Highlights

- A methodology based on walking school bus guided by paid staff is presented
- 43.7% of the families completely or partially changed their transportation routines
- A large recurrence in the children’s participation was objectively measured
- Improvement in daily organization and less concern were the most reported benefits
- This methodology can increase walking for children who live further from school

Title page

Article Title:

"Evaluation of a walking school bus service as an intervention for a modal shift at a primary school in Spain"

Authors information:

P. Pérez-Martín (Pedro Pérez Martín), G. Pedrós (Gerardo Pedrós Pérez), P. Martínez-Jiménez (Mª Pilar Martínez Jiménez), M. Varo-Martínez (Marta Mª. Varo Martínez)

Applied Physics Department. Higher Polytechnic School. University of Cordoba.

Address:

Rabanales Campus. Albert Einstein Building (first floor).

Ctra. Madrid km. 398 Córdoba (Spain) Postal Code 14071

Corresponding Author:

M. Varo-Martínez: fa2vamam@uco.es Tlfn: + 34 957212085

Rest of authors email:

G. Pedrós: fa1pepeg@uco.es

P. Martínez-Jiménez: fa1majip@uco.es

M. Varo-Martínez: fa2vamam@uco.es

Evaluation of a walking school bus service as an intervention for a modal shift at a primary school in Spain

Abstract

In recent decades, the proportion of students using motorized transportation to school has increased while active transportation has decreased. The walking school bus is one of the most used interventions aiming to reduce problems resulting from this trend. However, no studies have analysed the influence of a WSB service provided by professional monitors on a shift in modes of transportation.

This study investigated a pioneer daily walking school bus service guided by paid staff implemented at a primary school in Córdoba, Spain. A mobile app is used to register the children's participation and to provide the parents with real-time information on the group's location and arrival at the destination. Collected data, including the families' responses to a questionnaire were used to assess participation and the shift in modes of transportation.

During the pilot study, a high recurrence in the children's participation was found and 43.7% of the participants had completely or partially changed transportation modes. The families reported fewer problems in the children's daily school travel organization (92.1%) and an improvement in their pedestrian safety behaviours (89.5%). Further, 92.1% of the participating families had less concern about their children's autonomous walking.

Results indicate that a walking school bus service guided by paid monitors can be an effective way to increase active travel to school, especially for children who live further from it. The use of the mobile app can reduce parents' concerns and facilitate the management and evaluation of the method. Implications are discussed for future Active Travel to School interventions that focus on changes in modes of transportation.

Keywords

Modal shift; walking school bus; mobile app; ICT; active travel to school; car reduction

Highlights

- A methodology based on walking school bus guided by paid staff is presented
- 43.7% of the families completely or partially changed their transportation routines
- A large recurrence in the children's participation was objectively measured
- Improvement in daily organization and less concern were the most reported benefits
- This methodology can increase walking for children who live further from school

1. **Introduction**

Children's modes of transportation to school have changed significantly during the past few decades, with an increase in parents driving their children to school and a decrease in walking to school (Fyhri et al., 2011; McDonald et al., 2011). As a result, fewer primary school students are now autonomously walking to school. The increase in driving children to school has caused problems at the urban level (Marique et al., 2013), in the daily organization of families (McDonald, 2008; He, 2013), and related to children's health and psychosocial development (Mackett, 2013; Foster et al., 2014).

In this context, a variety of activities and transportation policies have been developed to decrease the number of children driven to school and to promote active travel to school (ATE, 2007; NCSRTS, 2007; Chillón et al., 2011; Green Communities Canada, 2011). Many of these measures are based on improvements to infrastructure for pedestrian travel. However, some studies point out that the low efficiency of some of these projects might be because they do not meet families' needs (McDonald and Aalborg, 2009; Stone et al., 2014).

The problems related to primary school students' mobility must be understood in the context of household decisions (Faulkner et al., 2010). Some of the major factors that influence families' modes of transportation are the distance to the school, the parents' concerns about traffic or the possibility that their children might be hurt, and work-school time restrictions (Stewart et al., 2012).

Among the alternatives of the Active Travel to School projects, the walking school bus (WSB) is a promising intervention; however, the benefits and potential to trigger changes in transportation routines have yet to be widely studied (Smith et al., 2015). The WSB consists of a group of children that walks to school accompanied by one or more adults, usually along a previously agreed-on route with possible intermediate stops. The WSB could be an appropriate way to overcome the major barriers to active transportation, such as families' fears related to autonomous walking, parents' needs to escort their children, and the distances that the children walk (Stone et al. 2014). Although the WSB solution does not offer complete autonomy to the children, it could be a valuable tool to reduce fears about children walking unaccompanied by their relatives and to help parents feel comfortable about their children walking to school.

Several studies have identified many advantages, challenges, and limitations of WSB (Table 1). The major benefits to participants or other people involved in a WSB programme are the time saved by the parents (Kearns et al., 2003), health benefits (Collins and Kearns, 2005; Kearns et al., 2003; Kingham and Ussher, 2007), increased sense of community (Collins and Kearns, 2010; Kingham and Ussher, 2005), children's socialization (Kearns et al., 2003; Kingham and Ussher, 2005), children's greater independence (Kingham and Ussher, 2005), and a high level of participant satisfaction with a healthy and supportive environment that promotes social interaction and physical activity (Kong et al., 2009).

Table 1. Previous studies about Walking School Bus (WSB) programmes

Study	Study Site	Methods	Results
Kearns et al., 2003	One school in Auckland, New Zealand	Evaluation of one school's WSB, survey to participants' parents (16), conversations with WSB drivers and children, interviews with people responsible for road safety (7)	Although health, social and time-saving benefits were reported by the participants, the authors concluded that WSBs were an ambivalent response to the hegemony of motorized transport.
Collins and Kearns, 2005	Auckland, New Zealand	45 interviews with 23 school representatives (mostly principals) and 22 WSB coordinators conducted providing information on 29 of 34 schools with WSBs in Auckland	Participants identified benefits from WSBs, e.g., an estimated 429 saved vehicle journeys each day. However, the authors concluded that WSBs had limited ability to address public health challenges in an inequitable and car-dominated urban political system.
Kingham and Ussher, 2005; 2007	Christchurch, New Zealand	A combination of interviews (33) and questionnaires with people conducting some WSBs	The authors concluded that WSBs were suffering a significant decline on the long term. Some of the difficulties identified were: a lack of volunteers, lack of children through them wanting to make the journey alone, insufficient ongoing support from the school or council
Heelan et al., 2009	Nebraska, US	The prevalence of walking to school was evaluated by self-report six times, and the objective physical activity levels among a sample of research participants (201 intervention children and 123 control children) in two WSB intervention schools and one control school were compared by having participants wear an accelerometer four times.	At each later timepoint, a significantly greater percentage of children actively commuted to and from WSB schools compared with control school.
Kong et al., 2009	Albuquerque, New Mexico, US	A feasibility trial used a process evaluation of two WSBs at an elementary school with 29 participants (kindergarten through fifth grade students living within a one-mile radius of school). Qualitative and quantitative data were obtained from field notes, attendance records, student and parent satisfaction surveys, focus groups, and interviews with two lead coordinators.	Student and adult participants reported high levels of satisfaction with the WSB. The authors concluded that WSB studies in urban, underserved school districts were feasible but required attention to ensure participants' involvement, safety, and investment from stakeholders.
Mendoza et al., 2009	Seattle, WA, US	This study assessed students' methods of transportation to school in a classroom survey at baseline and a one-year follow-up There was an intervention school with a WSB program with volunteer parents and a part-time coordinator and two control schools.	Although no significant differences between proportions of students walking to school at intervention and control schools at baseline were identified, significantly higher proportions of students walked to school at the intervention school than control schools and this result was maintained in time.
Collins and Kearns, 2010	Auckland, New Zealand	This research was a longitudinal assessment of the major WSBs in Auckland primary schools using telephone interviews and questionnaires. Slight changes from 2002 to 2006 were found.	The number of WSB was growing, but most activity still remained in the wealthiest areas. Some of the benefits of WSB reported were sense of community, opportunity for exercise and health promotion, reduction in car use and local congestion, and reduced risk of injury for child pedestrians.
Mendoza et al., 2011	Houston, TX, US	Pilot cluster randomized control trial with four intervention and four control schools. Intervention schools had one to three WSBs with trained staff to and from schools five days per week. The percentage of trips made by active commuters was assessed using a questionnaire. Minutes per day of moderate to vigorous physical activity (MVPA) were measured using GT1M accelerometers worn by students for seven days.	Intervention schools increased active commuting (AT), whereas control schools decreased AT. Intervention children increased the daily MVPA from 46 to 48 minutes, whereas control children decreased MVPA from 46 to 41 minutes. The WSB children achieved 7 minutes/day more MVPA than control children.

However, the previous studies all refer to WSB as staffed by volunteer adults. Although this approach could positively influence parents' decisions to not use their cars, Collins and Kearns (2010) pointed out that taking part as accompanying adults is an additional burden and liability on the families, which reduces the convenience to the families that are relatively willing to use it. Thus, the difficulty obtaining volunteers becomes a major barrier to the sustainability of WSBs. Smith et al. (2015) suggested paying the WSB coordinators/monitors and using mobile applications to support WSB management as possible solutions to recruitment and liability problems.

Furthermore, although there is evidence that WSB promotes an increase in the number of children that walk to school, it has been evaluated using self-assessment questionnaires, which can produce social desirability bias (Heelan et al., 2009; Mendoza et al., 2009; Mendoza et al., 2011). Only Collins and Kearns (2005, 2010) estimated the savings in car trips achieved by the WSB. However, they used indirect methods, such as personal estimates provided by WSB coordinators and survey data.

Moreover, mobile technologies currently have a particularly relevant role in the daily organization of personal transportation. Some activities, such as checking on bus locations in real time (Watkins et al., 2011) or identifying a group of individuals for carpooling (Shaheen et al., 2016), have become increasingly common. Public administrations also are beginning to understand that dynamic transportation data allow them to devise more effective plans for transportation infrastructure and services (Yujuico, 2015). These trends are helping to develop an emerging discipline known as Computational Transportation Science (Winter et al., 2011). In this sense, new technologies could be useful (Dickinson et al., 2015; Weiser et al., 2016) for promoting the creation of WSB groups at educational centres, management of the daily development of WSB and communication among the participants, and for the collection of real-time operational data.

Considering this background, it is necessary and possible to implement objective assessments to support the potential of these interventions as transportation policies. For example, a pilot WSB service using professional monitors was offered free of charge to the families of a primary school in Córdoba, Spain. A mobile app was used to log the children's participation in the WSB. This paper presents an analysis of that programme along with an analysis of an initial mobility survey and a final assessment questionnaire. Thereby, the study aims to lower participation barriers and objectively assess the potential reduction of car trips that might be obtained through this innovative service.

2. **Methodology**

2.1. Characteristics of the School Study Site

This study was conducted at a publicly subsidized school in Córdoba, Spain, with a student body of 450 primary grade children, in 2014–2015. The school also offers Preschool, Compulsory Secondary Education, and Non-compulsory Post-Secondary Education modules. The school is in a middle-class neighbourhood with commercial and residential

urban zoning, and it is near the city centre. The distances from the children's homes to the school widely range due to its easy access on foot and by motor vehicle and because of the criteria used to allocate students to schools in Andalusia. No previous Active Travel to School campaign had been tried among these families and the school administration had not previously considered any problems with the daily transportation of their pupils.

2.2. Design Characteristics of the Pilot Study

A cost-free daily WSB pilot programme using professional paid monitors to and from school was implemented at the school. The participants' family members were not required to accompany the children, although it was permitted during the first few days of the programme for any family member who deemed it essential to gain sufficient confidence before participating in the WSB programme.

The families were provided with a mobile application for the smartphone Trazeo (Trazeo, 2014), which allowed them to pinpoint the group's location, obtain relevant notifications, and communicate with the monitors and other participants in the WSB in real time. The monitors used the same application to collect the children's participation data and provide information on the location of the group. The human resources used in the programme (excluding the research team) were one WSB monitor for each 12 children and one coordinator of all of the WSBs, who managed problem-solving, organizing and supervising routes, and for communication and diffusing the project to the educational community. An educational service company recruited the monitors from among young candidates with previous experience as school monitors or in children's recreational activities. The coordinator was a person with training and experience in citizen participation and sustainable mobility. The monitors and the coordinator needed basic technological skills in mobile applications. The costs of the WSB staff were covered by the research project (see Acknowledgments).

Because of the temporary nature of the research project, the pilot lasted 14 weeks. The first stage began at the end of a school year and the reactivation (second) stage began at the beginning of the next school year. Before implementation, the families were informed that the service would not continue after the study concluded.

2.3. Previous Collection of Information and Route Design

Before the implementation of the WSB service, a voluntary questionnaire was distributed to the family members of all of the primary school children to collect data on their modes of travel to school on a daily basis, the locations of their homes, their willingness to participate in the WSB service, and to ask for consent to participate in the study.

In the project's framework, a Google Maps-based application was developed to visualize the participants' family data. Each item was associated with the following variables: (1) home, (2) mode of transportation, and (3) willingness to participate in the WSB, using the answers to the following questions: (1) How does your child usually get to school? and (2) Would you take part in the walking school buses if they suited your needs? On the map shown in Figure 1, the location of the icon indicates the location of the home. The transportation mode is

symbolized by the type of icon, such that a figure of a pedestrian indicates that a child walked or biked to school and a car indicates children driven to school. The willingness to participate is shown via the colour of the icon: green indicates that they would participate and red indicates that they would not participate. For each item, the walking distance from the home to the school was calculated for the shortest route using the Google Maps function.

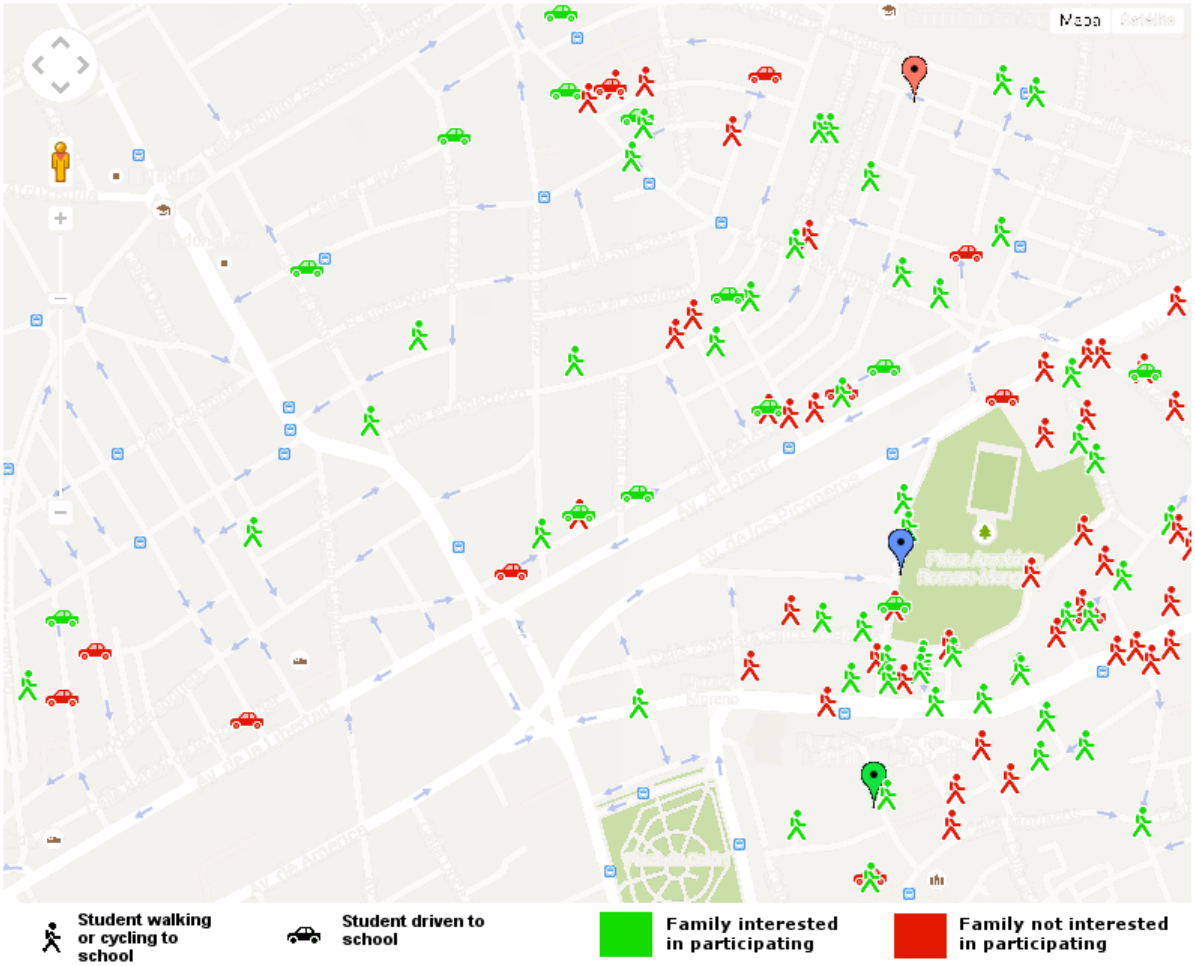


Figure 1. Map of children's homes, transportation modes, and willingness to take part in the WSB (Source: Web application developed by the project team)

Using the information in Figure 1, three WSB routes were designed that complied with the following criteria:

- First, the proximity of routes to the homes of the families willing to participate.
- Second, the proximity of routes to the homes of the families that were driving the children to school.
- Third, the total length of the routes of about 1500 meters, the locations of the starting points, and some intermediate stops to pick up and drop off children to facilitate participation for parents who needed to continue on to their workplace after dropping off their children at school. Later, the lengths of some of the routes were extended in response to some parents' requests because they lived beyond the routes' starting points.

2.4. Development of the Walking School Bus Service

After the routes were designed and verified on-site, and before the WSB service was implemented, a comprehensive campaign publicized it along with trainings and awareness-raising efforts regarding child mobility and the use of the application. The routes and schedules were published on the project's Internet website, through which interested families could register their children for their preferred route.

The WSB operation proceeded as follows. The monitors began walking at the starting points of each route and collected or delivered the children at their pre-determined stops until the destination was reached. Whenever a child joined or left the group, the monitor logged the information in the available group list of the mobile app (Figure 2a) and ticked or unticked the names of those children. Thus, during a group's progress along a route, the parents of the participants could know in real time the location of the group (Figure 2b). In addition, parents could receive notifications alerting them that the WSB had begun, that their child had joined or left the group, and that the WSB had finished the route. Moreover, a group chat (Figure 2c) was available to all family members registered for a given WSB route, the monitors, and the coordinator to inform all interested parties of any problem or incident. The following data was automatically recorded in the database through the mobile application: the participation of a child in the group; the time, date and location where he or she was collected or delivered; the number of participants in each WSB; and the total distance walked.

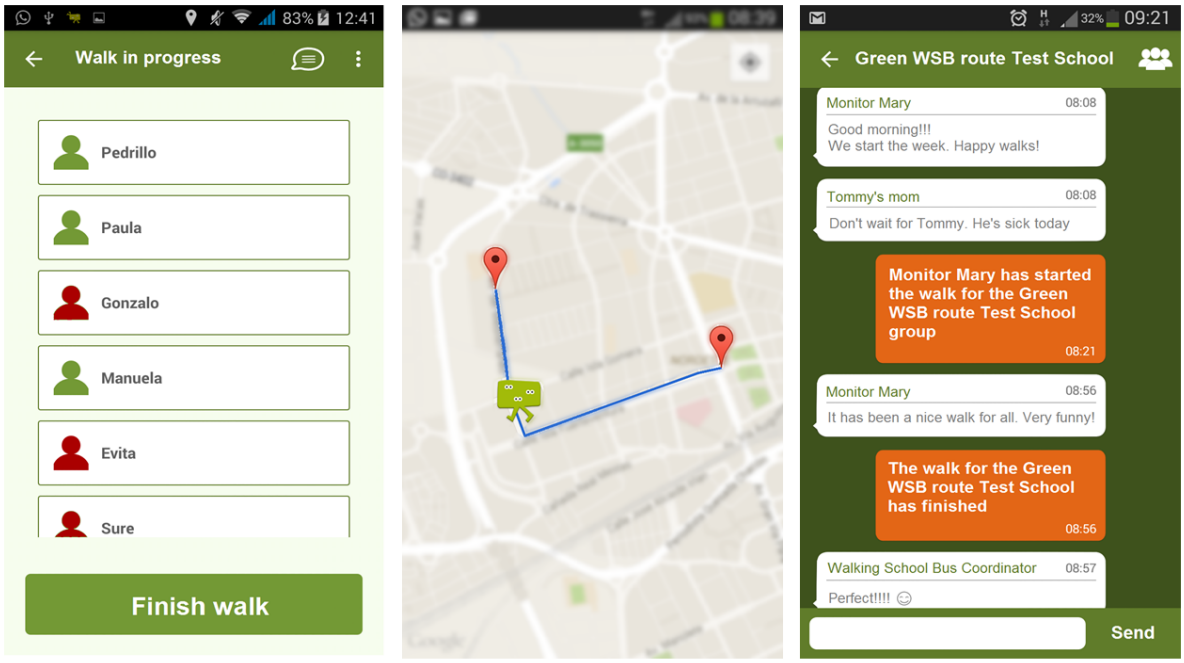


Figure 2. Screenshots of the mobile app Trazeo: a) List of children, b) Real-time monitoring, c) Notifications (Source: Trazeo)

During the third week of the WSB project, some information on the development of the project was sent to families and different educational activities, adapted to each of the educational levels at the school, were developed in the classrooms, to explain to the children

how a WSB operates and how they could join one, with the goal of increasing participation in the WSB programme.

To compute the churn rate after a lengthy break, such as the summer holidays, the authors implemented a reactivation (second) stage for the groups during the first four weeks of the second school year. The coordinator used the group chat function of the mobile app during the week before the beginning of the reactivation stage to inform the participating families of the first stage that the project would be reactivated.

During the final week of the study, the participating families received an assessment questionnaire about the WSB service. Among other questions, they were asked whether any changes in their children's transportation to school had occurred, whether the mobile app had lessened their fears about their children's autonomous walking to school, and about the observed benefits and disadvantages that they experienced after participation in the WSB.

3. **Results and Discussion**

3.1. Participant characteristics

From the 304 initial mobility questionnaires collected, 294 reported their address with which the home-to-school distances could be calculated. Although a wide range of distances was found (Table 2), most of the students lived between 500 and 2000 m from the school.

Table 2. Distribution of students by distance from home to school

Distance from home to school (m)	% of students (*n* = 294)
0 < x ≤ 500	3.74
500 < x ≤ 1000	21.43
1000 < x ≤ 1500	27.55
1500 < x ≤ 2000	25.51
2000 < x ≤ 2500	7.48
≥ 2500	14.29

During the study, the three WSB groups operated daily. The WSB routes began during the last term of school year 2014–2015 (from April 28, 2015, to June 22, 2015), and these routes were reactivated on the first day of school of the following school year (2015–2016), running from September 10, 2015, to October 9, 2015, totalling 59 days and 354 walks. Altogether, 55 students from 31 families participated in the WSB service in both stages. In the first stage, 47 students participated, and the second one had 39 participants.

The characteristics of the sample are shown in Table 3, which indicates no children living between zero and 500 m from the school took part in the project. Although a high potential for participation among children living 1500–2000 m from the school (27%) was observed,

most of the participants lived between 1000 and 1500 m from the school. The WSB service particularly attracted the interest of families with more than one child, possibly because it offered an alternative that inspires confidence regarding the youngest children's walk to school while enabling the older children to gain responsibility and autonomy.

Table 3. Demographic characteristics of the participant children

Variable	Participants (*n* = 55)	Percentage (%)
Gender		
Male	32	58
Female	23	42
Age		
≤ 5	9	16
6	9	16
7	6	11
8	9	16
9	7	13
10	12	22
11	1	2
12	2	4
Number of participating children per family		
1	15	27
2	30	54
3	6	11
4	4	7
Distance from home to school		
500 < x ≤ 1000	10	18
1000 < x ≤ 1500	22	40
1500 < x ≤ 2000	15	27
2000 < x ≤ 2500	6	11
≥ 2500	2	4

3.2. Evolution and Recurrence of Participation

Thanks to the systematic collection of data on the children's attendance by the mobile app, it was possible to study the temporal evolution of new additions to and dropouts from the WSB and to assess the daily participation of the children. Altogether, 1,705 daily attendances were registered. Because the children could walk to school and back home on one day, the total number of registered child participations to and from school was 2,642, and the average of daily walks per child was 1.70 walks per day. This finding indicates that many of the children used the WSB both to and from school. Figure 3 shows the numbers of active participants, additions, and dropouts for each week, calculated as the difference between the accrued additions and dropouts.

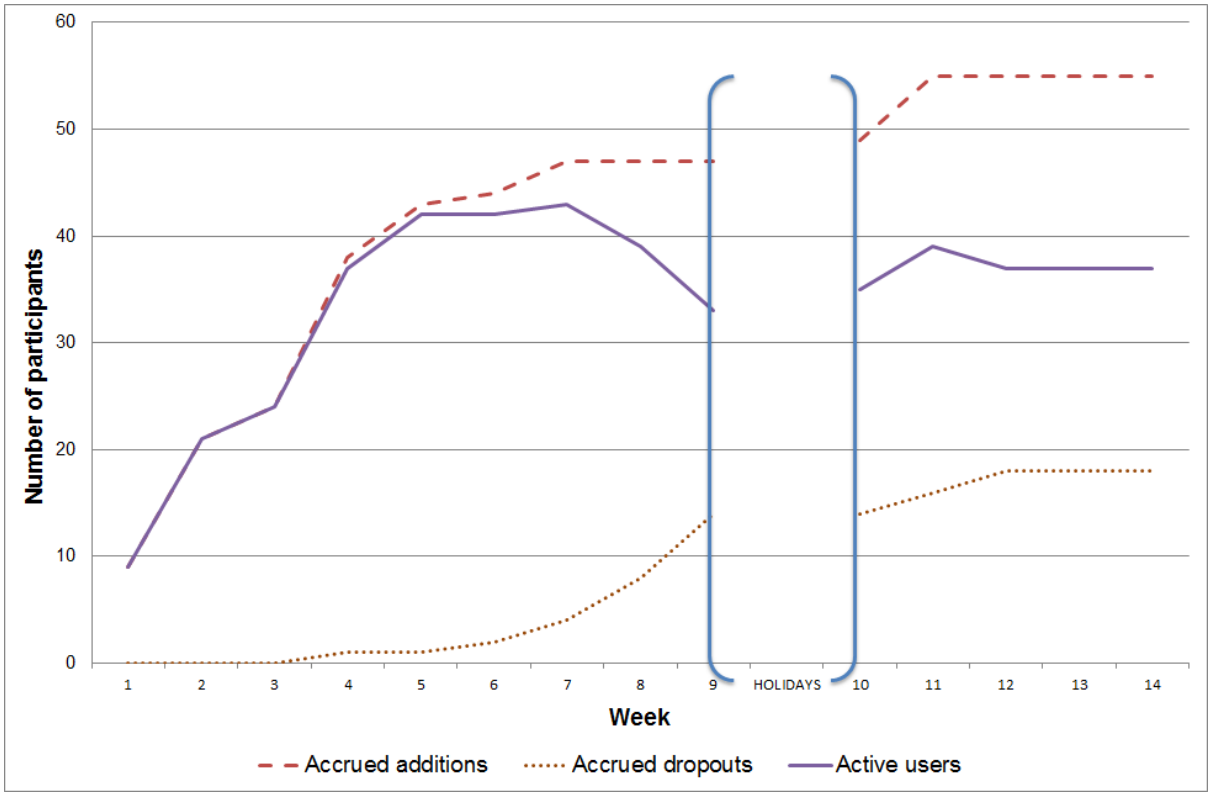


Figure 3. Weekly evolution of additions, dropouts, and active participants

Figure 3 indicates that the biggest increases in new additions occurred during the first two weeks and the fourth week of the first stage, when the intense communication campaign took place. At the beginning of the second stage, the coordinator communicated again about WSB availability, which led to another increase in participants. However, during the weeks when no intense campaign was made, participation was stable. This result suggests that appropriate communications before and/or during implementation of a WSB service could enhance the recruitment of participants.

Regarding dropouts, most of the children who left the WSB did so during the last weeks of the first stage because, among other reasons, the 12-year-olds stopped participating in the project after finishing Primary education, which also triggered the loss of some of their younger brothers and/or sisters. Collins and Kearns (2010) found that, in a volunteer WSB, dropouts by older siblings could trigger the loss of the WSB. In this study's WSB service

model, this problem was not as relevant because the younger children who began traveling to school without depending on their parents' escort could replace the older participants who left the service as they yearly aged out. Also, some families decided not to use the WSB service in the second stage, despite their high levels of satisfaction with the service, because of the temporary nature of the research project. It is possible that maintaining the service would have prevented these dropouts.

On the other hand, the recurrence index (I_R) was defined using the participation data as the sum of a child's effective participation days divided by the total number of days from his or her first to his or her last participation. In this way, a recurrence index of '1' indicates daily participation during the stay in the project, regardless of the day in the stage that they joined the group for the first time or the day that they left it. Table 4 shows the results of this index calculated for the 55 child participants and the percentages by quintile.

Table 4. Recurrence index

I_R	Number of children (*n* = 55)
1.0 ≥ x > 0.8	45
0.8 ≥ x > 0.6	8
0.6 ≥ x > 0.4	1
0.4 ≥ x > 0.2	0
0.2 ≥ x > 0.0	1

Overall, 82% of the children participated for more than 80% of the days during their participation in the project, and 96% used the WSB more than 60% of the days. Therefore, this WSB service could be a popular daily alternative mode of transportation for the children and it could result in rapid and permanent modal shifts if it were designed to meet the families' needs, particularly those families that drive their children to school. The monitors and many of the families reported that the children enjoyed their daily social experiences with other children while walking to school. In fact, the children often asked their parents to continue participating in the project after they tried it out.

Although the novelty of the WSB might have influenced participation, the qualitative comments, the monitors' and the coordinator's direct observations, and the participation data indicate that novelty was not a decisive factor. On the contrary, the temporary nature of the service caused some interested families to postpone their decisions for a few weeks until they heard from participating families. Others decided not to join because it was not a long-term activity. It can be inferred from the evolution of the participation and the performance of other regulated services offered by the school, such as before-school care and the school dining room, that a WSB service regularly operating free of charge for all participants would attract many children in the mid-term.

The automatic data collection was a substantial step forward for this type of project. If this type of implementation were conducted on a large scale, it would be possible to develop a robust statistical analysis, such as assessing the influences of the WSB on driving distances or estimating relational models on the effects of the adoption of this service on other travel

behaviours. These future studies could provide more precise knowledge about children's mobility in cities and support optimization of and improvements to the Active Travel to School projects.

3.3. Modal shift

The families of every participating student answered this question asked in the final assessment questionnaire: 'Has the participation of your child in the walking school bus meant that he/she has replaced being driven to school by walking to school?' Table 5 shows the answers, grouped according to the distance between home and school, whether a modal shift (MS) had occurred, and whether the participant already walked (AW). Among those who changed their transportation mode, answers were divided into three categories: (1) 'Yes, every day, on the way to school and back home', *full modal shifters* (FMS); (2) 'Yes, but just on the way to school or back home', *partial modal shifters* (PMS); and (3) those who reported a change to their transportation mode on some days, *occasional modal shifters* (OMS).

Table 5. Change of transportation mode by distance between home and school

	Responses by distance in m (*n* = 55)					**Total (%)**
Response/Distance	**500–1000**	**1000–1500**	**1500–2000**	**2000–2500**	**≥ 2500**	
Change transportation mode (MS)	5	4	9	4	2	24 (43.7)
Every day go and back (FMS)	0	2	5	2	0	9 (16.5)
Every day only go or back (PMS)	5	1	4	1	2	13 (23.6)
Some days (OMS)	0	1	0	1	0	2 (3.6)
Already walked (AW)	5	18	6	2	0	31 (56.3)

In Table 5, 56.3% of the participants already were walking to school before the pilot programme, but 43.7% of them partially or totally changed their transportation mode. Thus, it is reasonable to conclude that the WSB provides a desirable transportation alternative for the children in the MS category, simultaneously promoting an increase in autonomy among those who already were walking to school. The modal shift percentages were higher among those living more than 1500 m from the school, particularly among those living between 1500 and 2000 m away from the school, where many of the FMS children lived. Among those living between 500 and 1000 m from the school, a large modal shift also occurred, but all of them were in the PMS category, suggesting that the WSB could replace car trips for families living quite close to the school and who choose the WSB for personal convenience.

Fewer changes in transportation mode occurred among those who lived 1000–1500 m from the school. On the other hand, by extending the length of the WSB routes, children living further than 2000 meters from the school were attracted to the WSB. As expected, the

participants living farther away changed their transportation modes (MS). In addition, a Kruskal-Wallis test was performed relating the distance interval (between home and school) to the transportation mode change. The values obtained for 1500–2000 m confirmed that the intervention was more effective for children living that far from the school (Chi-square = 6.4862; *p*-value = 0.03904).

These findings have important implications for designing measures aimed at increasing the number of children engaged in active transportation to school because, based on this study's results, the focus should be on providing attractive alternatives to families living close to school that drive the children to school for convenience, those living farther than 1500 m away from school and driving to school because of the distance, and, particularly, those living between 1500 and 2000 m from the school.

3.4. Benefits and Disadvantages for the Families

In the final assessment questionnaire, the parents of the participants were asked to indicate all of the benefits they experienced after their participation in the WSB, noting the importance of each of them on a scale of 1 to 5 (where 1 is the most important and 5 is the least important). Table 6 shows the total accrued results on each item in percentages of answers and the percentages on importance. In addition, it shows the percentages on the total number of answers obtained on each item between the MS and the AW groups.

Table 6. Benefits reported by the families

Reported benefit	% by importance					% Total	% Total MS	% Total AW
	1	2	3	4	5			
More available time for me	47.4	10.5	7.9	2.6	0.0	68.4	68.4	68.4
Fewer complications in the organization of the family	71.1	15.8	2.6	2.6	0.0	92.1	84.2	100.0
Less use of the car	31.6	5.3	7.9	10.5	7.9	63.2	78.9	47.4
My child shows more responsible pedestrian safety behaviours	55.3	15.8	10.5	0.0	0.0	81.6	89.5	73.7
My child shows a more positive attitude towards school	28.9	23.7	5.3	2.6	5.3	65.8	68.4	63.2
My child shows a more positive attitude at home	10.5	10.5	23.7	0.0	2.6	47.4	47.4	47.4
My child shows a more sociable attitude towards other children	26.3	15.8	15.8	2.6	0.0	60.5	57.9	63.2
My child seems to be more active	28.9	15.8	5.3	2.6	0.0	52.6	42.1	63.2
Other	13.2	5.3	0.0	0.0	0.0	18.4	15.8	21.1

% by importance: Percentage of participants (calculated over the whole number of participants) that reported the benefit, disaggregated by the level of importance marked in the survey.
% Total: Accrued percentage of participants (calculated over the whole number of participants) that reported the benefit, independently of the importance scale.
MS: Children who changed totally or partially their transportation mode.
AW: Children who already walked before the WSB.

The family members who responded to the survey pointed out that fewer complications were in the family organization (92.1% overall and 100% for AW) and the parents reported more free time (68.4%). Thus, the tested WSB service frees up family resources because it does not involve parental participation. It increases convenience compared to driving children to school, which is a factor that motivated parents' decisions. This factor is argued as important (McDonald and Aalborg, 2009), despite the scant attention it has received (Faulkner et al., 2010). Among the benefits experienced by the parents who had previously driven their children to school, reduced use of the car was an important and commonly mentioned benefit (78.1%). Hence, WSB seems to have released the parents from a self-imposed obligation.

Another important benefit mentioned by the participants' parents (81.6%), in particular by the MS group (89.5%), was improvements in the children's pedestrian safety behaviours after participation in the WSB, which has previously been found (Mendoza et al., 2012). This finding suggests a positive reinforcement in the parents' decision-making processes when they are deciding whether their children will walk to school because it also helps parents to be relatively more confident regarding safety around vehicular traffic. Other benefits mentioned by the family members, although to a lesser extent and of less importance, were the children's improved positive attitudes towards school (in particular among the MS group) increased sociable attitudes towards other children, and a more active lifestyle, which was particularly important to those in the AW group.

In the final survey, families were required to report problems or disadvantages of the methodology of WSB implemented too. Four families reported in the final satisfaction survey that they could not install the app on their smartphones, either because they did not have one or because they had an operating system other than Android, which is a disadvantage of the app. Although these families could access the group's location on the Internet and receive notifications via email, future implementations should adjust to the technological context of the community in which the WSB service is being implemented and its specific needs.

3.5. Reduced Fears related to Autonomous Walking

Regarding the mobile app that was used during the WSB experience, it is important to mention that 92.1% of the participating families reported that using the tool contributed to reducing their concerns about their children's autonomous walking. The parents' fears were usually related to not knowing where and with whom their children were. However, the proposed solution, which works non-intrusively when the monitor marks the group's location, provides sufficient information and control of the situation to meet parents' needs.

3.6. Cost assessment of the pilot programme

The cost to the company for each monitor was EUR 13 per hour for two hours per day. It was necessary to hire four monitors for the three WSB routes because one route exceeded the twenty-children threshold. The coordinator was paid EUR 25 per hour for 1.5 hours per day. The total cost of the WSB service during the pilot amounted to EUR 8350. Considering the total number of participants, the walks offered, and the cost of the pilot, the total cost of providing the service to the children during the entire project period of 14 weeks was EUR

152 per child. The cost is comparable to bus service in the same city, which is on average EUR 80 per month per student. Furthermore, although those services are similar in terms of organization, the WSB provides a wide range of social, energetic, psychological, health, and environmental advantages not available through bus service. Consequently, although larger implementations are necessary and its range of action is relatively limited in distance from the school, this comparison suggests that the WSB service could be cost competitive under optimal operating conditions. In future applications, if the cost of the service is covered by the public funds or project sponsors, it is reasonable to assume that results similar to those presented in this paper could be expected. Additionally, future studies are needed to assess the effect of transferring the total cost or a part of it to the families.

To assess the cost per car trip eliminated as the result of using the WSB, the questionnaire data were contrasted with the participation data collected by the mobile app. To determine the number of car trips eliminated, two data were added: I) the total number of participations for those children that reported a modal shift from car to walking every day go and back (540), and II) the number of days of participation for those children that only changed every day their mode of transportation in one of the trips home-school (368). Altogether, 908 car trips were eliminated. Neither the data of those children that used the service occasionally nor the possible utilization of shared cars have been considered in this analysis. The cost per car trip eliminated was EUR 9.19, considering the total cost of the pilot. Although that number seems high, the temporary nature of the pilot experience and the fact that the intervention did not exclusively focus on students previously traveling to school by car should be considered. As stated above, the recurrence of participation, once the service had been experienced, was very high. However, student enrolment was progressive, which meant that participation in the first few weeks was lower, which could have biased this cost upward.

4. **Conclusions**

In this study, a method was developed to implement a walking school bus (WSB) service provided by professional monitors with the support of a coordinator in a primary school in Córdoba, Spain. Its possible influence on shifts in modes of transportation was studied. During the last nine weeks of school year 2014–2015 and the first four weeks of school year 2015–2016, three WSB routes (to and from school) were developed, and a total of 55 children participated. The monitors used mobile app Trazeo to register participation by each child along each route, and the families received real-time information on the locations of the WSB and on the arrival/departure status of the group. Objectively measured participation was combined with responses on an initial mobility diagnostic questionnaire before the intervention, and an assessment questionnaire was administered after the WSB ended.

Despite some negative factors, such as the temporary nature of the study, lack of campaigns to raise awareness, and lack of direct involvement by the school, changes in the transportation routines of many families were found and sustained during the project. The recurrence in participation was high, with 82% of the children participating more than 80% of the days. Moreover, participation was successfully reactivated in the groups starting on the first day of the second school year in the study.

About 43.7% of the participants completely or partially changed their modes of transportation to school from automobile to walking. The largest variations in the transportation modes of the children were among those who lived 1500 meters from the school, particularly those in

the range of 1500–2000 m from the school. Thus, the WSB could be an effective way to increase the distance threshold currently walked by children and to reduce car trips undertaken for the parents' convenience or because of lack of alternatives.

With this WSB model, the researchers tackled the major barriers to participation in the WSB, such as parents' lack of free time for escort, concerns about the risk of accidents, and the safety of the children. All of the families that used the mobile app stated that it helped them to reduce their fears about their children's autonomous walking. The families particularly valued the less complicated family organization, the children's improved pedestrian safety behaviours, and the additional free time as benefits of participation. In addition, many of the parents who drove their children to school indicated that the decreased use of their cars was a benefit.

Thanks to the mobile app, it was possible to collect data for this study and assess the evolution of the use of the WSB in an automatic and easy way, which is a substantial step forward for this type of project. Larger implementations over longer periods are necessary to assess the continuity of the changes found in this study and the long-term cost benefits when the service is integrated into regular school activities. This study's results offer an interesting perspective on the implementation of WSB services focused on increasing convenience for families, using professional monitors, and applying mobile applications to increase the active transportation of children to and from school.

Acknowledgements

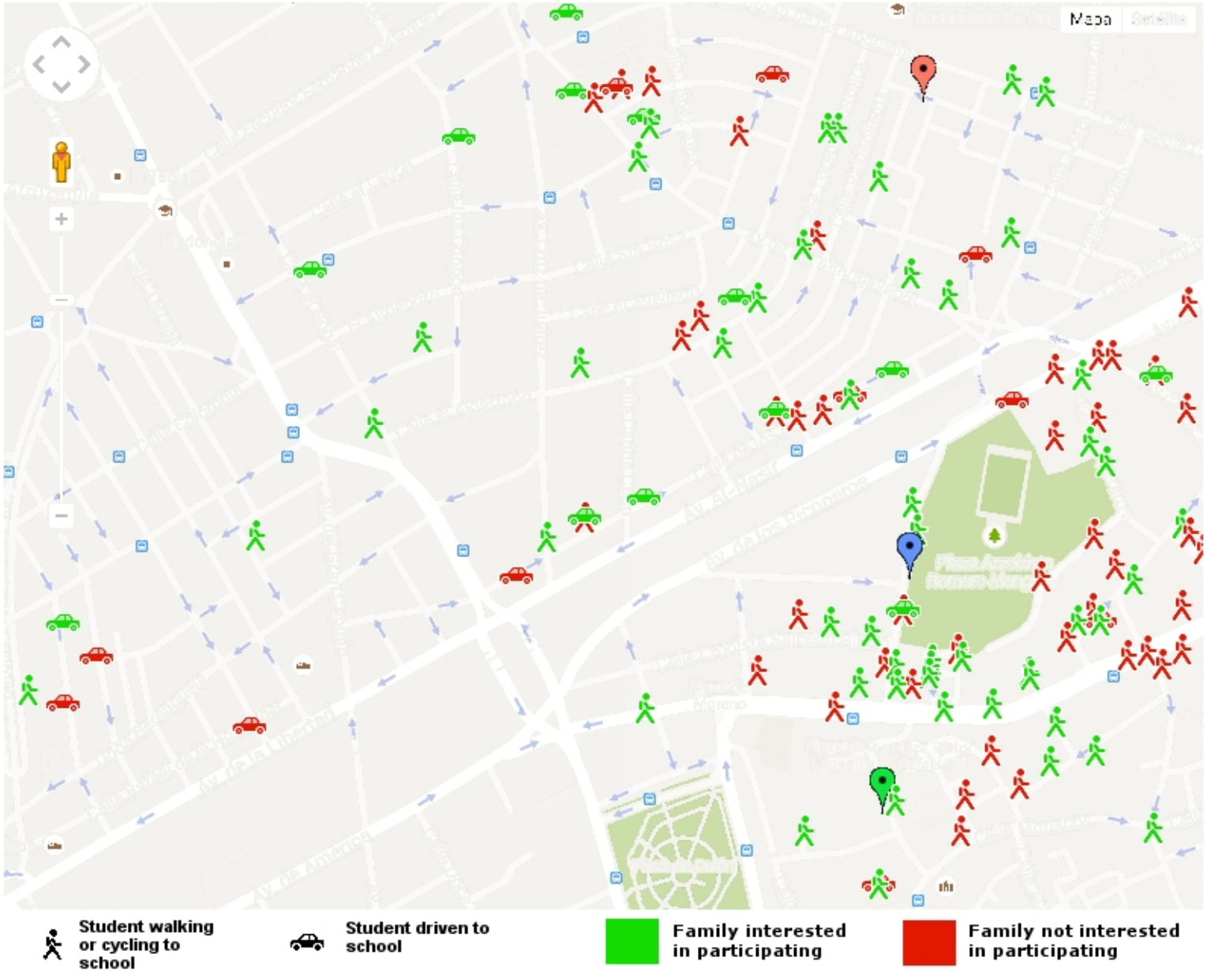
We are grateful to the European Regional Development Fund of the European Union for the financing received for this study through *Metodología de Implantación de Rutas Escolares a Pie Apoyadas en Una Herramienta Tecnológica y Su Aplicación en Centros de Educación Primaria* (Implementation Methodology of Walking School Routes Supported by a Technological Tool and its Application in Primary Schools), framed in the *Programa Operativo FEDER de Andalucía 2007–2013* of the Public Works Agency and the Department for Housing and Development of the Regional Government of Andalusia.

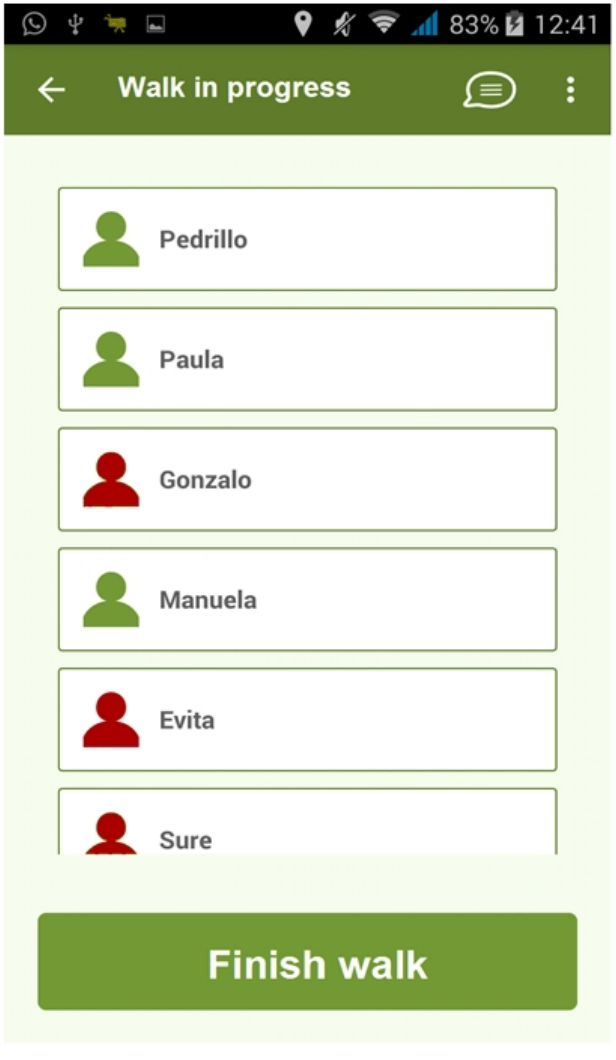
References

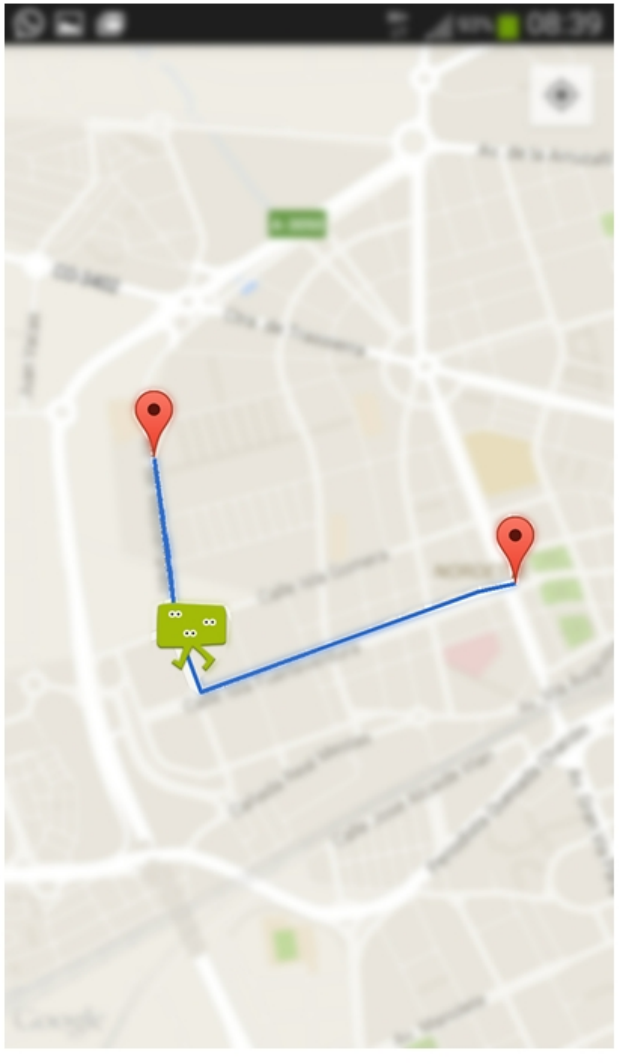
- ATE - Association Transports et Environnement (2007). Pédibus. À pied. À l'école. Accompagné. Retrieved September 30, 2017, from http://pedibus.ch/
- Collins, D. C., & Kearns, R. A. (2005). Geographies of inequality: child pedestrian injury and walking school buses in Auckland, New Zealand. *Social Science & Medicine*, 60(1), 61-69. DOI: 10.1016/j.socscimed.2004.04.015
- Collins, D., & Kearns, R. A. (2010). Walking school buses in the Auckland region: A longitudinal assessment. *Transport Policy,* 17(1), 1-8. DOI: 10.1016/j.tranpol.2009.06.003
- Chillón, P., Evenson, K. R., Vaughn, A., & Ward, D. S. (2011). A systematic review of interventions for promoting active transportation to school. *International Journal of Behavioral Nutrition and Physical Activity,* 8(1), 10. DOI: 10.1186/1479-5868-8-10

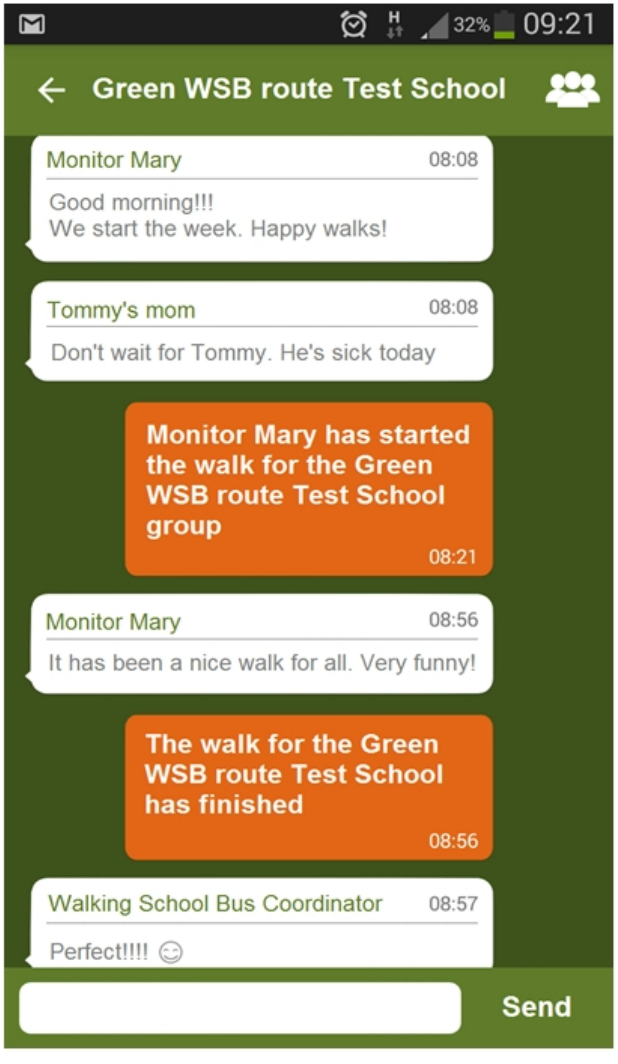
- Dickinson, J. E., Cherrett, T., Hibbert, J. F., Winstanley, C., Shingleton, D., Davies, N., Norgate, S. & Speed, C. (2015). Fundamental challenges in designing a collaborative travel app. *Transport Policy*, 44, 28-36. DOI: 10.1016/j.tranpol.2015.06.013
- Faulkner, G. E., Richichi, V., Buliung, R. N., Fusco, C., & Moola, F. (2010). What's "quickest and easiest?": parental decision making about school trip mode. *International Journal of Behavioral Nutrition and Physical Activity*, 7(1), 1. DOI: 10.1286/1479-5868-7-62
- Foster, S., Villanueva, K., Wood, L., Christian, H., & Giles-Corti, B. (2014). The impact of parents' fear of strangers and perceptions of informal social control on children's independent mobility. *Health & Place*, 26, 60-68. DOI: 10.1016/j.healthplace.2013.11.006
- Fyhri, A., Hjorthol, R., Mackett, R. L., Fotel, T. N., & Kyttä, M. (2011). Children's active travel and independent mobility in four countries: Development, social contributing trends and measures. *Transport Policy*, 18(5), 703-710. DOI: 10.1016/j.tranpol.2011.01.005
- Green Communities Canada (2011). Active and safe routes to school. Retrieved September 30, 2017, from http://www.saferoutestoschool.ca/
- He, S. Y. (2013). Will you escort your child to school? The effect of spatial and temporal constraints of parental employment. *Applied Geography*, 42, 116–123. DOI: 10.1016/j.apgeog.2013.05.003
- Heelan, K. A., Abbey, B. M., Donnelly, J. E., Mayo, M. S., & Welk, G. J. (2009). Evaluation of a walking school bus for promoting physical activity in youth. *Journal of Physical Activity & Health*, 6(5), 560. DOI: 10.1123/jpah.6.5.560
- Kearns, R. A., Collins, D. C., & Neuwelt, P. M. (2003). The walking school bus: extending children's geographies? *Area*, 35(3), 285-292. DOI: 10.1111/1475-4762.00177
- Kingham, S., & Ussher, S. (2005). Ticket to a sustainable future: an evaluation of the long-term durability of the Walking School Bus programme in Christchurch, New Zealand. *Transport Policy*, 12(4), 314-323. DOI: 10.1016/j.tranpol.2005.05.002
- Kingham, S., & Ussher, S. (2007). An assessment of the benefits of the walking school bus in Christchurch, New Zealand. *Transportation Research Part A: Policy and Practice*, 41(6), 502-510. DOI: 10.1016/j.tra.2006.11.008
- Kong, A. S., Sussman, A. L., Negrete, S., Patterson, N., Mittleman, R., & Hough, R. (2009). Implementation of a Walking School Bus: Lessons Learned*. *Journal of School Health*, 79(7), 319-325. DOI: 10.1111/j.1746-1561.2008.00418.x
- Mackett, R. L. (2013). Children's travel behaviour and its health implications. *Transport Policy*, 26, 66–72. DOI: 10.1016/j.tranpol.2012.01.002
- Marique, A. F., Dujardin, S., Teller, J., & Reiter, S. (2013). School commuting: the relationship between energy consumption and urban form. *Journal of Transport Geography*, 26, 1-11. DOI: 10.1016/j.jtrangeo.2012.07.009
- McDonald, N. C. (2008). Household interactions and children's school travel: the effect of parental work patterns on walking and biking to school. *Journal of Transport Geography*, 16(5), 324–331. DOI: 10.1016/j.jtrangeo.2008.01.002
- McDonald, N. C., & Aalborg, A. E. (2009). Why parents drive children to school: implications for safe routes to school programs. *Journal of the American Planning Association*, 75(3), 331-342. DOI: 10.1080/01944360902988794

- McDonald, N. C., Brown, A. L., Marchetti, L. M., & Pedroso, M. S. (2011). US school travel, 2009: an assessment of trends. *American Journal of Preventive Medicine*, 41(2), 146-151. DOI: 10.1016/j.amepre.2011.04.006
- Mendoza, J. A., Levinger, D. D., & Johnston, B. D. (2009). Pilot evaluation of a walking school bus program in a low-income, urban community. *BMC Public Health*, 9(1), 122. DOI: 10.1186/1471-2458-9-122
- Mendoza, J. A., Watson, K., Baranowski, T., Nicklas, T. A., Uscanga, D. K., & Hanfling, M. J. (2011). The walking school bus and children's physical activity: a pilot cluster randomized controlled trial. *Pediatrics*, 128(3), e537-e544. DOI: 10.1542/peds.2010-3486d
- Mendoza, J. A., Watson, K., Chen, T. A., Baranowski, T., Nicklas, T. A., Uscanga, D. K., & Hanfling, M. J. (2012). Impact of a pilot walking school bus intervention on children's pedestrian safety behaviors: A pilot study. *Health & Place*, 18(1), 24-30. DOI: 10.1016/j.healthplace.2011.07.004
- NCSRTS - National Center for Safe Routes to School. (2007). Safe Routes to School Guide. Retrieved September 30, 2017, from http://www.saferoutesinfo.org
- Shaheen, S. A., Chan, N. D., & Gaynor, T. (2016). Casual carpooling in the San Francisco Bay Area: Understanding user characteristics, behaviors, and motivations. *Transport Policy*, 51, 165-173. DOI: 10.1016/j.tranpol.2016.01.003
- Smith, L., Norgate, S. H., Cherrett, T., Davies, N., Winstanley, C., & Harding, M. (2015). Walking school buses as a form of active transportation for children--a review of the evidence. *Journal of School Health*, 85(3), 197-210. DOI: 10.1111/josh.12239
- Stewart, O., Moudon, A. V., & Claybrooke, C. (2012). Common ground: eight factors that influence walking and biking to school. *Transport Policy*, 24, 240-248. DOI: 10.1016/j.tranpol.2012.06.016
- Stone, M., Larsen, K., Faulkner, G. E., Buliung, R. N., Arbour-Nicitopoulos, K. P., & Lay, J. (2014). Predictors of driving among families living within 2km from school: Exploring the role of the built environment. *Transport Policy*, 33, 8-16. DOI: 10.1016/j.tranpol.2014.02.001
- Trazeo (2014). Retrieved September 30, 2017, from http://www.trazeo.com/
- Watkins, K. E., Ferris, B., Borning, A., Rutherford, G. S., & Layton, D. (2011). Where Is My Bus? Impact of mobile real-time information on the perceived and actual wait time of transit riders. *Transportation Research Part A: Policy and Practice*, 45(8), 839-848. DOI: 10.1016/j.tra.2011.06.010
- Weiser, P., Scheider, S., Bucher, D., Kiefer, P., & Raubal, M. (2016). Towards sustainable mobility behavior: Research challenges for location-aware information and communication technology. *GeoInformatica*, 20(2), 213-239. DOI: 10.1007/s10707-015-0242-x
- Winter, S., Sester, M., Wolfson, O., & Geers, G. (2011). Towards a computational transportation science. *Journal of Spatial Information Science*, (2). DOI: 10.5311/josis.2011.2.2
- Yujuico, E. (2015). Considerations in the diffusion of a public traffic app for Metro Manila. *Journal of Transport Geography*, 42, 48-56. DOI: 10.1016/j.jtrangeo.2014.011.001


Mapa
Student walking or cycling to school
Student driven to school
Family interested in participating
Family not interested in participating


83% 12:41
Walk in progress
Pedrillo
Paula
Gonzalo
Manuela
Evita
Sure
Finish walk




32% 09:21
Green WSB route Test School
Monitor Mary 08:08
Good morning!!!
We start the week. Happy walks!
Tommy's mom 08:08
Don't wait for Tommy. He's sick today
Monitor Mary has started the walk for the Green WSB route Test School group
08:21
Monitor Mary 08:56
It has been a nice walk for all. Very funny!
The walk for the Green WSB route Test School has finished
08:56
Walking School Bus Coordinator 08:57
Perfect!!!!
Send

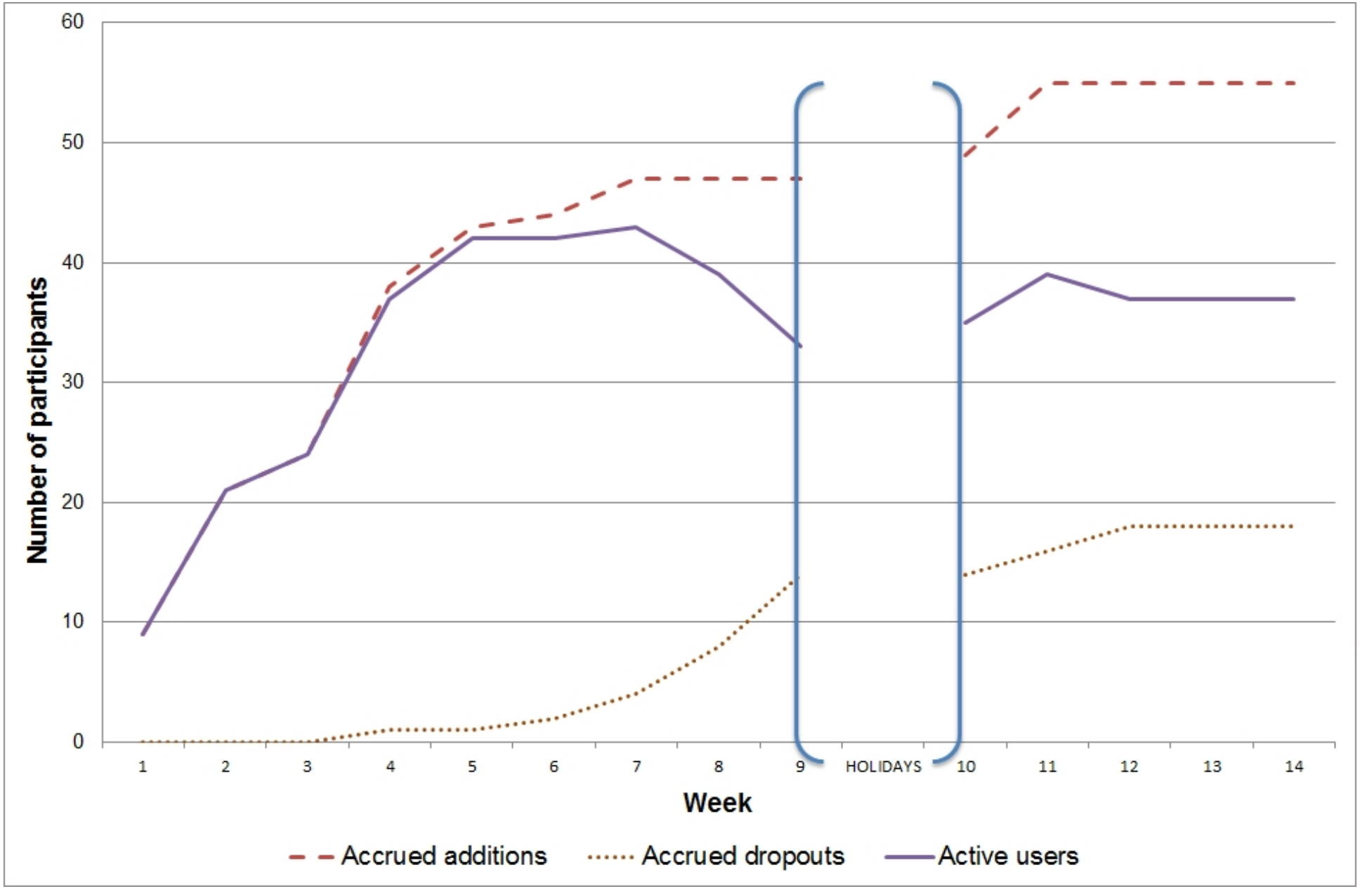

60
50
40
30
20
10
0
Number of participants
1
2
3
4
5
6
7
8
9
HOLIDAYS
10
11
12
13
14
Week
Accrued additions
Accrued dropouts
Active users

Table 1. Previous studies about Walking School Bus (WSB) programmes

Study	Study Site	Methods	Results
Kearns et al., 2003	One school in Auckland, New Zealand	Evaluation of one school's WSB, survey to participants' parents (16), conversations with WSB drivers and children, interviews with people responsible for road safety (7)	Although health, social and time-saving benefits were reported by the participants, the authors concluded that WSBs were an ambivalent response to the hegemony of motorized transport.
Collins and Kearns, 2005	Auckland, New Zealand	45 interviews with 23 school representatives (mostly principals) and 22 WSB coordinators conducted providing information on 29 of 34 schools with WSBs in Auckland	Participants identified benefits from WSBs, ~~e.g~~e.g., an estimated 429 saved vehicle journeys each day. However, the authors concluded that WSBs had limited ability to address public health challenges in an inequitable and car-dominated urban political system.
Kingham and Ussher, 2005; 2007	Christchurch, New Zealand	A combination of interviews (33) and questionnaires with people conducting some WSBs	The authors concluded that WSBs were suffering a significant decline on the long term. Some of the difficulties identified were: a lack of volunteers, lack of children through them wanting to make the journey alone, insufficient ongoing support from the school or council
Heelan et al., 2009	Nebraska, US	The prevalence of walking to school was evaluated by self-report six times, and the objective physical activity levels among a sample of research participants (201 intervention children and 123 control children) in two WSB intervention schools and one control school were compared by having participants wear an accelerometer four times.	At each later timepoint, a significantly greater percentage of children actively commuted to and from WSB schools compared with control school.
Kong et al., 2009	Albuquerque, New Mexico, US	A feasibility trial used a process evaluation of two WSBs at an elementary school with 29 participants (kindergarten through fifth grade students living within a one-mile radius of school). Qualitative and quantitative data were obtained from field notes, attendance records, student and parent satisfaction surveys, focus groups, and interviews with two lead coordinators.	Student and adult participants reported high levels of satisfaction with the WSB. The authors concluded that WSB studies in urban, underserved school districts were feasible but required attention to ensure participants' involvement, safety, and investment from stakeholders.
Mendoza et al., 2009	Seattle, WA, US	This study assessed students' methods of transportation to school in a classroom survey at baseline and a one-year follow-up There was an intervention school with a WSB program with volunteer parents and a part-time coordinator and two control schools.	Although no significant differences between proportions of students walking to school at intervention and control schools at baseline were identified, significantly higher proportions of students walked to school at the intervention school than control schools and this result was maintained in time.
Collins and Kearns, 2010	Auckland, New Zealand	This research was a longitudinal assessment of the major WSBs in Auckland primary schools using telephone interviews and questionnaires. Slight changes from 2002 to 2006 were found.	The number of WSB was growing, but most activity still remained in the wealthiest areas. Some of the benefits of WSB reported were sense of community, opportunity for exercise and health promotion, reduction in car use and local congestion, and reduced risk of injury for child pedestrians.
Mendoza et al.,	Houston, TX, US	Pilot cluster randomized control trial with four intervention and four control schools.	Intervention schools increased active commuting (AT), whereas control schools

2011		Intervention schools had one to three WSBs with trained staff to and from schools five days per week. The percentage of trips made by active commuters was assessed using a questionnaire. Minutes per day of moderate to vigorous physical activity (MVPA) were measured using GT1M accelerometers worn by students for seven days.	decreased AT. Intervention children increased the daily MVPA from 46 to 48 minutes, whereas control children decreased MVPA from 46 to 41 minutes. The WSB children achieved 7 minutes/day more MVPA than control children.

Table 2. Distribution of students by distance from home to school

Distance from home to school (m)	**% of students (*n* = 294)**
$0 < x \leq 500$	3.74
$500 < x \leq 1000$	21.43
$1000 < x \leq 1500$	27.55
$1500 < x \leq 2000$	25.51
$2000 < x \leq 2500$	7.48
≥ 2500	14.29

Table 3. Demographic characteristics of the participant children

Variable	Participants (*n* = 55)	Percentage (%)
Gender		
Male	32	58
Female	23	42
Age		
≤ 5	9	16
6	9	16
7	6	11
8	9	16
9	7	13
10	12	22
11	1	2
12	2	4
Number of participating children per family		
1	15	27
2	30	54
3	6	11
4	4	7
Distance from home to school		
500 < x ≤ 1000	10	18
1000 < x ≤ 1500	22	40
1500 < x ≤ 2000	15	27
2000 < x ≤ 2500	6	11
≥ 2500	2	4

Table 4. Recurrence index

I_R	**Number of children (*n* = 55)**
1.0 ≥ x > 0.8	45
0.8 ≥ x > 0.6	8
0.6 ≥ x > 0.4	1
0.4 ≥ x > 0.2	0
0.2 ≥ x > 0.0	1

Table 5. Change of transportation mode by distance between home and school

	Responses by distance in m (*n* = 55)					**Total (%)**
Response/Distance	**500–1000**	**1000–1500**	**1500–2000**	**2000–2500**	**≥ 2500**	
Change transportation mode (MS)	5	4	9	4	2	24 (43.7)
Every day go and back (FMS)	0	2	5	2	0	9 (16.5)
Every day only go or back (PMS)	5	1	4	1	2	13 (23.6)
Some days (OMS)	0	1	0	1	0	2 (3.6)
Already walked (AW)	5	18	6	2	0	31 (56.3)

Table 6. Benefits reported by the families

Reported benefit	% by importance					% Total	% Total MS	% Total AW
	1	2	3	4	5			
More available time for me	47.4	10.5	7.9	2.6	0.0	68.4	68.4	68.4
Fewer complications in the organization of the family	71.1	15.8	2.6	2.6	0.0	92.1	84.2	100.0
Less use of the car	31.6	5.3	7.9	10.5	7.9	63.2	78.9	47.4
My child shows more responsible pedestrian safety behaviours	55.3	15.8	10.5	0.0	0.0	81.6	89.5	73.7
My child shows a more positive attitude towards school	28.9	23.7	5.3	2.6	5.3	65.8	68.4	63.2
My child shows a more positive attitude at home	10.5	10.5	23.7	0.0	2.6	47.4	47.4	47.4
My child shows a more sociable attitude towards other children	26.3	15.8	15.8	2.6	0.0	60.5	57.9	63.2
My child seems to be more active	28.9	15.8	5.3	2.6	0.0	52.6	42.1	63.2
Other	13.2	5.3	0.0	0.0	0.0	18.4	15.8	21.1

% by importance: Percentage of participants (calculated over the whole number of participants) that reported the benefit, disaggregated by the level of importance marked in the survey.
% Total: Accrued percentage of participants (calculated over the whole number of participants) that reported the benefit, independently of the importance scale.
MS: Children who changed totally or partially their transportation mode.
AW: Children who already walked before the WSB.