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REVIEW ARTICLE

Children's active trips to school: a review and analysis

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This paper provides a review of academic articles in English and some in Spanish, concerning active trips (walking and cycling) to school. It was found that decision on transport mode to travel to school can be rather complex, which is affected by environmental, social, economic, and geographical factors. Experiences from existing programmes and policies highlight the importance of complementing engineering approaches with education to increase active trips and to improve safety. 'Proactive trips' programmes should consider parental concerns and time constraints. Active trips provide benefits for children and parents, yet an attendant risk of being involved in traffic accident exists. There is a notable dearth of research into children's active trips to school (ATS) for tropical environments, and analysis of the economic impact of ATS is minimal. Practices highlighted in this paper can be implemented in countries with conducive active trips infrastructure such as Singapore.

Keywords: children; active mobility; non-motorised transport; trips to school; influencing factors

1. Introduction

In line with the growing research interest in sustainability and 'green' transport modes, authorities, researchers, and planners have, in recent years, started to focus on non-motorised transport or active mobility, mainly walking and cycling. Children's mobility recently gained popularity in many fields of studies, for example, medical, social science, and engineering disciplines, and increasing number of research articles has been published in this regard. Trips to/from school are part of most children's daily activity. Thus, many researchers choose these trips to analyse children's active trips characteristics, determine factors that affect children's mobility, and develop policies and/or programmes that encourage walking and/or cycling among children (Morency & Demers 2010; Stanley et al. 2015). Given that trips TO school are more routine, that is, less variation and follow an approximately common commuting time, they are more often analysed than trips FROM school (McMillan 2007; Yeung et al. 2008; Hume et al. 2009b).

Trips to school have undergone changes. Around three decades ago, most children commuted to school on foot or by bicycle. However, in recent years, walking and cycling have been overtaken by motorised transport modes. Child (ren) being driven to school engenders inactivity and contributes to traffic congestion, especially in the AM peak hour (McDonald & Aalborg 2009; Carver et al. 2013a). To address the situation, ways to 'revive' active trips to school (ATS) are being analysed (Buliung et al. 2011). Influences of different factors upon school mode choice have been much studied (Bringolf-Isler et al. 2008; Larsen et al. 2009; Mitra et al. 2010). Impacts of trips to school on physical health have also been examined, with walking and cycling trips being

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the most common trips studied (Mitra & Buliung 2015; Stanley et al. 2015).

The current paper presents a comprehensive review of the available literature (mostly in English language domain, with some in Spanish) on children's ATS. Following Mitra's framework, the paper helps to gain insights into the main issues that affect ATS, highlights best practices, forestalls the potential of value-add areas for future research. In addition, aspects that affect children's ATS that are specific to certain geographical areas are also indicated. Three main areas were considered and compared for the review:

(1) Factors that exert influence on children's ATS;
(2) Policies and programmes that encourage/facilitate ATS; and
(3) Benefits and risks of walking and/or cycling to school.

Following this introduction, the methodology for gathering 'trips to school literature database' is elaborated and the most common areas covered by researchers are presented (Section 2). In Section 3, key frameworks previously formulated to analyse children's trips to school are introduced. Afterwards, environmental factors influencing ATS discussed in the literature are presented (Section 4), followed by social and economic factors (Section 5). Then, most relevant external factors are discussed (Section 6). Finally, the current review concludes with gaps found in the literature, highlighting the niches for future research with discussion on ways to address them.

2. Data retrieving method

To gather a comprehensive database, available articles regarding children's trips to school were collected. An online search was carried on 'Scopus' platform. Scopus is a major database for different types of literature, and it covers international journals for most disciplines (Elsevier 2011). In addition, 'Google Scholar' was selected to collect additional publications, for example, references cited in core papers, pertaining to areas covered in this review study. The first online search was conducted using the following keywords: 'child* AND trips to school AND travel to school OR journey to school'. Using Scopus' default search settings, 'article titles, abstracts and/or keywords' were considered (Stanford 2014). All types of documents either in English (97%) or Spanish (3%) were considered for this study. On October 2016, a final search (using the same keywords) was performed to include recently published literature relevant to the areas of interest as indexed up to October 2016. All relevant articles were included in the review.

A total of 188 documents (in English and Spanish) were obtained, of which, 80% (150) are journals articles and 7% (14) are conference papers. The remaining documents are review papers, book chapters, or articles in the mass media. Retrieved documents date from 1968 to present. The topic has received more attention primarily in the past 10 years; hence, most documents (88%) date from 2005 onwards. All retrieved documents were analysed. Abstracts were reviewed and 107 articles were found to contain information somewhat relevant to the areas of interest. From the 107 reviewed articles, 78 considered 'children's ATS' (with oldest from 2003). Relevant references within the core articles were retrieved and most relevant ones were also included in the analysis. Figure 1 shows the articles' eligibility criteria, and articles analysed by publication year and continent where the studies were conducted.

Trips to school are a multidisciplinary subject studied from different angles, including transport, environment, and health. While the subject matters are somewhat interrelated, the approach taken by researchers differs. From the core articles (n = 78), the majority (64%) analysed environmental, demographic, and social factors that affect children's trips to school. The second most commonly analysed topic was the health impact of ATS (17%), followed by policies and/or programmes that promote ATS (13%). Other included articles analysed less common topics, such as independent mobility to school and economic impact of ATS. Taking into consideration the geographical area of study

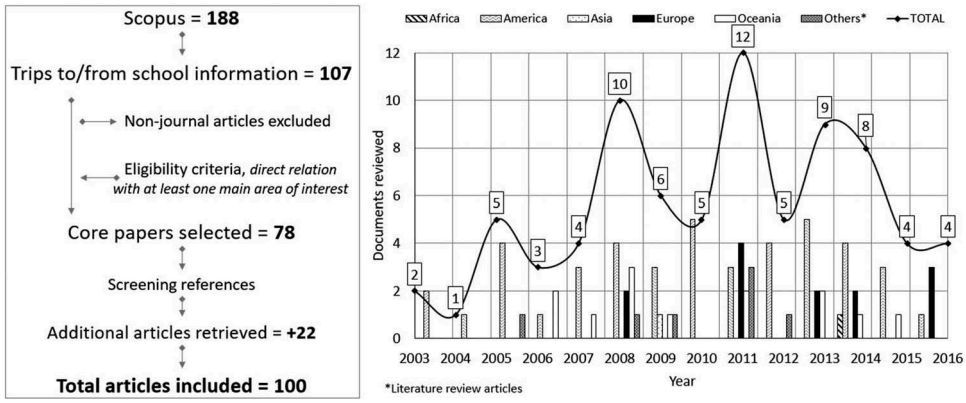

Figure 1. Eligibility criteria and articles reviewed per year.

of the available literature (n = 78; Figure 1), almost 60% studied trips to school characteristics and trends in America (especially the United States [US] and Canada), followed by Oceania (especially New Zealand and Australia) and Europe at 17% each. Very few studies analysed ATS in Asia or Africa.

3. Trips to school analysis frameworks

Children's travelling characteristics are, most of the time, shaped by the features of the place where they live, self and/or parents'/guardians' perceptions about these places, and social conditions (Booth et al. 2007; Pont et al. 2013; Carver et al. 2014; He & Giuliano 2015). To explain relationship among factors, models and frameworks have been presented. Many have been used to analyse trips to school (McMillan 2005; Panter et al. 2008; Pont et al. 2011; Mitra 2012). Some of the most relevant ones are: (1) the social–ecological (or human–ecological) model, (2) the McMillan framework, (3) the ecological and cognitive active commuting (ECAC) framework, (4) the model of children's active travel (M-CAT), and (5) the Mitra's framework (Sirard & Slater 2008; Pont et al. 2011; Mitra 2012). Frameworks are not completely independent on each other. They usually built upon previous models by adding/improving specific areas. Figure 2 presents a broad outline of these frameworks which are described as follows.

(1) The social–ecological model considers how the environment (social and physical) interacts with personal attitudes towards an activity. The model has been used to analyse trips in general and some have applied it to study ATS. Personal characteristics, social interactions, the built environment, and policymaking factors are considered as layers, one affecting the other and altogether affecting children's active trips (Timperio et al. 2004; Sirard & Slater 2008; Christiansen et al. 2014). Some factors act as mediators (variable that links cause and effect) and others as moderators (variable that modifies causal effect; Wu & Zumbo 2008; Christiansen et al. 2014).
(2) Later on, McMillan (2005) proposed a similar framework built specifically for trips to school. According to her model, parents have an important role in the decision about their child(ren)'s trip to school mode, especially parents of younger children. Their decision is mainly influenced by the urban form, as well as the mediators (real and perceived traffic, personal safety, and transportation options) and moderators (social characteristics, attitudes towards

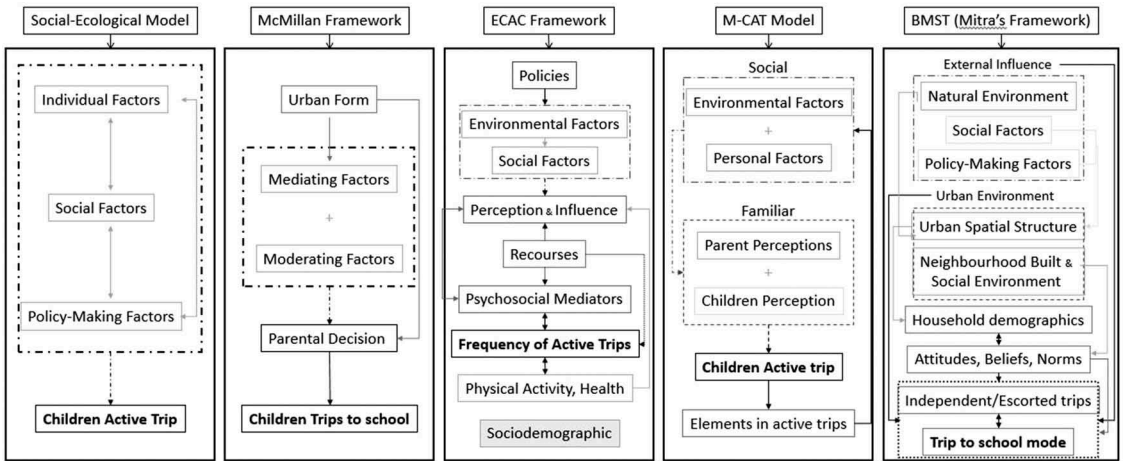

Figure 2. Frameworks to analyse active trips to school (adapted from Timperio et al. 2004; McMillan 2005; Sirard & Slater 2008; Mitra 2012; Pont et al. 2013; Christiansen et al. 2014).

different modes, and socio-demographics) (McMillan 2005).

(3) By fusing factors of the afore-mentioned frameworks, and including the social-cognition theory, the ECAC framework was developed. This framework asserts that socio-demographic factors of all household members strongly affect the parents' decision of allowing the use of active modes to commute to school. Thus, these are considered after the effect of all other variables has been studied (Sirard & Slater 2008).

(4) The M-CAT model proposed in 2011 highlights the complexity regarding child (ren)'s engagement in walking and cycling. It includes social, environmental, personal, familial, and individual (parents' and child(ren)'s perceptions) factors (2011; Pont et al. 2013). This model has specific applications to plan alternatives to promote active mobility to school.

(5) The most recently formulated framework is the behavioural model of school transportation or Mitra's framework. It explains how the built environment, household characteristics and household members' interaction, and transport policies have a multilevel influence in trips to school (Mitra 2012). In addition, the model asserts that parents/guardians allow child (ren) escorted or independent school trips based on children capabilities (physical and cognitive), household activities, and transport options (Mitra 2012).

Mitra's framework presents a holistic overview of children's mobility to school (based particularly in the North-American context). The current research is guided by Mitra's framework to reaffirm the common factors affecting trips to school and identify specific factors that impact ATS. Influences of the environment – built, perceived, and natural (weather) – are discussed first. Then, this review presents a sum of the social and economic factors influencing ATS at child(ren) and household level. Afterwards, external factors, such as policies and programmes, are presented. Finally, gaps in the current literature are highlighted for future research.

4. Environmental factors influencing ATS

Most researchers agree that the predominant factor affecting trips to school is *distance* from residence

to school (Schlossberg et al. 2006; McDonald 2008a; Hume et al. 2009a, 2009b; Carver et al. 2013b; Ermagun & Samimi 2015). Regardless of child(ren)'s age, short distances from home to school favours walking and cycling (Schlossberg et al. 2006; Panter et al. 2008; McDonald 2008a; Lang et al. 2011; Oliver et al. 2014). In many countries, most walking trips to school are made by children living within 1–1.6 km from school (Heelan et al. 2005; Villa González et al. 2011; Christiansen et al. 2014; Pojani & Boussauw 2014). For cycling, researchers note that children travel slightly longer distance to school than those who walk. Yet, an average distance is yet to be established (De Vries et al. 2010; Larouche et al. 2013). It is also reported that, in general, the active trip's distance increases as child(ren) get older (Morency & Demers 2010).

With the nascence of 'school-sprawl,' schools are built away from residential areas (Schlossberg et al. 2005; McDonald 2007a). As a result, children live further away from school (McDonald 2007a; Panter et al. 2008; Yang et al. 2016). This phenomenon has been reported to occur mostly in America, where schools are built away from the centre of the community. At these locations, wider and cheaper lands are available, which allows schools to have larger campuses (Schlossberg et al. 2005). Larger campuses can provide better facilities, including sport fields and cater for more students. Political issues are also involved in establishment of larger school campuses; however, these are out of the scope of this paper. To engage child(ren) active mobility regardless of school-sprawl, researchers recommend that parents could drop-off children at a 'walkable' distance from school so that they can complete the trip using active modes (Larouche et al. 2013). Such proactive policies as the walking school bus (WSB) will be discussed later.

The influence of *levels of urbanisation* on trips to school has been discussed from contradictory points of view. Urban (high urbanisation of residential and commercial land-use), suburban (mid-urbanisation), and in rural (low urbanisation) areas are the common classifications (Sirard et al. 2005a; Carver et al. 2013a, 2013b). Not much difference in ATS was reported between urban and suburban areas (Sirard et al. 2005a). More ATS were reported in urban and suburban areas than in rural areas (Sirard et al. 2005b; Bringolf-Isler et al. 2008; Kemperman & Timmermans 2014; Yang et al. 2016). However, some studies reported more walking trips to school in rural areas (Larouche et al. 2014b). Two points affecting trips to school in rural areas are: (1) child(ren) live far from school limiting their choice of walking or cycling; and (2) limited choice in transport modes result in child(ren) using the same mode daily (Carver et al. 2013b; Noland et al. 2014; Larouche et al. 2014b). In many cases, virtually all students in rural areas who live near to school (which is a longer distance in rural than urban and suburban areas) commute by active modes (Larouche et al. 2014b).

Regarding accessibility and connectivity, some have reported a positive association between these variables and trips on foot or by bicycle (Wong et al. 2011; Yang et al. 2012; Noland et al. 2014). *Accessibility* (e.g. pedestrian and cyclist infrastructure, roads, distance, etc.) exerts influence on adult walking behaviour (McMillan 2005; Schlossberg et al. 2006; Mitra et al. 2010; Koh & Wong 2013), yet research is limited on children's mobility. Accessible neighbourhoods seem to have a positive relation with walking/cycling among children (Ewing et al. 2004; Yang et al. 2012; Christiansen et al. 2014; De Sá et al. 2015a). Especially in high-income economies, parents prefer high walkability levels in promoting ATS (Christiansen et al. 2014; Oliver et al. 2014; Pojani & Boussauw 2014). Studies have also noted the positive influence of *connectivity* (paths connecting child's home and school) on ATS (Wong et al. 2011; Noland et al. 2014; Oliver et al. 2014; Yang et al. 2016). Nonetheless, other reported that connectivity is associated with reduced ATS (Timperio et al. 2006; Sirard & Slater 2008; Mitra et al. 2010; Helbich et al. 2016), mostly because well-connected layouts attract motorised traffic, thereby increasing traffic-safety concerns (Helbich et al. 2016).

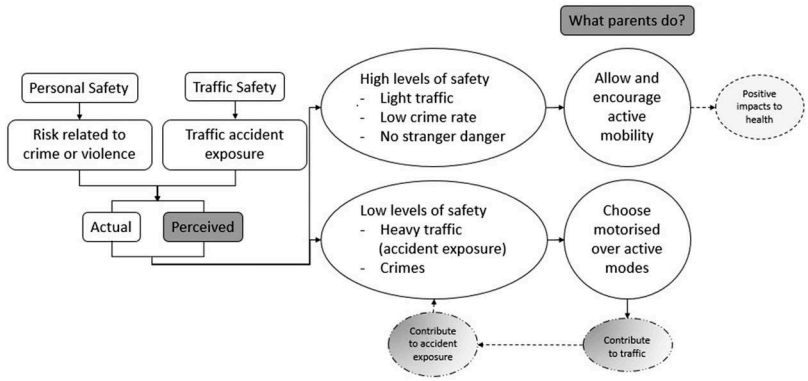

Figure 3. Safety perception and accident exposure.

It must be noted that parents' and child(ren)'s *perception* towards accessibility and connectivity is influenced by preferences (Hume et al. 2009a; Yang et al. 2012). Perception might differ from actual operating conditions. Researchers have found that a more positive perception can increase the number of ATS regardless of the actual operating conditions (Veitch et al. 2012; Zuniga 2012; DeWeese et al. 2013). For child(ren) who already makes ATS, their or their parents' perception towards accessibility and connectivity affects the roads/paths taken to commute to school (McMillan 2007).

Moreover, ATS are affected by *traffic-safety* and *personal-safety*. The former refers to traffic accident exposure and the latter to risks related to crime or violence (Pont et al. 2011; Lavoie et al. 2014; see Figure 3). As for accessibility and connectivity, safety perception of the environment also plays an important role in ATS (Timperio et al. 2004; Boarnet et al. 2005; DeWeese et al. 2013; Potoglou & Arslangulova 2016). In most cases, positive safety perception, that is, few traffic accidents, low crime rate, and absence of stranger-danger (harassment, bullying), prompts parents to allow/encourage ATS (Al-Homoud and Al-Oun, 2009; Faulkner et al. 2010; Trapp et al. 2011). Contradictorily, some parents who chauffeur child(ren) to school do it because of traffic-safety concerns (Buliung et al. 2011; Lang et al. 2011; Carver et al. 2013a), thereby themselves contributing to traffic accident exposure (see Figure 3). Safety concerns are more common among parents of younger children, that is, 5–11 years (McDonald 2008b), and of girls (Al-Homoud and Al-Oun, 2009; Yang et al. 2012). Commonly, parents have lower perception of safety levels than actual conditions and child (ren) have more positive perception of safety in their neighbourhoods than their parents (Timperio et al. 2004; McMillan 2007; Faulkner et al. 2010).

Increased motorised traffic has been related to higher accident risk exposure (Merom et al. 2006; Yeung et al. 2008). Children are inexperienced road users with distinctive task and physical capabilities (slow walking speed, low eye-sight level, and short attention periods). Thus, they are considered at higher risk than their parents or caregivers, that is, adults. When comparing trips to/from school with other accident scenarios, some have found that the school trips post less risk to children as pedestrians or cyclists (Boarnet et al. 2005; Schofield et al. 2008; Wong et al. 2011). Cycling to school is considered riskier than walking (Schofield et al. 2008; Trapp et al. 2011), mainly due to low cycling proficiency of children, higher travelling speed, and higher interaction with motorised traffic. Indeed, cycling accidents, not necessarily while travelling to school, are a common cause of children's physical injury

(Briem et al. 2004; Pucher & Buehler 2008; Trapp et al. 2011).

Finally, regarding *weather*, although it has been cited as a barrier for walking and cycling, no actual relationship has been established between weather conditions and walking trips to school (Sirard et al. 2005a; Oliver et al. 2014). Even in countries with very low temperatures (below zero, for example, Canada and Norway), the distance between home and school, and trips' habits are found to be more closely associated with ATS than weather conditions (Faulkner et al. 2010; Børrestad et al. 2011; Mitra & Faulkner 2012). Nevertheless, cycling to school is affected by snow. To remove snow from streets and bicycle lanes takes time and child(ren) would prefer (or be advised) to choose other modes to go to school than bicycle (Børrestad et al. 2011). Hardly any tropical country reported weather influences on ATS. Indeed, only a few tropical countries (e.g. Singapore) have reported mobility patterns in general. This area is of special interest since the hot, humid, and rainy weather of these countries affects users' willingness to commute by walking or cycling (Meng et al. 2016).

5. Social and economic factors influencing ATS

Society plays a big role in mobility. Studies have reported that higher levels of *social-cohesion* induce parents to perceive a safer environment and thus increases the likelihood of allowing their child(ren) to actively commute to school (McDonald 2007b; Mitra 2012; Kemperman & Timmermans 2014). In addition, parents and their son's and daughter's perception of other children in the neighbourhood has been shown to increase the odds of ATS (Timperio et al. 2006; Bringolf-Isler et al. 2008; Hume et al. 2009a). Girls in particular prefer to commute to school in company of others (Mikkelsen & Christensen 2009). It has been hypothesised that the reason for this is gender socialisation and tendency of girls' aversion of 'vulnerability feeling' (Mikkelsen & Christensen 2009).

Mixed results are found regarding the influence of *child(ren)'s age and gender* on ATS. Twelve of the reviewed articles specifically considered age and gender influence on ATS (Cooper et al. 2003a; Merom et al. 2006; Bringolf-Isler et al. 2008; McDonald 2008b, 2012; Larsen et al. 2009; Hume et al. 2009c; Trapp et al. 2011; Deka 2013; Noland et al. 2014; Mitra & Buliung 2015; Potoglou & Arslangulova 2016). In general, as shown in Figure 4, it has been commonly reported that older male children are more likely to actively commute to school and also to do it independently. The reasons for these high or low ATS may not be age itself, but distance to school, car ownership, and accessibility to public transport (Morency & Demers 2010; Deka 2013; Elias 2015). Regarding gender, the previously mentioned gender socialisation has also been hypothesised as the reason for fewer and less independent active trips among girls (Merom et al. 2006; McDonald 2012; Noland et al. 2014).

Different influence about household characteristics has also been presented in the literature. Some reported that the higher number of siblings, the more common the ATS (McDonald 2008b; Deka 2013). This is because children travelling together increases parents' confidence in allowing ATS. In contradiction, others suggested that ATS decrease as the number of siblings increases since parents apply 'economy of scales' in chauffeuring them to school (McMillan 2007; Yarlagadda & Srinivasan 2008). Yet, other researchers did not find any correlation between number of siblings and mode taken to school (Pojani & Boussauw 2014; Potoglou & Arslangulova 2016).

Moreover, some researchers have found *adult-availability* to be inversely associated with child(ren)'s ATS and public transport usage to/from school (Carver et al. 2013a; Mitra & Buliung 2015). In other words, adults with 'free time' were found to be likely to chauffeur child (ren) to/from school. It has also been found that parents who commute to work by private transport in the morning commonly drive their child (ren) to school 'on their way' (Schlossberg et al. 2006; Wen et al. 2008; McDonald 2008b;

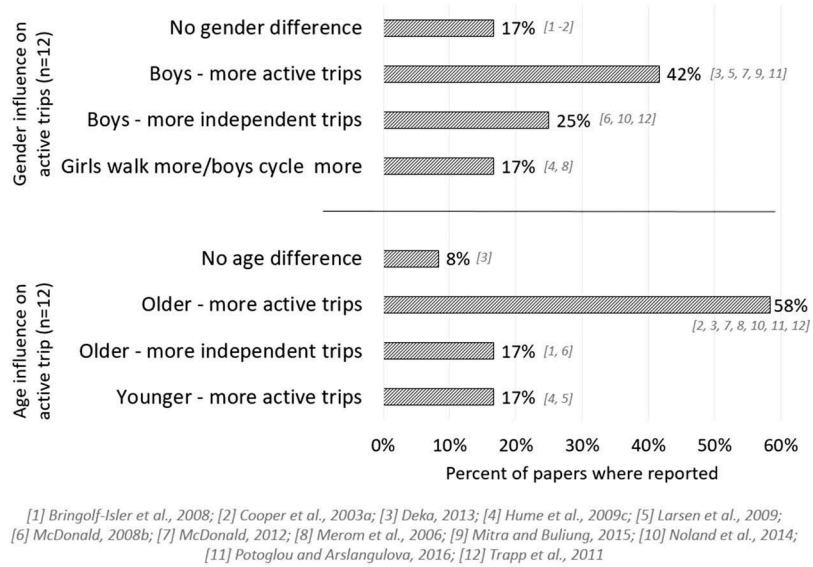

Figure 4. Age and gender influence on trips to school.

McDonald & Aalborg 2009; Deka 2013; Park et al. 2013). However, other researchers have suggested that allowing parents' flexible hours, that is, eliminating the 'rush' to work/increasing morning 'free time', can reduce the number of children being driven to school and thus increases ATS (Wen et al. 2008, 2009; Larsen et al. 2012; Faulkner et al. 2010).

Attitudes towards walking and cycling in general have also been found to affect ATS (Bringolf-Isler et al. 2008; Zuniga 2012; Rodríguez-López et al. 2013). Parents' attitude can be positive, negative, supportive, and/or protective (Bringolf-Isler et al. 2008; Yeung et al. 2008; Pojani & Boussauw 2014). Attitudes, as well as the earlier mentioned factors, need to be taken into consideration when designing policies and programmes aimed at increasing ATS and/or ensuring children's safe trips from home to school.

Car ownership, which is related to *household income (HI)* (Yarlagadda & Srinivasan 2008; He & Giuliano 2015), is widely mentioned as a factor affecting ATS. Researchers explained that high HI and availability of a car in the household decrease the likelihood of ATS (McDonald 2008c; Pont et al. 2009; Villa González et al. 2011; Oliver et al. 2014). Interestingly, only one study, from the Netherlands, attempted to analyse association between children's *bicycle ownership* and participation in ATS (Kemperman & Timmermans 2014). In that study, 96% of the children owned a bicycle and the ATS rate was at 63% (36% cycling and 27% walking). Yet, results cannot be generalised given the pervasive 'cycling-centric culture' in the Netherlands (Heinen et al. 2010).

Walking and cycling are virtually free modes of transport (Waller 2005; Pucher & Buehler 2008). Yet, not much research exists about the actual economic benefit of ATS, individually or to the society. One research explained that, in the US, by remedying hazardous traffic situations, policies such as hazard bussing (when school provides bus service even for short distance because the environment to walk to school is unsafe) can be reviewed. By reducing bussing demand, the cost of 100–500 million US$ in such transport per year can be reduced (McDonald et al. 2014). Hazards elimination provides economic benefits to

the community, and attendant shift to free transport modes reduces travel cost of individuals. The research study affirmed that if after hazards remediation, parents still choose to drive their child (ren) to school, transportation costs shall be reduced for the community but increased for families (McDonald et al. 2014).

6. External factors influencing ATS – programmes and policies

It has been highlighted by researchers that most schools face a high amount of motorised traffic and congestion when children arrive (usually morning) and leave (usually afternoon) the school (McMillan 2007; Lang et al. 2011; Ermagun & Samimi 2015). Increasing the number of ATS entails a reduction in motorised traffic. Such reduction alleviates traffic congestion and its associated negativities, such as environmental air and noise pollution and accident exposure at school zones (SZs; Yeung et al. 2008). Policies that advocate to promote ATS have been suggested to reduce motorised traffic (therefore, emissions) at SZs.

Planners, authorities, and schools themselves have developed and implemented programmes and policies to entice children to walk and/or cycle to school and elevate levels of safety for children in the trips to/from school (McMillan 2007; McDonald 2007a; Buliung et al. 2009; Hume et al. 2009b). Based on the literature, there are three main schemes that affect ATS: (1) safe routes to school (SRTS or SR2S); (2) the WSB; and (3) school-siting policies. Interestingly, most of these have been mostly applied in Europe, North America, and Oceania (Boarnet et al. 2003; McDonald et al. 2011; Smith et al. 2015; De Sá et al. 2015b) and virtually none in tropical or Asian countries. This highlights another gap in the ATS research area. At tropical and Asian countries, not only the weather is different from other countries (hot and humid weather that can be seen as a constraint to implement such programmes), but also there exists quite different household and societal composition, and activities scheduling. Such factors must be taken into consideration in developing empirical research on ATS in tropical and/or Asian countries.

The *SRTS programme* gained popularity in the last two decades (SafeRoutes 2015). Some countries have implemented it as a national health/wellness programme to increase children's physical activity (Hendricks et al. 2009; Fyhri et al. 2011). Others as a transport measure to improve traffic situation outside schools (Boarnet et al. 2005; McMillan 2007; McDonald & Aalborg 2009; Ermagun & Samimi 2015). Allocation of funds to specific SRTS features also varies. Some allocate more money on improving the environment around schools, while others (e.g. schools with conducive walking/cycling environment) choose to focus on different features (Boarnet et al. 2005; Morency & Demers 2010; McDonald et al. 2013). These differences have relationship with each school 'needs' for the success of the programme. Most SRTS have yielded positive results, especially in increasing ATS (thus, physical activity). Better social interaction, economic benefits, and higher safety levels have also been registered (McDonald 2007a; Fyhri et al. 2011, 2013; McDonald et al. 2014; De Sá et al. 2015a). However, whether these benefits are a direct or indirect impact of SRTS is yet to be evaluated.

SRTS programmes are commonly developed using the 5Es approach (engineering, education, encouragement, enforcement, and evaluation; Boarnet et al. 2005; McDonald et al. 2014; Elias 2015). This is important because research shows that engineering improvements alone, while necessary, are not sufficient to increase walking or cycling (Boarnet et al. 2005; McMillan 2007; McDonald 2008b; McDonald & Aalborg 2009). Improvements are complemented with users' education in traffic-safety behaviour, encouragement to participate in the programme, and enforcement to ensure compliance with recommendations (Deka 2013; Park et al. 2013). When evaluating SRTS, its overall efficiency in increasing ATS is analysed. Some combinations of the approaches, for example, engineering + education, are considered (McDonald et al. 2013).

Moreover, the *WSB* entails students meeting at a designated point and from there walk to school with adult supervision (McDonald 2012). This addresses parental time constraint that involves them walking their child(ren) part-way to school (parents do not need to walk or cycle all the way to school everyday) and concerns about independent travel (McDonald 2008b; McDonald & Aalborg 2009; Fyhri et al. 2011). Overall, the WSB has shown success in increasing ATS rates (Kingham & Ussher 2007; Wen et al. 2008; Park et al. 2013). Besides encouraging child(ren) 'independent' active mobility, WSB also increases levels of interaction with other children and the environment (Kingham & Ussher 2007; Sidharthan et al. 2011; Smith et al. 2015). Some limitations of the WSB are recruitment of adult companion volunteer (parents or other members of the society) and encouraging children to participate in such programme (Mackett et al. 2003; Smith et al. 2015).

To measure feasibility of implementing and maintaining the WSB, it has been suggested that pre, during, and post-WSB data be collected from school members, children, parents, and volunteers (Mackett et al. 2003). Geographical differences also need to be considered. 'Social geography' (income level, political characteristics, etc.) was found to have correlation with effectiveness of the programme. Research pointed that children from neighbourhoods with high economic income are more likely to take part in the programme (Collins & Kearns 2010; Lang et al. 2011). 'Environmental-geography' (landscape, weather, etc.) effects on the WSB are yet to be studied in depth.

Other policies affecting ATS are *school-siting* or *school-assignment policies* that define catchment areas of schools (McDonald 2007b; McDonald et al. 2011; Yang et al. 2012). Some countries allow for 'school-choice' policy (child can attend any school, even if it is located outside the neighbourhood of his/her residence) while others advocate for 'neighbourhood-only' policy (child attends a school within the neighbourhood of his/her residence). Well-planned neighbourhood-only policies can help to reduce the travel distance to school, which increase ATS, maximise the effects of SRTS (Sidharthan et al. 2011), and reduce transport cost and air pollutants (especially CO_2 and CO) within the neighbourhood (Marshall et al. 2010; Yang et al. 2012). However, while reduced distance can be suitable for ATS (perceived or actual), unsafe transport characteristics within neighbourhoods can promote the use of motorised modes even for short distances.

Other factors besides mobility are also affected by school-siting policies. While some argue that neighbourhood-only policies provide students of different social levels with the same education, such policies can also cause racial aggregation, especially in countries where people of different demographics tend to cluster at specific neighbourhoods (McDonald et al. 2011; Yang et al. 2012). School-choice can affect unbiased access to education. Some argue that the policy favours child (ren) from high-income households, causing parents' choice of school to be shifted to better schools regardless of their location (Boarnet et al. 2005; Marshall et al. 2010; Yang et al. 2012; Voss et al. 2015).

Additionally, although not widely considered, perceived and actual health benefits of ATS also exert influence on mode of transport taken to school and success rate of programmes and policies. In general, children who walk or cycle to school on a regular basis (3–5 times a week) are more physically active throughout the week (7 days), as compared to those who travel by car (Cooper et al. 2003b; Sirard et al. 2005b; Morency & Demers 2010; Larouche et al. 2014a). ATS cause an increase in children's moderate-vigorous physical activity (Cooper et al. 2003b; Sirard et al. 2005b; Chillon 2008; Pizarro et al. 2013). Although minimal (around 10 min), this increase helps to reduce sedentary lifestyles and childhood obesity (Sirard et al. 2005b; Bere et al. 2011; Laguna Nieto et al. 2011; Pizarro et al. 2013). Emotional benefits of ATS have also been studied. ATS encourage social interaction among children and help them reach maturity by independent travel (Yeung et al. 2008; Laguna Nieto et al. 2011).

Positive emotions were shown to be associated with active trips as well (Lewicka 2005; Lambiase et al. 2010; Ramanathan et al. 2014), and as a result, a reduction in stress and cardiovascular reactivity can be achieved by increasing ATS (Lambiase et al. 2010). Policies and programmes should consider making parents and children aware of such benefits. Such awareness may increase the percentage of children who actively commute to school.

7. Current gaps and discussion

After a careful review of most relevant academic articles, guided by the most recently proposed framework regarding ATS – Mitra's Framework, influences of environmental, social and economic, and external factors were highlighted. Two notable dearth of research into children's ATS were identified (see Figure 5). First, it was found that there is minimal research about school trips in general (not only active trips) for tropical environments. Also, analysis of the economic impact of ATS is minimal and no specific analysis approach has been suggested. Alternatives to address found niche areas and overall findings are discussed next.

Most research has been developed by analysing school trips in North America, thus a gap exists in similar studies in the tropical countries in Africa and Asia. Future research shall focus on analysing ATS in these geographical areas, including factors such as economic income, societal composition, and weather (hot, humid, and rainy) conditions, as these differ the most from European and American countries. Weather characteristics of tropical countries can deter people from walking and cycling. Thus, there is a reduced chance of ATS among children. A comparison of trips to school across different continents shall help to shed light on 'global' factors concerning trips to school as well as 'localised' factors. By understanding these factors, suitable alternatives can be proposed and implemented to further increase the number of walking and cycling trips to school worldwide.

Moreover, the reason why economic impact of ATS has not been widely studied could be the complexity of the issue and a holistic approach is needed. Transport, economic, social and even health concepts and evaluations need to be applied to evaluate the cost-effectiveness of walking and cycling and the implementation of different policies and programmes (Litman 2009). Direct (money not spent in transport) and indirect savings (e.g. medical expenses, reduced congestion) of ATS on households (and its' members), schools, and neighbourhoods need to be considered to

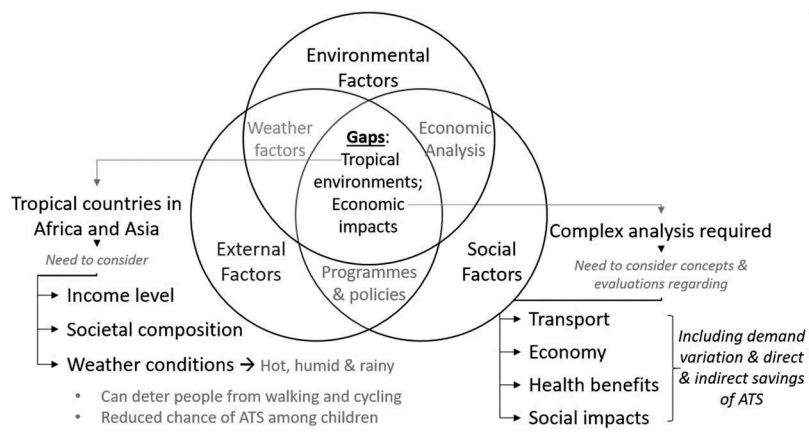

Figure 5. Gaps in the active trips to school literature.

estimate overall benefit of different alternatives (Litman 2010; Speck 2012). In addition, in order to fully weight the economic impact of ATS, the variation in transport demand during arriving/leaving (school peak period) and off-school periods should also be included in the economic analysis (Litman 2009, 2010).

Different economic impacts of ATS are expected from different geographical areas of similar economic level (Speck 2012). This is related to different usages of modes of transport in general (e.g. high-income countries: US – mainly private transport (McDonald et al. 2011), the Netherlands – mainly active modes (Dessing et al. 2014), Singapore – mainly public transport (SINGSTATS 2011)). Such differences can be explained by cultural issues, weather, and/or transport characteristics. Nevertheless, researchers studying ATS should follow a standard economic-analysis approach so that findings can be compared internationally.

Regarding findings from the current review, distance is reaffirmed as the most influential factor affecting ATS. Children living within a range of 1–1.6 km to school are more likely to walk or cycle to school. School-sprawl and level of urbanisation affect the school location, thereby affecting distance and mode taken to school. Perception plays an important role in ATS. An environment perceived to be accessible, safe, and secure is more conducive for walking and cycling. It has been noted that perception and actual operating conditions might be different and parents' perceptions are different from child(ren)'s.

Actual traffic-safety condition highlights that travelling situations other than ATS are riskier. Children travelling to school as cyclists are more vulnerable than those travelling as pedestrians. Increasing children cycling proficiency and encouraging safe cycling approaches, for example, proper crossing behaviour and traffic schemes to look out for traffic, can help to reduce traffic vulnerability when cycling. Although the use of helmets can reduce the severity of traffic accidents, the use of helmets among children travelling on bicycles has not been well studied (or reported).

Although inconsistent results were reported, most studies agree that older male children are more likely to make independent ATS. It is rationalised that maturity (physical and cognitive) and gender-socialisation contribute to such travelling differences. Moreover, parents' availability plays an important role in allowing child(ren) to walk or cycle to different locations, including schools.

Also, car availability has been consistently shown to be inversely related to the likelihood of walking or cycling to school. Children's bicycle availability, on the other hand, is yet to be investigated as a specific factor encouraging ATS. Bicycle ownership is related to high number of cycling trips in general. Thus, it is hypothesised that it will have impacts on trips to school.

Common distance suitable for active trips (1–1.6 km) has encouraged the promotion of well-panned 'neighbourhood-only' school-siting policy. The policy can help to maximise the number of ATS and effectiveness of programmes such as SRTS. However, besides transport considerations, social and educational impacts of the 'neighbourhood-only' school-siting policy need to be considered.

Regarding the SRTS, the programme focuses on enhancing safety by infrastructural modifications at SZs (if necessary), education of users, encouragement for participation, and enforcement of safe behaviour when travelling. The programme is focused on children and parents to increase ATS in general. Evaluated programmes have yielded positive results in increasing ATS (thus reducing traffic at SZs and increasing levels of safety). Yet, SRTS impacts on social interaction, economic benefits, and accident reduction are yet to be properly evaluated.

As discussed, the WSB addresses parental concerns about children independent travel and time constraints. By walking from designated locations to school with adult companions, children get the benefits of active mobility and also get to interact with other children and the environment. Benefits of the SRTS programme and the WSB are very appealing; however, these are not widely applied (or are not yet studied) in Asian and African countries. Reasons might

include the costs needed for engineering modifications and the challenge in recruiting volunteers. Future research can focus on analysing the feasibility and benefits (social, personal, and economic) of this kind of schemes to promote ATS. Geographical differences need to be considered as well as these have shown to have influence in such programmes.

Health benefits of walking and cycling influence ATS and efficiency of discussed programmes and policies are not widely factored in. Besides increasing children's levels of social interaction, physical and emotional health benefits can be derived from ATS.

Findings highlighted in this paper and presented gaps can be used by researchers in analysing children's mobility and ATS benefits. These are also useful for planners and schools of different countries to develop children-friendly alternatives aimed to increase the number of walking and cycling trips to school and encourage a healthy lifestyle. Based on results and best practices, well-fitting programmes and policies can be implemented considering specific geographic characteristics. Special interest exists for countries that have an overall safe environment; already-conducive walking/cycling infrastructure, and well-trained professionals and technology access, such as the case of Singapore.

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