Assessing the impact of discussing and practicing urban mobility on the travel behavior of young children and their caregivers: mixed-method empirical research in public preschools in São Paulo (Brazil)

Mateus Humberto*, Filipe Moura, Mariana Giannotti

* mateushumberto@tecnico.ulisboa.pt

Abstract (222 words)

This manuscript seeks to evaluate changes in the travel behavior of young children (5-6 y/o.) and their caregivers following the implementation of a 4-month program in public preschools in São Paulo (Brazil) with a high prevalence of low-income immigrants. The program was developed around two intervention types: i) weekly inquiry sessions about urban mobility through the Philosophy with Children approach and ii) bimonthly outdoor walking activities in the surroundings of schools. In this way, it was possible to observe positive changes in the perceptions of children's statements and in the social norms of their caregivers about transportation, as well as significant modal shifts of caregivers towards sustainable mobility, which were evaluated using difference-in-differences and time-series analyses.

Besides the identification of changes in the behavior of adult caregivers through child-centered intervention types, this empirical research enabled unraveling the effect of the proposed measures according to the child's gender, nationality, and level of social vulnerability, including the significant modal shifts towards walking and cycling identified among boys and out of car and motorcycle among native children, which were significant both in post and follow-up measures.

In addition to contributions to the evaluation of school-based interventions with data from developing countries, the discussions presented in this paper intend to provide insights into the role of early childhood and perceptions in behavioral changes towards sustainable transport.

Graphical abstract

Keywords

Active transport; Behavior change; Methodology; Early childhood; Global South; Philosophy with Children.

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1. Introduction

Home-school trips made by children and youth represent a significant share of daily trips in several parts of the world, however, many countries have registered a decline in children's active and independent mobility in the last decades, which is undesirable for building safe, sustainable, and inclusive cities (Fyhri et al., 2011). In this sense, schools can have a major role in promoting sustainable habits, including the right to live in sustainable cities, to use clean transport modes and to have good access to relevant destinations. This paper seeks to explore the mechanisms underlying changes in the travel behavior of young children and their caregivers due a set of school-based interventions.

Previous research has identified the impact of interventions on children's physical activity and active commuting to school, although it has tended to disregard younger children and the case of low-income communities, especially in developing countries. Furthermore, there is still much to be researched on the interaction between people's perceptions and the reported travel behavior, mainly related to participatory approaches to incorporating children's voices and the impact assessment of child-centered interventions on adults. Finally, there is a limited number of studies evaluating the interplay between different types of interventions, including the differential impact of outdoor and in-classroom interventions on the effectiveness of such programs.

To address this research gap, this manuscript seeks to evaluate the changes in travel behavior following the implementation of a 4-month school-based program focused on: i) exploring the open public space in the surroundings of schools through walking and ii) inquiring children about urban mobility through the "Philosophy with Children" (PwC) participatory approach. The research project was implemented together with 5 to 6-year old children and their caregivers between February and August 2019, in public preschools in São Paulo (Brazil) with a high prevalence of low-income immigrants.

Henceforward, the paper provides an overview of empirical studies covering changes in the travel behavior of children, in section 2. *Literature review*. This is followed by the description of intervention types, sources of data, and methods for analyzing data, in section 3. *Methods*. Subsequently, in section 4. *Results* the observed changes in the travel behavior of children and their caregivers are presented, whose discussion, limitations and possible avenues for future research are presented in section 5. *Discussion and conclusion*.

2. Literature review

The first empirical studies addressing behavioral changes in children emerged in Medicine-related publications in the 2010s, with the evaluation of established programs to increase children's active commuting to school and decrease traffic congestion, namely the Walking School Bus (Mendoza et al., 2011; Sayers et al., 2012) and school travel plans (Hinckson and Badland, 2011). These topics were further incorporated by transport-related academic journals, which assessed the health benefits of active transport and injury reduction that were brought by cycle training courses (Ducheyne et al., 2014), increased crossing guard presence (Gutierrez et al., 2014), and school-based interventions (Christiansen et al., 2014), whose narratives were commonly embedded with the belief that "reducing this dependence [of auto transportation] at an early age may establish a lifelong pattern of active transportation" (Sirard et al., 2015).

The evaluation of such interventions covered a broad range of school-based strategies, including obesity prevention programs (Xu et al., 2015), peer-mentoring about physical activity (Tymms et al., 2016), lessons about active transport in a driving license course (Verhoeven et al., 2016), and a variety of initiatives aiming to encourage active commuting with children (*e.g.*, cycle training, school travel plan, Safe Routes to School). Many of them nonetheless reported no significant effect of the implemented measures on increasing moderate-to-vigorous physical activity (Harrington et al., 2018; Sayers et al., 2012; Tymms et al., 2016) or promoting walking or cycling to school (McMinn et al., 2012; Østergaard et al., 2015; Teixeira et al., 2019), even when large-scale policy changes were considered (Sirard et al., 2015). The lack of evidence of the interventions' impact is reported predominantly among older children (aged 11 and above), and no difference in effect across gender and socio-economic position has been identified (Love et al., 2019).

However, other studies did identify a positive impact of the interventions among younger children (aged under 10 years old), including the increase in active transport due to school travel plans (Hinckson and Badland, 2011), awareness raising activities (Villa-González et al., 2016), and the implementation of the Safe Routes to School program (Hoelscher et al., 2016). Similarly, an intensification of physical activity was noted among younger children as a result of other school-based initiatives, namely the Healthy Choices Programme (Shannon et al., 2018) and the Walking School Bus (Mendoza et al., 2011).

Besides the paucity of intervention studies covering younger children and teenagers, another limitation reported in the literature is associated with the substantial heterogeneity and low quality of evidence across studies, underscoring a need for stronger study designs in this area of research (Larouche et al., 2018), which is still in an early stage (Schönbach et al., 2019). The search for robust studies includes the consideration of longer follow-ups, standardized outcome measures, and potential mediators of travel behavior change to help refine current interventions (Larouche et al., 2018).

The papers reviewed for this manuscript were collected through the ISI Web of Knowledge platform¹, resulting in 17 papers, as presented in Table 1.

¹ Studies within the ISI Web of Knowledge platform (apps.webofknowledge.com) on March 16, 2020 that cover the topics "transport*" or "mobility", followed by "child*" and one of the following terms: "behavior change", "behaviour change", "treatment group", "control group", or "causality", totaling 10 different combinations. From the 410 publications originally collected, only 18 involved empirical research in children's physical activity or urban mobility with children. From these, 13 works were excluded due to the following exclusion criteria: no pre/post research design (n = 8); no intervention (n = 3); and review article (n = 2). The two review articles obtained then provided 12 other studies involving pre-post research with children and were included in the review process apps.webofknowledge.com

Table 1: Review of empirical studies covering changes in the travel behavior of children using a pre/post research design (in reverse chronological order). Interventions with an identified positive effect on active commuting or moderate-to-vigorous physical activity are highlighted (in gray). * Consultation to school officials; † Schools as unit of analysis; NA: not available.

Author-year	Age range (children)	Intervention	Consult. (child / caregiver)	Sample size (children)
Teixeira et al. 2019	NA	Soft transport policy package	N / Y	NA
Harrington et al. 2018	11 to 14	Programme to increase physical activity	Y / N	1 211
Shannon et al. 2018	8 to 9	Healthy Choices Programme	Y / N	155
Hoelscher et al. 2016	9 to 10	Safe Routes to School	Y / Y	78 †
Verhoeven et al. 2016	17 to 18	Lesson in driving license course	Y / N	441
Villa-Gonzalez et al. 2016	8 to 11	Awareness raising activities	Y / N	494
Tymms et al. 2016	11 to 12	Peer mentoring + participative learning	Y / N	1 494
Ostergaard et al. 2015	10 to 12	Cycling promotion programme	Y / N	2 401
Sirard et al. 2015	10 to 11	School choice policy change	N / N *	40 †
Xu et al. 2015	9 to 10	Obesity prevention program	Y / Y	1 182
Ducheyne et al. 2014	9 to 10	Cycle training course	N / Y	94
Christiansen et al. 2014	11 to 14	Physical activity intervention	Y / N	1 014
Gutierrez et al. 2014	NA	Increased crossing guard presence	Y / Y	NA
Sayers et al. 2012	NA	Walking School Bus	N / Y	77
McMinn et al. 2012	8 to 9	School-based active commuting intervention	Y / N	166
Mendoza et al. 2011	9 to 10	Walking School Bus	Y / Y	149
Hinckson and Badland 2011	NA	School Travel Plan	Y / N	13 631

Most published research has been implemented in a set of countries in Western Europe (mainly in the UK, Belgium, and Denmark) and in the USA, with a varied sample size (min: 77, max: 13,631, median: 494) and covering a wide age range (8 to 18 y/o.), with a prevalence of children and adolescents aged between 8 and 14 years old. The majority of the research approaches is school-based, with a widespread adoption of questionnaires for data collection and a set of tools for analyzing data, including regression models and

other statistical tests to assess differences in the relevant metrics (*e.g.*, T-test, F-test, Chi-squared test, odds ratio).

Some studies that included control and treatment groups in their research approaches acknowledged difficulties comparing intervention schools with "business as usual" controls (Tymms et al., 2016), especially with regard to the recruitment of public schools (Østergaard et al., 2015). In this sense, other studies made adjustments by either categorizing schools according to their funding allocation in infrastructure (Hoelscher et al., 2016) or combining strategies from a baseline intervention (Verhoeven et al., 2016). These controlled evaluations, however, were not limited to the effect of the proposed interventions on established measures such as the degree of active commuting to school and the level of children's moderate-to-vigorous physical activity, but have also included the change in children's perceptions towards active modes, including the safety perception and motivation to walk (Villa-González et al., 2016), attitude towards bicycling (Christiansen et al., 2014), and psychological needs and autonomy-support from teachers (Shannon et al., 2018). In a recent evaluation of the Walking School Bus program, Nikitas et al. (2019) indicate that exploring perceptions and attitudes of both students and adults (caregivers, teachers, *etc.*) about school travel can be particularly helpful in expanding the understanding behind the uptake of school-based interventions and their long-term viability.

A number of research findings have indeed acknowledged the mutual influence between travel behavior and its psychosocial determinants, particularly the attitude and perceptions towards using different transport modes (Kroesen et al., 2017; Line et al., 2010; Villa-González et al., 2016). These follow the usual assumption that attitudes influence behavior (Janke and Handy, 2019) and resonate with the reported associations of active transport and physical activity with parental perceptions on environmental characteristics (De Meester et al., 2014), as well as positive cycling experience and negative attitudes towards cars (Sigurdardottir et al., 2013). Some of these studies did not detect any intervention effect on active commuting, but on "parental encouragement and student attitude towards bicycling" (Christiansen et al., 2014) and on creating "awareness and intentions of change" (Teixeira et al., 2019), supporting the assumption that such psychosocial factors of active transport are "the first step in order to achieve a change in behaviour" (Verhoeven et al., 2016).

Despite being primarily implemented with children and school staff, such interventions seem to also influence the behavior of other family members, as does the positive parental attitude towards cycling due to a course to improve children's cycling skills (Ducheyne et al., 2014) and a school-based physical activity program (Christiansen et al., 2014). The influence of children on the transportation needs of their caregivers is similarly found in research covering awareness activities about environmental characteristics (Villa-González et al., 2016), children's independent mobility (Vlaar et al., 2019), and the impact of the children's development on the bicycling attitudes and behavior of caregivers (Janke and Handy, 2019).

In effect, Nikitas et al. (2019) acknowledge the role of enhancing children's "perceived safety, health, emotional and environmental value" as a way of optimizing school-based initiatives to change children's travel behavior. Here, the use of active discussion groups with young people has been successful (Shannon et al., 2018), more suitable and less intimidating than quantitative methods (Line et al., 2010). Nevertheless, the adoption of such research approaches to acknowledge behavioral changes in children commonly disregarded low-income populations (Shannon et al., 2018), the situation of children with

migration background (Schönbach et al., 2019), and the communities in developing countries (Xu et al., 2015), which may also limit the quest for effective interventions.

3. Methods

Two intervention types (inquiry sessions and outdoor walking activities) were implemented in three public schools in São Paulo (Brazil) with similar levels of mobility resources according to the Capability Approach, indicating comparable “conditions to walk provided for the children and their caregivers” (Humberto et al., 2020b).

Baseline measures were collected with caregivers before the interventions (T1), after the interventions (T2) and in a two-month follow-up (T3). Data provided by children (aged 5-6 y/o.) consist of the sentiment orientation (positive to negative) of the children’s statements during the inquiry sessions as obtained using sentiment analysis (Humberto et al., 2020a).

The gathered data were analyzed by comparing the measures delivered by children and their caregivers through a set of statistical tests, including time-series analysis (pre-post and pre-follow-up), difference-in-differences (accounting for time-series and differences due to the combination of strategies), and the stratification in relevant groups (gender, nationality, and level of social vulnerability). The description and context of children and caregivers involved in this study are presented in section 3. *Results*

3.1. Intervention types

The intervention types analyzed in this manuscript stem largely from a joint research project between the University of São Paulo and the non-government organization *apê - estudos em mobilidade*², which sought to assess the impact of both discussing and practicing active mobility in the school setting on the travel behavior of young children and their caregivers. To achieve this, a set of inquiry sessions about urban mobility (indoor) and educational activities through walking in the schools’ surroundings (outdoor) was implemented together with children and staff from the participating schools.

The outdoor activities consisted of walks either to a relevant destination located around the schools (e.g. library, museum, public garden, carpet factory) or in the neighborhood itself, which were proposed in collaboration with the local NGO, whose projects seek to “arouse a permanent curiosity in young people” as an “experience of education in urban mobility” (Nogueira, 2015). These educational activities lasted approximately one hour and were applied every two months to 29% of the surveyed sample (N = 87 children from three classes).

The inquiry sessions were built on the concepts of the Philosophy with Children (PwC) approach, which “thinks of philosophy not as knowledge or content but as a relationship with knowledge and thought” (Kohan, 2015). According to Gomes (2019), the “experiences of thinking” proposed by the PwC practices promote the “possibility to change” by affirming students’ and teachers’ different voices and following some methodological steps, including the gathering of collective inquiries and the identification of relevant themes and questions for further discussion (*Ibid.*). Recent applications of the PwC involving urban mobility include the discussion of “themes related to mobility and permanence in the public space, such as going from home to school, playing in the garden and going out to open spaces” (Barreiros et al., 2019). In this study, a series of eleven PwC

² <http://apemobilidade.org/>

1 sessions was carried out to address different dimensions of urban mobility from the
2 children's point of view, whose detailed description is provided by Humberto et al.
3 (2020a). The inquiry sessions were applied weekly to the entire sample (N = 299 children
4 from nine classes).

6 **3.2. Data sources**

7 Questionnaires were completed by the caregivers in three stages: i) two weeks before the
8 beginning of the PwC sessions (T1: pre); ii) at the end of the inquiry sessions and outdoor
9 activities (T2: post, four months after T1); and iii) after winter school break (T3: follow-
10 up, six months after T1), covering a set of socio-demographic variables, the adopted
11 transport modes by children and caregivers³, and descriptive social norms towards active
12 mobility⁴ as informed by the caregivers (N=232, 78% response rate).

13 The transcription of the inquiry sessions yielded a text corpus with 27,943 segments of
14 text. The comments of the participants during the PwC sessions (before and after the first
15 outdoor walking activity, T1 and T2) encompasses both children and adults (school staff
16 and participating researchers) and can vary from short comments to long contributions to
17 the discussions at stake. Approximately one third (28%) of such segments were associated
18 to children whose caregivers answered the questionnaires, and 7% of them (N=1,909)
19 could be joined to the AFINN sentiment lexicon (Nielsen, 2015). This includes polarity
20 values for children's statements between -3.000 and 4.000 once terms are reassembled in
21 the corresponding segments and divided by the segment of text's word count (mean: -
22 0.080, median: -0.125). Likewise, a detailed description of the sentiment analysis used in
23 this manuscript is provided by Humberto et al. (2020a).

24 Information about the nationality of children and their caregivers was provided by the
25 school staff. Finally, the georeferencing of the children's households as provided by the
26 caregivers enabled the association with public datasets about the housing conditions,
27 including the determination of social vulnerability levels (SEADE, 2012). The data
28 collection and processing were approved by the Research Ethics Committee of the
29 Institute of Psychology at the University of São Paulo (CEPH-IPUSP) on December 2018
30 (No. 3.092.675, CAAE: 03318918.0.0000.5561). The first author was part of the group of
31 four researchers that coordinated the data collection and the implementation of the
32 intervention types (inquiry sessions and outdoor walking activities) in the analyzed
33 schools.

34 The methodology previously described is summarized schematically in Figure 1.

³ Children: usual transport modes to school; Caregivers: usual transport modes during the week. Multiple response question.

⁴ Four alternatives to complete the statement "Children generally walk to school": 1) Never; 2) A few times; 3) Many times; 4) Always.

Figure 1: Schematic representation of the adopted methodological steps (intervention types and sources of data)

3.3. Time-series analysis and difference-in-differences

To handle the data from the questionnaires and inquiry sessions, two analytical approaches for comparing the collected measures were implemented: time-series analysis and difference-in-differences. While both methods stem from quantitative methods commonly used in economic and health assessments for the estimation of policy effects, a difference-in-differences analysis “compares the change in outcome for an exposed group between a moment before and a moment after the implementation of a policy to the change in outcome over the same time period for a non-exposed group” (Hu et al., 2017). Similarly, a time-series analysis (also known as interrupted time-series) compare the outcomes before and after policy implementation and differs from a difference-in-differences analysis by not requiring a separate control group (*Ibid.*).

In this study, the time-series analysis accounts for the differences in the observed variables between the stages of the study (pre, post, and follow-up, i.e., T1, T2, and T3), whereas the difference-in-differences analysis regards the differences in the consecutive observations (T1, T2, and T3) between the group of children exposed either to the baseline intervention (inquiry sessions, I1) or a combination of interventions (inquiry sessions + outdoor walking activities, I2).

In both approaches, the time is incorporated in the regression models by examining the collected measures before the interventions (T1) and in the following stages, i.e., pre-post (T1-T2) and pre-follow-up (T1-T3). In the regression models, this is represented by defining the variable *Stage*, as follows.

$$\text{Pre to post: } Stage = \begin{cases} 0 \text{ for T1;} \\ 1 \text{ for T2;} \\ null \text{ for T3.} \end{cases} \quad \text{Pre to follow-up: } Stage = \begin{cases} 0 \text{ for T1;} \\ null \text{ for T2;} \\ 1 \text{ for T3.} \end{cases}$$

Similarly, the consideration of the intervention types is done by comparing groups of children participating in both intervention types (I2) or in inquiry sessions only (I1) by means of variable *Group*, for both pre-post and pre-follow-up analysis, as follows.

$$Group = \begin{cases} 0 & \text{for I1 (baseline intervention);} \\ 1 & \text{for I2 (combination of interventions).} \end{cases}$$

In this sense, differential effect of outdoor walking activities on travel behavior, as compared to the baseline intervention (I2 vs. I1), can be expressed by the variable *StageGroup*, defined as follows.

$$StageGroup = Stage * Group$$

Accordingly, the interest coefficient for time-series analysis is the one related to the variable *Stage*, whereas in difference-in-differences analysis the interest coefficient is related to the variable *StageGroup*, both indicated as β_3 in Figure 2. In the results and discussion presented in the following sections, both coefficient and statistical significance (P-value) are observed to evaluate the changes in travel behavior of children and their caregivers due to the interventions implemented, which are further stratified by the most sampled groups of gender, nationality and level of social vulnerability according to questionnaires and statements during the inquiry sessions. The methods for processing the collected data are largely based on a set of tools from the *tidyverse* package within R software (version 3.6.1), an environment for statistical computing and graphics (Wickham and Grolemond, 2017).

Figure 2: Schematic representation of the adopted analytical approaches (time-series and difference-in-differences). The interest coefficient for assessing the impact of interventions is highlighted (β_3). LR: Linear Regression model; AT: active transport (walking or cycling); MT: motorized transport (car or motorcycle).

4. Results

The assessment of the proposed interventions is based on the abovementioned empirical research project implemented in three public preschools in the city of São Paulo (Brazil). Despite being located within a region known as the "Expanded Center" (*Centro Expandido*) that concentrates most of the jobs and public facilities in the municipality (health, education, transport, culture, etc.), the surroundings of the analyzed schools are characterized by poor housing conditions and the concentration of low-income immigrants working in the clothing and textile sector, predominantly from Bolivia (Pucci, 2013). The study sample also points to lower incomes when compared to the whole municipality. Moreover, 44% of the analyzed children live in households composed by non-native caregivers, 68% of them from Bolivia. For further description about the context of children and selected schools cf. Humberto et al. (2020a).

The children surveyed seem to present a share of active school commuting above the city's average, mainly girls, non-native children and those living under high social vulnerability, as presented in Table 2. In contrast, the children's caregivers present lower share of walking trips when compared to the whole municipality, probably due to the greater availability of public transportation in relation to the distant peripheral areas of the city. The children affected by both intervention types (I2) have a more active modal share in accessing schools and seem to be less vulnerable than the other children, which can be related to the profile of caregivers who allow children to attend outdoor activities with no parental participation.

Regarding the participation in the inquiry sessions, represented by the number and the polarity of statements during the PwC sessions, the prevalence of native and least vulnerable children is remarkable, even when considering the larger sample size of these groups. Moreover, girls and children under low social vulnerability present the most positive polarities among other groups. On the other hand, the negativity of the statements made by non-native and more vulnerable children is also outstanding.

Table 2: Descriptive statistics of collected measures (questionnaires and inquiry sessions), stratified by relevant groups (gender, nationality of children, level of social vulnerability, and inclusion in intervention types) and comparison with the municipality of São Paulo.

Source of data	Measure	All children	Boys/Girls	Native/ Non-native	Low/high social vuln.	I1 / I2	São Paulo ^c
Quest. to caregivers	Sample size (N)	232	117 / 115	118 / 44	155 / 24	212 / 87	-
	% AT (children) ^a	61	57 / 64	59 / 68	61 / 73	54 / 75	45 ^c
	% AT (caregivers) ^b	28	29 / 27	29 / 23	29 / 27	29 / 25	38 ^c
	% of boys	53	-	51 / 59	50 / 58	53 / 54	51 ^c
	% of natives	75	72 / 78	-	72 / 92	82 / 61	-
Inquiry sessions	% in low social vuln.	87	85 / 89	84 / 96	-	81 / 94	56 ^d
	No. of statements (N)	1909	766 / 562	1154 / 174	847 / 61	870 / 405	-
	Polarity statem. (x100)	-8.0	-6.7 / -2.5	-4.3 / -9.4	-2.7 / -28.0	-4.9 / -6.7	-

AT: active transport (walking or cycling); I1: Baseline intervention; I2: Combination of interventions. ^a Share of active transport to/from school (T1); ^b Share of AT in the usual transport modes during the week (T1); ^c Includes households with children aged 5-6 y/o. attending public schools in the municipality of São Paulo, extracted from METRÔ-SP (2018); ^d Extracted from SEADE (2012).

Regarding the modal shifts throughout the implementation of the intervention types (pre, post and follow-up), no significant changes can be detected in the way children access

schools, as shown in Figure 3. With initial measures (T1) largely oriented towards active modes, especially in the group of children combining intervention types, changes in children's travel behavior are hardly noticeable, both for active and motorized modes of transport. On the other hand, the impact on caregivers towards sustainable mobility (increased adoption of active modes and decrease in motorized transportation) seems considerable, notwithstanding their indirect role in the proposed interventions: greater use of active modes and reduced adoption of motorized modes, particularly in pre-post analysis, with relatively sustained effects on follow-up measures. Both effects seem to be more pronounced among caregivers whose children attended both outdoor walking activities and inquiry sessions.

Figure 3: Modal share of trips (active and motorized) of children and their caregivers throughout the implementation of the intervention types (pre, post and follow-up)

Apart from the observed changes in the travel behavior of children and their caregivers, it was also possible to observe whether there were any variations in the perceptions that might follow or trigger behavioral changes in urban mobility (see Figure 4). Whereas caregivers were asked to complete a statement regarding their perceived frequency of children's walk share to school throughout the stages of the study (pre, post and follow-up), the polarity of children's statements was obtained by associating the transcripts of the inquiry sessions with a sentiment lexicon (before and after the first outdoor walking activity). There was a positive impact on the social norms of caregivers in all groups, particularly considering the follow-up measures, although caregivers whose children have been involved in both intervention types (I2) seem to have had greater increases in their perceived walk share of transport to school.

This phenomenon points to early findings that seem relevant, as it seems to demonstrate an effect of the inquiry sessions (baseline intervention) not only on the direct beneficiaries (children), but especially on their caregivers, who were not directly involved in any other intervention seeking to change their behavior throughout the project. The fact of discussing urban mobility *per se* seems to have led parents to think that more children were walking to schools, although this topic was not mentioned in the inquiry sessions or

in the interactions with the caregivers to complete the questionnaires. In addition, the children's active modal share to school, predominantly composed by walking, has remained constant along the stages of the project.

Figure 4: Changes in social norms and polarity of children's statements during the inquiry sessions throughout the implementation of the intervention types (pre, post and follow-up).

For some of the measures collected, the identification of changes due to the intervention types seems straightforward, including the unvarying modal shares among children to access schools towards both active and motorized modes. However, in addition to the observed changes throughout the project (T1 vs. T2 and T3) and between the intervention types (I1 vs. I2), it is necessary to examine the respective statistical significance in order to consolidate a careful evaluation, also considering stratified evaluations by gender, nationality and level of social vulnerability, as presented in Table 3.

For time-series analysis, significant modal shifts towards active modes were found in both pre-post (T1-T2) and pre-follow-up (T1-T3) tests, while for motorized modes this seems only applicable to pre-post analyses. In contrast, the increase in social norms was more significant in the follow-up measures, which may be linked to a possible triggering effect of modal shifts observed in the post-intervention period. With regard to the stratified analyses, it was not possible to detect any differential effect of the observed changes due to the child's gender, nationality or level of social vulnerability, although more pronounced modal shifts towards sustainable mobility (especially out of car and towards walking and cycling) were reported among caregivers of boys and less vulnerable children, particularly between T1 and T2.

On the other hand, analyses considering the differential effect of the intervention types over time identified fewer widespread changes. Higher modal shifts to active modes and out of motorized transport were statistically significant in the post-intervention period among caregivers of children in both intervention types (I2) as compared to those in the baseline intervention (I1). In the follow-up measurements, however, this appears to be significant only in the decrease of the motorized modal share. Caregivers of boys seem to have had a greater differential impact of outdoor walking activities on their increased adoption of active transport, both in post and follow-up measures. Among caregivers of native children, on the other hand, this differential impact seems to be more pronounced in decreasing their share of motorized transport only. Additionally, a positive impact on social norms was only observed among the less vulnerable households. This outlines possible indirect effects of interventions on adults, which seem to be mediated by a range of socioeconomic factors such as the child's gender and social vulnerability.

In general, more positive comments by children were noticed over time, with no marked gender, nationality or social vulnerability bias. However, once the effects of outdoor activities are taken into account, there are small positive variations in the polarity of

children's statements (especially among the less vulnerable ones), which nevertheless are not statistically significant.

Table 3: Changes in selected measures following the implementation of the intervention types (coefficient β_3 and respective P-value). Fields whose estimates are statistically significant at the 10% level are highlighted (in gray).

Analysis			All children	Boys	Natives	Low vulnerability
Time-series	T1 to T2 (pre to post)	% AT	+44.7 (0.000)	+41.3 (0.000)	+41.8 (0.000)	+40.1 (0.000)
		% MT	-12.1 (0.012)	-12.5 (0.067)	-9.8 (0.073)	-13.6 (0.041)
		DN	+0.2 (0.010)	+0.3 (0.028)	+0.2 (0.055)	+0.1 (0.394)
		Pol.	+18.3 (0.000)	+15.1 (0.001)	+14.8 (0.000)	+14.0 (0.001)
	T1 to T3 (pre to follow-up)	% AT	+43.3 (0.000)	+35.1 (0.000)	+38.9 (0.000)	+35.6 (0.000)
		% MT	-6.0 (0.245)	+0.1 (0.988)	-3.0 (0.609)	-7.6 (0.268)
		DN	+1.1 (0.000)	+1.0 (0.000)	+1.1 (0.000)	+1.1 (0.000)
		Pol.	+15.8 (0.097)	+24.1 (0.083)	+15.4 (0.188)	+12.6 (0.314)
Diff.-in differences	T1 to T2 (pre to post)	% MT	-25.3 (0.015)	-19.1 (0.200)	-29.2 (0.020)	-15.9 (0.233)
		DN	-0.1 (0.559)	-0.2 (0.394)	-0.3 (0.243)	-0.1 (0.667)
		Pol.	+2.7 (0.719)	-0.7 (0.945)	+4.1 (0.624)	+7.3 (0.427)
	T1 to T3 (pre to follow-up)	% AT	+9.3 (0.367)	+27.4 (0.064)	+5.3 (0.683)	+10.1 (0.438)
		% MT	-20.4 (0.072)	-24.3 (0.126)	-27.0 (0.056)	-6.2 (0.658)
		DN	+0.3 (0.126)	+0.1 (0.729)	0.0 (0.987)	+0.4 (0.083)
		Pol.	+15.8 (0.097)	+24.1 (0.083)	+15.4 (0.188)	+12.6 (0.314)
		% MT	-25.3 (0.015)	-19.1 (0.200)	-29.2 (0.020)	-15.9 (0.233)

AT: active transport (walking or cycling); MT: motorized transport (car or motorcycle). DN: descriptive social norms. Pol.: Polarity of children's statements during the inquiry sessions (AFINN lexicon, x100).

5. Discussion and conclusion

In this manuscript, the evaluation of changes in perceptions and travel behavior is introduced following the implementation of a 4-month program in public preschools in São Paulo (Brazil). To do this, the impact of two intervention types on young children (5-6 y/o.) and their caregivers was tested: i) weekly inquiry sessions about urban mobility through the Philosophy with Children approach (299 children); and ii) bimonthly outdoor walking activities in part of the sample (87 children). In this way, the impacts of discussing and practicing urban mobility with young children were observed both on children and their caregivers. As a general result, it was possible to observe that the act of discussing urban mobility as such seems to have a significant impact not only on the perceptions of children (polarity of statements) and caregivers (social norms), but mostly on the modal shifts of caregivers towards sustainable mobility, even if they were not direct beneficiaries of the interventions.

The minor variations in children's modal share to access schools seem convergent with children in this age group, whose travel choices are relatively stable (Panter et al., 2013). This converges in a way with the findings by Teixeira et al. (2019), whose tested interventions "were able to create awareness and intentions of change" but needed "more extensive activities throughout time" to effectively change travel behavior. However, both inquiry sessions and outdoor walking activities here analyzed over a five-month period seem to have contributed to alter the observed travel behavior of caregivers and certain perceptions of children and their caregivers (polarity of statements during the PwC sessions and social norms, respectively). Moreover, the methods adopted have provided

an opportunity to deepen qualitative research designs by capturing the perceptions of preschool-age children (up to 6 years old) using their own words (Humberto et al., 2020a), bridging the gap of previous research on the influences on travel behavior intention, which has "often depended heavily on obtaining information through research questionnaires and interviews using the words of the researcher". (Line et al., 2010).

The major role of the intervention types identified here does not preclude nevertheless the effective role of physical changes in changing and shaping sustainable mobility behaviors, which require a "high degree of political involvement and support" (Christiansen et al., 2014) and may be well combined with soft interventions. The integration of initiatives focused on perceptions and attitudes into transport projects can be effective in changing "car use intentions and willingness to accept car restrictions" (Sigurdardottir et al., 2013), mitigating "gender inequities in transport cycling." (Bourke et al., 2019), and promoting "well-planned natural experiments focusing on AST" based on the "engagement of local authorities [that] can form the basis for solid knowledge of promoting active transportation for the generations to come" (Christiansen et al., 2014). In this research, even though outdoor walking activities and inquiry sessions did not have the encouragement of sustainable mobility as a common objective, the changes observed towards active modes in both behavior and perceptions seem to have occurred primarily as a result of the experience in the participatory debates in the classroom, which in some cases had their effects reinforced by participating in the outdoor walking activities around schools.

However, a thorough analysis of the changes identified is needed, as the difficulties in reaching new levels for sustainable mobility may be influenced by different baseline values. A first consideration refers to the high share of pedestrian trips by children in accessing schools, which is above average for the city of São Paulo and might explain the modest modal shifts identified towards active modes. Among the caregivers, with an active modal share below the city average, significant modal shifts were identified in two directions: i) a 45% increase in the adoption of active modes, which was sustained in the follow-up, and ii) a 12% decrease in motorized transport use, notwithstanding a mild recovery after the winter school break (T3), with greater reductions among caregivers whose children were involved in both interventions (I2). This rationale can be similarly applied to the stratified analyses, where the modal shifts analyzed were observed in groups with the lowest active modal shares (caregivers of boys, native children and those in low social vulnerability), possibly with greater likelihood of shifting to active modes compared with girls or vulnerable children, for instance.

Once these changes are acknowledged, one should inquire about the factors that seem to determine such shifts in the perceptions and transport modes, i.e., how the cycle of these changes is unfolded. The findings of this study may be useful to observe the impact of encouraging dialogue and the practice of urban mobility with children on the perception of their caregivers, which in turn changed their mobility behavior. However, how can the cycle of behavior change in urban transport be understood considering the child-caregiver relationship? Have children's statements during the inquiry sessions at school been raised in discussions back home and directly influenced their caregivers' travel behavior? Or had children's statements affected at first the caregivers' social norms and thereby changed their travel behavior?

This debate is similar to interventions in the field of environmental education in schools, in which programs "received by children indirectly influenced their parents in recycling paper, plastics, and tin cans" (Evans et al., 1996). This points out that even children this

1 young, who still rely on their caregivers for many activities, have agency and constitute a
2 culture of their own to discuss relevant transport-related aspects, besides having the
3 potential to promote behavior change in their households. This indicates the significant
4 role of children as social actors and of childhood as a social category, which resonates with
5 a range of theoretical backgrounds criticizing the “ideas about ‘vulnerability’ and
6 ‘innocence’ usually attributed to childhood” and endorsing a “renewed vision of childhood
7 such as those related to agency, childhood cultures, public policies for childhood and social
8 practices, and institutional settings for children” (Sarmiento et al., 2018).

9 These considerations suggest possible lessons for the evaluation of child-centered
10 interventions in the transport domain, particularly with regard to the role of perceptions
11 and early childhood in behavioral changes involving school-based interventions towards
12 sustainable transportation. First, the perceptions seem to indicate triggers for behavior
13 change and might be the starting point for future measures, converging with the
14 suggestion brought by Gutierrez et al. (2014) regarding the “prioritization towards
15 engaging in and acknowledging safety before physical activity” to promote active
16 transportation. Furthermore, the participatory and pragmatic aspect of combining
17 discussion and practice with children may overcome the challenges found in shifting
18 parental attitudes, such as the ones found by Ducheyne et al. (2014) in cycle training with
19 children, where “multiple efforts might be needed to change parental attitudes”. In this
20 manuscript, changes in both descriptive social norms and travel behavior were identified
21 in the caregivers, even though they were not the direct beneficiaries of the proposed
22 interventions.

23 In addition, although no significant increase in active modal share has been identified
24 among children to access schools, this positive impact has been detected in the reported
25 travel behavior of caregivers. This observed effect may unravel intra-household
26 interactions beyond the monodirectional influence of adults on children and indicates
27 potential pathways for the impact assessment of school-based interventions on
28 sustainable habits. Furthermore, this may also disclose the possible impact of parental
29 behavioral changes on children, such as the primary focus on “attitude and behaviour
30 change among parents to grant children more freedom” suggested by Vlaar et al. (2019) to
31 design “future interventions to increase children’s territorial range”.

32 Evidently, it is difficult to claim that long-term effects may persist in this group of children
33 and caregivers from this manuscript, particularly in a context of large-scale economic and
34 social repercussions brought by the COVID-19 pandemic in 2020. This would be of
35 particular importance to assess the persistence of the gaps identified between children
36 from different nationalities and social vulnerability levels, as well as to verify whether the
37 impact of these interventions at an early stage are somehow correlated with permanent
38 changes in behavior, such as the significant influence of school-age physical activity on
39 adult physical activity identified among 9 to 18 year old children (Telama et al., 2005). In
40 addition, the quarantines enforced by the spread of the novel coronavirus might prompt
41 long-lasting changes in the travel behavior and social norms related to urban mobility,
42 since the COVID-19 pandemic has implications in many spheres relevant to transport
43 issues, including school closures, occupation of public places, changes in work routines,
44 family organization, and isolation, leading to feelings of insecurity and avoidance of
45 crowds (Brooks et al., 2020; Ornell et al., 2020).

5.1. Limitations and further research

Nevertheless, this study presents limitations and some considerations must be underscored. Similar to other empirical qualitative research, there is a concern of social-desirability bias, whose mitigation was pursued through the adoption of the PwC participatory approach, which seeks to build the “experiences of thinking” from the children’s questionings, in which the participating researchers seek to intervene only to gather collective questions and inquiries and to select themes to keep discussing in the following inquiry sessions (Gomes, 2019).

Additionally, there is a risk of recall bias in the methods adopted due to the adoption of self-reported measures provided in the questionnaire to caregivers. However, the information collected from caregivers addresses common events such as the usual means of transport and the current perception of pedestrian mobility. Data from children were gathered using a long-running qualitative research design, in which children have more time to recall and elaborate on change, especially when compared to self-administered surveys that are commonly applied in travel behavior research (Janke and Handy, 2019).

Possible idiosyncrasies associated with each of the participating schools were not considered, which may have omitted possible particularities of each school to promote active mobility. In addition, the central role of cycling mobility was not considered, which seems to be of large adoption especially among the population from Bolivia. As other limitations, the reviewed studies did not include manuscripts that were not written in English, which may result in incomplete representation of the relevant literature.

The methods of data analysis also present some limitations, mainly related to the adopted approaches (time-series and difference-in-differences) and the lack of a randomized controlled trial research design. In time-series analysis, other events occurring around the time of the intervention can be a source of confounding, whereas in the difference-in-differences approach the analyses are highly susceptible to confounding due to between-group differences (Bernal et al., 2019). Besides acknowledging the inability to control possible contemporaneous events during the school semester, the heterogeneity in the walking conditions was sought to be minimized through the selection of public schools with similar conditions to walk as calculated by Humberto et al. (2020). In addition, the difficulties faced by most public schools in developing countries complicate the implementation of research designs without providing clear benefits to the participating schools, i.e., including them as control schools. Similar challenges have also been identified in studies conducted in wealthier countries (Hinckson and Badland, 2011; Østergaard et al., 2015; Shannon et al., 2018).

To develop further studies, some suggestions can be outlined: i) evaluate the direction of the observed changes (polarity of children’s statements and caregivers’ travel behavior and social norms) using appropriate analytical tools (e.g. structural equation modelling); ii) conduct follow-up measurements one year later; iii) inclusion of treatment and control groups in further applications using a randomized controlled trial; iv) test the impact of the intervention types in schools with lower shares of active mobility; v) include other under-researched age groups, principally adolescents in secondary school settings; and vi) assess the combined impact of interventions directly addressing the engagement of parents.

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