. This ensures that children studying in private schools have not been left out of the picture. Parents of all students across the four selected schools were notified and given the opportunity to provide consent for participation. Upon obtaining parental consent, school surveys were conducted across 9 school days between November 2015 and June 2016 (Step 2). Primary school students, aged 5 to 12, were administered a questionnaire and also brought home a separate questionnaire for their parents to fill in. The detailed rationale, selection and administration procedure for the school questionnaire surveys can be found elsewhere and are not repeated here (see Leung and Loo, 2017). This study uses the parent questionnaires with valid data for the variables of interest (N = 585), as explained in Section 1, namely place of residence (to calculate network distance) and socio-demographic variables of the child and his/her household (age and gender and number of children, domestic helpers and cars in the household).

To complement the school survey, Step 3 involved the collection of available secondary data of the neighbourhood environment, collected from a variety of sources. Data from 2015 to 2016, when the primary data were collected, were not available and hence data from the closest year (i.e. 2018) were selected instead. None of the students' residences were in Hong Kong's most recent new development areas (see Task Force on Land Supply, 2018). Students primarily resided in urban and established new town areas of Hong Kong, where the neighbourhood facilities and streetscapes are settled and without major developments in terms of new transit stops or new leisure facilities. Differences in the neighbourhood environment between 2015 to 2016 and 2018, if any, would be negligible. From the Lands Department (2018) of the Hong Kong SAR Government, sport and leisure facility locations and public transit data, including bus routes and locations of bus stops and tram stops, were collected. Road network and land use type data were extracted from OpenStreetMap (2018). Government data are a reliable and authoritative source, and open source data are also quickly becoming increasingly accessible and popular in transportation studies around the world, either as the primary data resource or to complement other sources of data (e.g. Boeing, 2018; also see discussion in de Kadt et al., 2014). Also, metro station entrance/ exit locations were obtained from location maps produced by the metro operator (MTR, 2018). The wealth of data in this study provides a high level of detail not easily available in other study locations.

### 2.2. Methods of analysis

Moving onto the fourth step, these data were downloaded in their respective point, line and polygon formats. Using information about the child participants' residences, as provided in the parent questionnaires, XY coordinates were obtained, and network distance from school was calculated as a travel characteristics variable. After loading these data onto ESRI ArcMap 10.5, 500-metre buffers were created around each residence point, indicative of a distance reachable within a ten-minute walk, to represent the children's surrounding neighbourhood area (Loo and du Verle, 2017; Loo et al., 2017a). Buffer analysis was conducted to enumerate the sum of points, length of lines and percentage of polygons within the neighbourhood areas and overlaid on the Hong Kong base map to represent the neighbourhood environment characteristics around children's residences. To measure street connectivity within the neighbourhood, further transformation was required on the road network data. Street block size, as a measure of street interconnectivity, was generated in accordance with the block section measurement method suggested by Stangl (2015). Firstly, a 5-metre buffer was created around each road centreline, to approximate the area covered by a standard two-lane road and pavement as a road area polygon, in accordance with the *Hong Kong Planning Standards and Guidelines* (Planning Department, 2018) (motorways and trunk roads are not part of the walkable street network and were not considered in the analysis). Next, the area covered by the road polygon was erased from the Hong Kong base map, and each individual parcel of land that remained, enclosed by streets on all sides, was considered as a street block. Block section length, defined as the "maximum distance between any two points on the perimeter of a block" (Stangl, 2015, p. 4) was generated for all street blocks. The median block section length was calculated for all street blocks partially or fully within each child neighbourhood, serving as the street block size indicator in this study. The median was used to prevent irregularly large street blocks from skewing the street block size indicator away from a truthful representation of the reality on the ground.

In Step 5, to understand the children's socio-demographic characteristics and neighbourhood environment in which they lived, descriptive statistics were generated. Next, binary logistic regression modelling was conducted on IBM SPSS Statistics 25 to better understand the factors associated with AST, using a binary dependent variable of whether the child's journey to school was undertaken by active transport (i.e. walking or cycling) or not, with the independent variables including 1) network distance from school, 2) neighbourhood environment characteristics and 3) personal and household socio-demographic characteristics. For 1), the network distance was treated as a continuous variable and not grouped. For 2), public transport facilities were merged together into one single variable consisting the sum of bus, tram and Light Rail stops and metro station entrances/ exits, to serve as a composite measure of public transportation access in the area. For the street connectivity indicator, block section length was treated as a continuous variable. Block size-based measures have been gaining in popularity in the literature in recent years (see Berrigan et al., 2010), and smaller block sizes are indicative of more fine-grained and inter-connected neighbourhood streets (US Green Building Council, 2009). Sport and leisure facility data, also treated as a continuous variable, were used to represent the recreational opportunities in the neighbourhood area. The open and green space variable, measured as a percentage of neighbourhood area, included only such areas that can easily be accessed (i.e. OpenStreetMap land use data marked as 'park', 'garden' or 'playground', and excluding dense woodland, shrubbed slopes, etc.) It is a comprehensive measure of the amount of open-air recreational space where children can travel by, play and socialise in. For 3), apart from age and number of cars in household, which were modelled as continuous variables, the gender, domestic helper and number of children measures were all dummy coded as binary variables, with reference values being 'female', 'does not have a domestic helper' and 'is not an only child'. These specifications are straightforward to interpret and understand. Better knowledge of the various determinants of AST would be of considerable interest especially for policymakers who intend to target active travel-friendly policies toward different groups of children of different socio-demographic attributes and in a variety of geographical contexts.

Finally, moving onto the case study in Step 6, the authors conducted on-site field observations of the neighbourhood environment around one school, chosen with reference to the findings from the binary logistic regression analysis. The purpose of this on-site examination was to gain a deeper understanding of the variety of walking facilities and recreational space provision within a typical Hong Kong school neighbourhood. Results were presented in the form of maps, descriptive statistics and photographs of the area. This case study enables readers to visualise the geographical distribution of children with AST and also to recognise that neighbourhood environment attributes should be comprehensively considered at a micro-scale as well, beyond the analysis of territory-wide data from government and other sources.

**Table 2**
Descriptive statistics of the child participants.

| Characteristics | Description | Mean/% | SD |
|---|---|---|---|
| Personal | Age | 8.7 | 1.74 |
| | Male | 58.6^ | / |
| Household | Has car(s) | 29.6^ | / |
| | Has domestic helper(s) | 40.7^ | / |
| | Is the only child | 28.0^ | / |
| Travel to school | Independent* | 10.1^ | / |
| | Active* | 37.1^ | / |
| | Travel time (minutes) | 19.5 | 12.5 |
| | Network distance (kilometres) | 4.56 | 5.97 |
| Neighbourhood environment | Bus routes | 47.2 | 33.7 |
| | Bus stops | 22.2 | 12.3 |
| | Metro station entrances/ exits | 4.10 | 3.34 |
| | Tram/ Light Rail stops | 3.46 | 4.09 |
| | Street block size (metres) | 219 | 257 |
| | Sport/ leisure facilities | 5.03 | 3.60 |
| | Open and green space (%) | 5.97 | 4.31 |

^ = % of child participants (N = 585).
* Note: Child participants can travel to school actively, independently or both actively *and* independently.

## 3. Findings and discussion

This section provides an overview of the child participants in the study, including their travel behaviour to school, as well as their personal, household and neighbourhood environment characteristics. The estimation results of the binary logistic regression model in establishing the determinants of children's AST are also described and discussed in detail.

### 3.1. Descriptive statistics

Descriptive statistics of the child participants are shown in Table 2, with respect to their personal, household, travel to school and neighbourhood environment characteristics. The child participants had a mean age of 8.7 years, and 59% were boys. 41% had one or more domestic helper at home, 28% were the only child in the household and 30% of the children came from car-available households. Hong Kong's general population studying in primary schools had a mean age of 8.1 years and was 52% male (Education Bureau, 2016). For households in Hong Kong with children, 30–44% employ a domestic helper (Legislative Council Secretariat, 2017) and 63% are single-child households (Census and Statistics Department, 2018). Private vehicles were available for 15–28% of three-, four- and five-person households (here inclusive of childless households in the absence of a more sophisticated classification for this indicator) (Transport Department, 2014). While there seems to be an overrepresentation of children with siblings in the study data, which may be attributed to siblings attending the same school (Hui, 2015), the sample of child participants in this study is a satisfactory representation of the whole population of primary school students in Hong Kong. The mean travel time for the journey to school was around 20 min with a network distance of 4.6 km. 10% went to school independently (i.e. without adult accompaniment), and 37% travelled actively to school. These figures serve as an important reference of the characteristics representative of the children in this study. In particular, the figures for travel to school are considerably lower than the 29% (independent travel) and 51% (active travel) recorded in Lam and Loo (2014). This is a clear indication of an apparent decrease in children's independent and active mobility, in line with similar declining trends around the world (Shaw et al., 2013; Fyhri and Hjorthol, 2009).

Regarding children's neighbourhoods in the study, there were a mean of 47 bus routes, 22 bus stops, 4 metro exits and 3 tram stops. The street connectivity indicator, represented by street block size, had a mean of 219 m. Sport and leisure facilities averaged at 5, while open and green space percentage stood at around 6%. These figures provide useful context to understand what residential environments are typical of Hong Kong. In this part of the world, high-rise, high-density and high-intensity developments are common and increasingly more so, with open and green space at a premium (Chiu, 2007; Lau et al., 2005; Barter, 2012).

### 3.2. Travel characteristics to school

Child participants' travel characteristics to school are shown in Table 3. All active travellers (37%) travelled to school on foot, and none by bicycle. In Hong Kong, cycling is still mainly for recreation, and is not seen as a viable option for commuting to and from work and school (Loo et al., 2019; Loo and Tsui, 2010). Safety concerns and topographical realities are the main barriers preventing cycling as a travel mode for children and adults alike to become more popular, as are the lack of safety-in-number benefits that are common in European countries such as Denmark or the Netherlands (Yao and Loo, 2016). The next largest proportion of travel modes was school bus at 35%, followed by rail (including metro and tram) at 10% and other public transport at 9%. Those who travelled to school by private car or taxi accounted for around 8% of the sample. From Table 3, the percentage share of walking and public transport was higher for boys and older children than girls and younger children. The reverse was true for school bus and other private transportation. These descriptions are in line with societal norms that appear to be more protective of and place more restrictions on mobility upon girls and younger children than boys and older children (Fyhri and Hjorthol, 2009; Leung et al., 2019).

### 3.3. Binary logistic regression modelling

A binary logistic regression model was constructed to understand the predictors of children's AST, shown in Table 4, with three groups of variables entered, namely 1) network distance from school, 2) neighbourhood environment characteristics and 3) personal and household socio-demographic characteristics. Network distance from school was

**Table 3**
Child participants' travel characteristics to school.

| Description | | Walk | | Rail | | Other public transport | | School bus | | Car and taxi | | Overall | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *f* | *r%* | *f* | *r%* | *f* | *r%* | *f* | *r%* | *f* | *r%* | *N* | *col %* |
| Age | 5–6 | 21 | *30.4* | 3 | *4.3* | 6 | *8.7* | 31 | *44.9* | 8 | *11.6* | 69 | *11.8* |
| | 7 | 31 | *30.7* | 10 | *9.9* | 8 | *7.9* | 42 | *41.6* | 10 | *9.9* | 101 | *17.3* |
| | 8 | 47 | *43.1* | 8 | *7.3* | 6 | *5.5* | 38 | *34.9* | 10 | *9.2* | 109 | *18.6* |
| | 9 | 35 | *31.0* | 9 | *8.0* | 15 | *13.3* | 47 | *41.6* | 7 | *6.2* | 113 | *19.3* |
| | 10 | 37 | *39.8* | 10 | *10.8* | 9 | *9.7* | 28 | *30.1* | 9 | *9.7* | 93 | *15.9* |
| | 11–12 | 46 | *46.0* | 20 | *20.0* | 10 | *10.0* | 19 | *19.0* | 5 | *5.0* | 100 | *17.1* |
| Gender | Male | 132 | *38.5* | 36 | *10.5* | 34 | *9.9* | 116 | *33.8* | 25 | *7.3* | 343 | *58.6* |
| | Female | 85 | *35.1* | 24 | *9.9* | 20 | *8.3* | 89 | *36.8* | 24 | *9.9* | 242 | *41.4* |
| Overall | | 217 | *37.1* | 60 | *10.3* | 54 | *9.2* | 205 | *35.0* | 49 | *8.4* | 585 | *100.0* |

**Table 4**
Final binary logistic regression model showing the determinants of children's AST.

| Description | | Sig. | Exp(B) |
|---|---|---|---|
| Travel to school | Network distance from school (kilometres) | 0.000*** | 0.329 |
| Neighbourhood environment | No. of public transit facilities | 0.000*** | 1.042 |
| | Street block size (metres) | 0.035* | 0.997 |
| | No. of sport and leisure locations | 0.000*** | 1.363 |
| | Open and green space area (%) | 0.002** | 0.857 |
| Personal and household socio-demographic characteristics | Child age (years) | 0.035* | 1.169 |
| | Male child | 0.489 | 1.191 |
| | Only child in household | 0.698 | 0.902 |
| | Household has helper | 0.049* | 0.562 |
| | No. of cars in household | 0.926 | 0.977 |
| Constant | | 0.518 | 0.585 |
| Cox & Snell R Square | | 0.456 | |
| Nagelkerke R Square | | 0.623 | |

*** = $p < 0.001$; ** = $p < 0.01$; * = $p < 0.05$.

entered first. Next, the variables consisting the neighbourhood environment characteristics were entered, namely public transit facilities, street block size, sport and leisure locations and percentage of open and green space. Finally, personal and household socio-demographic characteristics were entered, consisting of age, gender, single child in household, presence of helper in household and number of cars in household.

The results of the final model showed the network distance variable to be highly significant and negatively associated with AST at the $p < 0.001$ level, with every kilometre increase in network distance from school associated with a 67.1% reduction in likelihood of children travelling actively. For larger distances, especially residences in excess of 2 km away from school, walking becomes an increasingly unrealistic option, and this is congruent with the current literature (Panter et al., 2008; Dalton et al., 2011; Larsen et al., 2009; Lubans et al., 2011).

For neighbourhood environment variables, there was a highly significant positive association between the presence of public transit facilities with AST at the $p < 0.001$ level. Each unit increase in public transit facilities was associated with a 4.2% increase in likelihood of active travel to school for children. This finding is in line with most studies in the literature (see Wang and Wen, 2017), which indicate that areas with good access to public transportation are compact, urban and highly amenable for active travel behaviour as well, in contrast to poorly connected and car-oriented suburban or rural areas. With that being said, some studies have also shown there to be an association between better perceived public transport access with more active travel behaviour (e.g. Timperio et al., 2004; Handy et al., 2006). In other words, neighbourhoods may not necessarily need to have a great quantity of public transit facilities to be seen to have 'good' public transport. Future research may move beyond quantity and further consider the quality and convenience of access to public transit, and their relationship with sustainable travel modes.

To represent neighbourhood street connectivity, the street block size indicator was significant and negatively associated with AST at the $p < 0.05$ level, indicative of a 0.3% reduction in likelihood of travelling actively to school with every metre increase in block section length. Larger street block sizes are often accompanied by wider roads and larger traffic volumes (Tao et al., 2010), which means it would be more difficult for children to explore their neighbourhood and community by walking to and from school. The neighbourhood would be less walkable as a whole, with fewer route choices. This finding is in agreement with past literature investigating street connectivity with respect to children's AST (e.g. Dalton et al., 2011; Kerr et al., 2006), and has also been echoed in studies about work commutes and other trips (e.g. Fan et al., 2014, 2017).

Sport and leisure facilities were also positively associated with AST and highly significant to $p < 0.001$, with an increase of 36.3% in likelihood of children to travel actively with a unit increase in the number of facilities. This means that children can easily visit these play areas on the way to and from school, illustrating the importance of having these places and facilities that enable children to have fun and socialise with their friends. This finding echoes that of Timperio et al. (2004), which reported an association between parental perceptions of limited sporting venues in neighbourhoods with reduced AST, and Panter et al. (2008), which finds that children are more likely to travel actively to destinations if there are recreational facilities for them to visit and play in along the way.

Percentage of open and green space was negatively associated with AST, significant to $p < 0.01$, indicative of a 14.3% reduction in likelihood of active travel with every percentage increase of open and green space. This result must be interpreted with care, as there are reasonable contextual explanations for this seemingly unexpected result. One consideration is that the presence of open and green spaces (e.g. large parks) may in some situations be an impediment to active travel, particularly in commutes (Wang and Wen, 2017; Fan et al., 2014; Fan et al., 2017). Indeed, a recent Finnish study revealed that an increased proportion of open and green space was associated with a lower likelihood of active travel to work (Mäki-Opas et al., 2016). Perhaps better access to green spaces like urban parks only encourages physical activity heading to and from, and within, these spaces, rather than in commutes. Future studies that comprehensively consider physical activity purposes including AST and beyond, such as travel to other activities, doing sports, etc., would be well-positioned to further investigate the relationship of active travel behaviour with open and green spaces.

Regarding personal and household socio-demographic characteristics, older children were more likely to be walkers to school, significant to the $p < 0.05$ level, indicative of a 16.9% increase in likelihood of children travelling actively to school for every unit increase in age (in years). This is in line with discussions in Rothman et al. (2017). As children grow older, they become more mature and are more capable to navigate their way on foot compared with younger children. Households with domestic helpers were negatively associated with children's AST, significant to the $p < 0.05$ level, and the likelihood of children in these households to be active travellers to school was 43.8% less than households with no domestic helpers. Employment of a domestic helper can be seen as a proxy measure for household income, since only families that are wealthier and of a higher socioeconomic status can afford a domestic helper. These findings are in line with research that shows an inverse relationship between family-level socioeconomic status (inclusive of household income measures) and the likelihood of active travel to school (Chillón et al., 2009; Carlin et al., 1997). Drilling deeper into the issue, the negative relationship between domestic helper employment and children's AST appears to be a reflection of the culture of supervision and protectiveness in Hong Kong, especially among wealthier households. Working-class families are

often struggling to make ends meet and cannot afford a domestic helper. Having their child(ren) walk to school (with or without adult supervision) would be the most straightforward and inexpensive option. More well-off families, on the other hand, can afford a domestic helper. The domestic helper would be expected to escort the child on journeys that children are perceived to be unable to make alone, even relatively short journeys to school (Lam and Loo, 2014; Karsten, 2014). These journeys would more conveniently be undertaken by motorised travel (e.g. by bus, school bus or metro), which is quicker than walking and would allow the domestic helper more time to complete other errands. In Hong Kong and increasingly in other Asian societies, it is common for middle-class families to employ domestic helpers to take care of children as a result of more and more households becoming dual-earner ones (The Hong Kong Council of Social Service, 2013). Future research should continue to address the effect of having a domestic helper, as well as interactions between different members of the household, on children's active and independent mobility for school travel and beyond.

Child gender was not significant to the $p < 0.05$ threshold, and neither were single-child households nor the number of cars in the household. This was unexpected, given common associations between gender (McMillan et al., 2006) and car ownership (Panter et al., 2008) with AST. The more significant explanations of variance by network distance from school and neighbourhood environment characteristics together may mean that the personal and household socio-demographic variables, while requiring attention, are relatively less important. The Nagelkerke R-squared value was 0.623, which indicates that 62.3% of the variance in the final model can be attributed to network distance, neighbourhood environment characteristics and personal and household socio-demographic characteristics variables together.

## 4. Case study of one selected school

With reference to the binary logistic regression model result that shorter distances are associated with more walking to school, one school in Kwun Tong District was selected for a detailed on-site field observation and qualitative examination of the surrounding environment. Children at this school had relatively lower travel distance and duration to school in comparison with the other three schools surveyed, and serves as a prime example of a neighbourhood school (see Bosetti, 2004), where the school is situated within the neighbourhood of a majority of the children's residences.

Two maps have been produced in Figs. 1a and b, which illustrate children's residential locations ($N = 152$) relative to their school location, the neighbourhood environment and also the distribution of children who do and do not walk to school. As seen from Fig. 1a, the children live relatively close to the school with those living outside and inside the neighbourhood of the school being a roughly half-half split (52% outside vs 48% inside). In Fig. 1b, the vast majority of children walking to school resided within the school neighbourhood, in government-sponsored housing estates, with residential locations of children not walking to school removed for better visualisation in the map. The most direct routes would typically be 10–15 min walks, via 1–2 road crossings and primarily along roadside pavements. From Table 5, more than two thirds of children at the selected school did not walk to school, and of those who did, a larger percentage were male and of older age, in line with the previous discussion about age, gender and AST in Sections 3.2 and 3.3. Fig. 2a–f are photographs of some walking facilities in the area surrounding the selected school. Apart from facilities more typically associated with walking, like pavements and signalised road crossings, which can be accounted for by the street block size indicator in this study, there are also footbridges, escalators, housing estate podiums, covered walkways and indoor walkways in the area. These facilities are beyond traditional street connectivity measures, necessitating a further assessment of the neighbourhood environment and walking facilities at a micro-scale. Their importance as part of the pedestrian network are discussed in detail in the following paragraphs.

With over 8000 m in road distance within the selected school's neighbourhood area, roadside pavements and at-grade signalised/ non-signalised crossings that traverse these roads are a common sight here, and also an important part of every school journey. The majority of the pavements in the neighbourhood area are 3 to 4 m wide, in line with the *Hong Kong Planning Standards and Guidelines* (Planning Department, 2018), which notes that footpaths need to be a minimum of 2 m in width to cater for basic pedestrian access and flow, and preferably at least 3.5 m wide for those that provide access to residential areas. Fig. 2a shows a pavement in the case study area. Typically, pavements in the area are situated between the road on one side and a concrete wall or slope (which may be greened) on the other. In this particular location, the pavement is partially covered overhead by an overhanging building façade and mostly in the shade. It appears to be a rather claustrophobic environment, being situated adjacent to a high-walled car park and its 30- to 40-storey residential block complex above. In the case study area, pavements serve as access passageways and locations for public transit stops, with little street furniture, barring traffic barriers and road signs. These routes, with a lack of shops, seating area or greenery and accompanied by a large street block, are rather undesirable for pedestrians (Giles-Corti et al., 2009; Loo and Lam, 2012), especially for children, who usually prefer there to be more natural elements and/ or retail facilities in finer-grained areas for them to enjoy walking to and from school (Romero, 2015).

Footbridges and escalators are important components of the elevated pedestrian network in the study area, as connectors between destinations separated by elevation differences, busy roads, or both (Tan and Xue, 2014; Lau et al., 2005). Fig. 2b shows a footbridge, arching over a main road, that connects a housing estate with the main shopping centre in the study area. This particular footbridge is outdoors and high-ceilinged, enabling natural light and wind to easily reach pedestrians using it. It is also well-equipped with ceiling lighting for pedestrians moving about in the evening and also has tactile strips for the blind. There are also indoor and air-conditioned footbridges connecting between other shopping centres and housing estates in the area. Footbridges provide safe ways to cross main roads especially for travel-disadvantaged groups like children, disabled people and the elderly (Loo and Lam, 2012). Fig. 2c shows a system of escalators connecting the ground level near the metro station to a housing estate, podium and shopping centre that are on higher elevation. Pedestrians are able to move between destinations more easily, and for children attending this school who need to use or pass by the metro station, escalator connections provide the option of making the journey by walking, instead of taking a connecting bus or minibus to reach the school. While the escalator systems in this district are more piecemeal and on a smaller scale compared to the well-known Central to Mid-Levels escalator and walkway system at the heart of Hong Kong's central business district (CBD), escalator connectors can help to reduce transport costs for both the user and the authorities (Zacharias, 2011). As long as they are used safely, escalators provide an efficient and comfortable alternative for short-distance travel between locations that differ in elevation without needing to use a stairway or motorised transportation.

Finally, the case study area also has a multitude of elevated estate podiums with open areas, covered walkways and seating on the side, as well as shopping centres that, in effect, are also providers of indoor passageways connecting different destinations, as shown in Fig. 2d, e and f respectively. These communal spaces are places where children can play, socialise and explore their own neighbourhood (Valentine, 1997b), with a variety of destinations like shops, playgrounds, leisure facilities and podium gardens on the way to and from school. The elevated estate podiums in the case study area also serve as connectors between different housing blocks, and pedestrians who are in a hurry or only need to pass through the area can easily use the covered walkways on the podium, providing shelter against the elements. Shopping

**Table 5**
Descriptive statistics of the child participants' AST status at one selected school.

| Description | | Walk | | Not walk | | Overall | |
|---|---|---|---|---|---|---|---|
| | | *f* | *r%* | *f* | *r%* | *N* | *col%* |
| Age | 5–8 | 18 | *26.5* | 50 | *73.5* | 68 | *44.7* |
| | 9–12 | 31 | *36.9* | 53 | *63.1* | 84 | *55.3* |
| Gender | Male | 30 | *33.7* | 59 | *66.3* | 89 | *58.6* |
| | Female | 19 | *30.2* | 44 | *69.8* | 63 | *41.4* |
| Overall | | 49 | *32.2* | 103 | *67.8* | 152 | *100.0* |

centres can be understood as another form of communal space in the case study area, providing retail and entertainment opportunities for children and their parents alike. The indoor passageways of shopping centres, like the one shown in Fig. 2f, are also important parts of the pedestrian network that must not be neglected, because they also connect between housing estates, the metro station and the public transport interchange, and in effect are also pedestrian links (Lau et al., 2005). The important caveat, of course, is that these privately-owned communal spaces need to be properly managed and still provide for the social needs of local people in the area – children, adults and the elderly alike (Luk, 2009; Tan and Xue, 2014) – for the neighbourhood environment to be desirable and convenient.

## 5. Conclusion and recommendations

This study has provided a timely overview of children's AST in Hong Kong and its associated factors through descriptive statistics and binary logistic regression modelling. The rate of AST in Hong Kong at 37%, as revealed by this study, is considerably lower than in other East Asian contexts, such as Beijing (60–70%) and the urban areas of Japan (nearly 100%) (Li and Zhao, 2015; Zhang et al., 2017; Mori et al., 2012). There are many context-dependent reasons setting Hong Kong apart that may

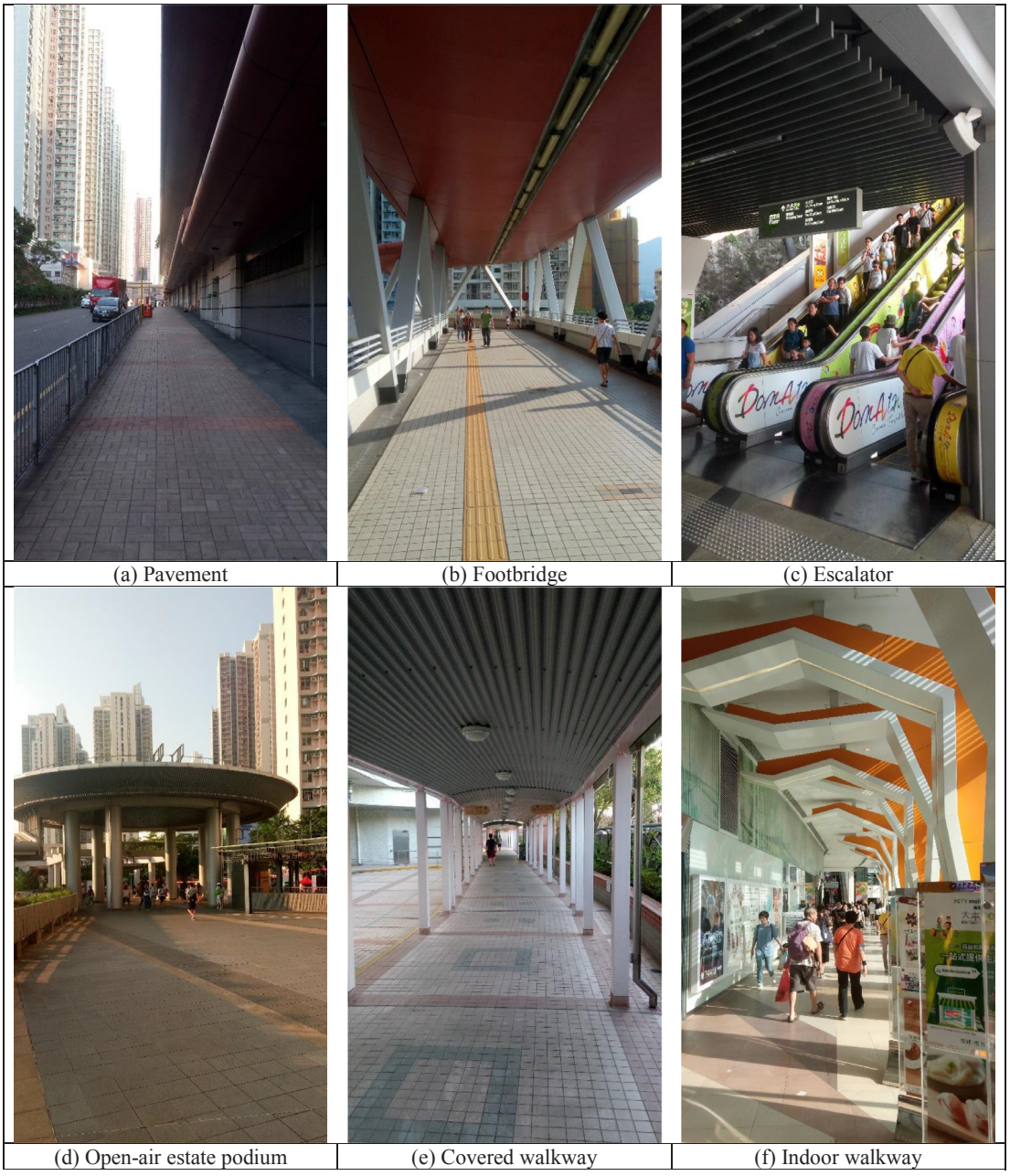


**Fig. 2.** An overview of different types of walking facilities in the pedestrian network in and around the neighbourhood area of one school in Kwun Tong District.

help to explain these differences. Hilly topography makes active travel, especially cycling, less amenable (Loo et al., 2019). In contrast, Beijing's flat topography seems to be one reason why a substantial proportion of students are able to cycle to school. Furthermore, policy factors also come into play. Japan's extensive public education policy that comes with strong encouragement of walk-to-school practices (Mori et al., 2012) differs quite significantly with Hong Kong's policy of developing a strong private school sector (Choi, 2005). This appears to be an important contributor to the further travel distances in Hong Kong as a whole, which leads to active travel being less feasible when compared with other East Asian societies. Clearly, even within the East Asian context, there are many differences despite cities being similarly high-density, compact and busy in traffic. Future studies may consider cross-city and cross-regional comparisons that would help researchers to further understand how location-specific factors – including but not limited to neighbourhood environment, topography, local policy, etc. – may influence AST rates and whether lessons can be learnt from the differences between locations.

This study also visualised a typical school neighbourhood area and its environmental attributes through maps and a presentation of on-site field observations. In the case study neighbourhood area, despite the roadside pedestrian environment being rather perfunctory and nondescript, and some street blocks being relatively large, other pedestrian facilities (many of them elevated) have compensated for this deficiency and enabled pedestrian networks to stay interconnected, which illustrates the importance of micro-scale considerations of pedestrian network connectivity. This study exemplifies the advantages of using both quantitative and qualitative methods to conduct research. Future studies may further consider children's and their parents' perceptions of the neighbourhood environment, stranger danger, road safety and their (children's) own abilities in navigating the road environment and daily activities. Academics should also begin to pay more attention to the different types of open and green spaces aside of parks, gardens and playgrounds, and how they influence travel behaviour. For example, there are spaces that are privately owned and/ or have not been properly documented, such as estate podiums, rooftop gardens, indoor/ covered areas within shopping centres, and these may have important influences on whether active travel occurs (Valentine, 1997b; Lau et al., 2005). Research into these aspects of children's mobility and road safety would be highly useful for researchers and policymakers in East Asia and beyond to develop and implement policies that can improve rates of active travel.

There is an opportunity for the education authorities to better allocate children to schools that are closer to their residences, as shorter route distances make active travel far more likely. In many cities, children's residence locations are taken into account when public schools are allocated to them as they prepare to enter primary school, and a similar policy exists in Hong Kong (Loo and Lam, 2015). However, parents may also have numerous other rationales and considerations when selecting a 'good' primary school for their child, especially those who can afford to educate their children in private schools, such as school reputation, teaching quality, smaller class size, etc., and the so-called 'good' schools may not always be within their neighbourhood of residence (Bosetti, 2004). To resolve this, there would need to be further incentives for parents to select schools in closer proximity, such as improvement in the quality of teaching and school reputation at neighbourhood schools at the longer term, given the trade-off in school choice observed between academic quality and distance to school (Burgess et al., 2015). At this juncture, the deliberate decision to move to certain neighbourhoods with better schools and better neighbourhood quality, i.e. residential self-selection, also needs to be mentioned. Although residential self-selection has not been considered in this study's model, future researchers may need to consider parental attitudinal factors relevant to residence location, especially to do with lifestyle choices (e.g. preference of a greener and more active lifestyle) and the choices they make for their children (e.g. enrolment into a school with better reputation) (Ettema and Nieuwenhuis, 2017; Leung et al., 2019). Ultimately, the key message is that attending a neighbourhood school has the advantage of most necessities being nearby, and young children would not need to travel too far to go to school, attend extra-curricular activities and to play with their friends (Leung et al., 2019). Active travel, as a result, becomes much more amenable.

Policymakers should also consider improvements to the neighbourhood environment and move toward compact, mixed-use and pedestrian-friendly designs that have a variety of destinations for residents to go to, which has been shown to increase walking behaviour (Giles-Corti et al., 2009; Loo et al., 2017b). The association between AST and more sport and leisure venues and public transit facilities shows that the provision of greater activity opportunities and destinations is related with increased physical activity in children, whether with more active travel, increased sport activities or both (Leung et al., 2019). On a related note, given the understandably protective mindset of parents, policymakers may also consider working with schools to make provisions for implementing programmes that encourage walking to and from school (Walking School Bus, 2018; Lee et al., 2017), as an alternative option for short journeys that are currently undertaken via public transportation or operated by school bus services. Parents would be aware that their children are being safely supervised home or to their after-school activities, while the children are able to obtain the physical activity that they need for healthy physical development.

In conclusion, this study has provided a quantitative and qualitative examination of AST and its associated factors of the neighbourhood environment and socio-demographic attributes for Hong Kong children. Future research should focus on investigating children's and parents' perceptions on the neighbourhood environment, concerns for safety, lifestyle decisions and personal capabilities. Researchers should also look beyond streets alone to examine the effects of the whole pedestrian network (elevated, at-grade and underground) on travel behaviour, in a world where cities are becoming increasingly vertically oriented and developing not only laterally, but also upwards and downwards. This needs to be accompanied by the appropriate changes in education policy and improvements in the neighbourhood environment, making use of lessons to be learnt from future cross-city and cross-regional comparison studies, in order for children to be able to walk on their journeys to and from school safely and happily.

## CRediT authorship contribution statement

**Kevin Y.K. Leung:** Software, Validation, Formal analysis, Investigation, Data curation, Writing - original draft, Writing - review & editing, Visualization. **Becky P.Y. Loo:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Writing - review & editing, Supervision, Project administration, Funding acquisition.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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