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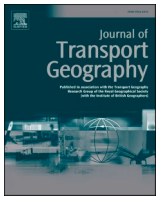

Can outdoor activities and inquiry sessions change the travel behavior of children and their caregivers? Empirical research in public preschools in São Paulo (Brazil)

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ABSTRACT

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 as reported by 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 caregivers of boys and out of car and motorcycle among those of 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.

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 mobility (*e.g.* walking and cycling) in the last decades, which includes cities both in the Global North and the Global South, for instance 48% to 13% in the United States between 1969 and 2009 (McDonald et al. 2011) and 70% to 49% in São Paulo between 1997 and 2012 (de Sá et al. 2016). This phenomenon seems to be associated to the facilitated acquisition of private vehicles (Fyhri et al. 2011; Sá et al., 2014), the parental concerns about traffic and stranger danger (McDonald et al. 2011), and to the spatial distribution of schools as a result of bigger units and more children in private schools, which increases distance to school (Fyhri et al. 2011; McDonald et al. 2011). In this sense, schools and education policies can have a major role in promoting sustainable habits, including the right to live in sustainable cities and to use clean transport modes. This paper seeks to explore the mechanisms underlying changes in the travel behavior of young children and their caregivers due to 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 (Porter and Abane 2008). 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

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differential impact of outdoor and in-classroom interventions on the effectiveness of such programs.

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 of data analysis, 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). These 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, p. 29).

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 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 panel research designs, 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 platform (apps.webofknowledge.com) on March 2020 and 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, resulting in 17 papers, as presented in Table 1.

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 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, p. 175) and on creating "awareness and intentions of change" (Teixeira et al. 2019, p. 20). That way, these studies support 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, p. 1).

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

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 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

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, p. 485) 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 qualitative research approaches to acknowledge behavioral changes in commonly disregarded groups of children has been limited to a reduced set of transport-related studies, including the situation of low-income populations (Shannon et al. 2018), children with migration background (Schönbach et al. 2019), and school communities in developing countries (Xu et al. 2015). Furthermore, there are few examples of participatory research methods tailored to children and youth in travel behavior research, even though these approaches have been recognized as drivers of "change in activity levels" throughout childhood (Tymms

et al. 2016, p. 5). That echoes a range of theoretical backgrounds demanding "new approaches that are more aware of social inequalities and diversity" and seeking to regard children as "subject of rights, participative, competent and socially active" (Sarmento et al., 2018, p. 152). In this sense, it seems necessary to elaborate research strategies tailored to vulnerable children, particularly in a context of child poverty generated by the economic and financial crisis (Sarmento et al., 2018) and escalating transnational and rural-urban migration in the Global South (Davis 2006), which might strengthen the quest for effective interventions to promote sustainable mobility.

3. Methods

Two intervention types (inquiry sessions and outdoor walking activities) were implemented as part of a 4-month program in three public preschools within the Municipality of São Paulo (Brazil), between March and June 2019. The Municipality of São Paulo (also referred to as City of São Paulo) is one of the municipalities that compose Metropolitan São Paulo, which covers a surface of 7947 km^2 and 21.6 million inhabitants distributed in 39 municipalities. The City of São Paulo itself accounted for 1521 km^2 and 12.1 million inhabitants in 2018 (Emplasa, 2019; Estado de São Paulo, 2011). Being acknowledged for its "growing social and economic inequalities (...) embedded through high spatial inequality" (Moreno-Monroy et al. 2018, p. 110), the context of Metropolitan São Paulo may also contribute to the development of the yet under-studied research agenda on the Global South concerning the travel behavior of children and their caregivers. In this study, only public preschools were considered as prospective sites for data collection and analysis. Furthermore, in the search for schools representative of the transport conditions encountered by preschoolers in São Paulo, the schools analyzed in this research were selected according to the "levels of mobility resources" as defined through the Capability Approach, indicating comparable "conditions to walk provided for the children and their caregivers" (Humberto et al. 2020b, p. 189).

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). During the six-month period analyzed, no marked changes were observed regarding public security and transport conditions, including facilities for pedestrians, cyclists and public transport users. The description and context of children and caregivers involved in this study are presented in section 4. *Results*.

3.1. Intervention types

The intervention types analyzed in this manuscript stem largely from a joint research project among the University of São Paulo, the University of Lisbon and the non-government organization *apẽ - estudos em mobilidade* (http://apemobilidade.org), 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, para. 8). As part of an education project seeking to practice urban thinking through walking with children, the proposal is drawn throughout meetings organized for a month before the day of the activity. The route planned is discussed together with schoolteachers, in which the themes to be approached are discussed, including the "senses that can be discovered by the children's curiosity through the walking experience" (Walk 21 Vienna, 2015, para. 3). At the day of the outdoor activity, the children are oriented by a map of the walking route, which proposes "stops in interesting points, such as big trees, squares and colorful paintings on the walls". (Walk 21 Vienna, 2015, para. 5). By stimulating the imagination and attention of children "through the senses and questions about the urban space, the project aims to present children and teachers as responsible commuters of the public spaces they walk and to make the experience outside school something comfortable and familiar" (Walk 21 Vienna, 2015, para. 5). 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, p. 156). In this sense, the PwC approach focuses on "creating the conditions to philosophize", which means that everyone sits in a circle, asks for the floor to speak and promotes the relationship between the participants of the inquiry sessions (Kohan 2015, pp. 156–157). 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 (Gomes, 2019, p. 34). A typical application of PwC involving younger children up to seven years old incorporates the *community ball* to give the "opportunity to call and be called upon by their peers" and sitting in a circle, which "nurtures collaboration amongst the children, helping them to be more focused on the topic", creating a safe place for philosophical inquiry (Jackson and Oho 1993, pp. 6–10). 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, pp. 183–184). In this study, a series of eleven PwC sessions was carried out to address different dimensions of urban mobility from the children's point of view, whose detailed description is provided by Humberto et al. (2020a). The inquiry sessions were applied weekly to the entire sample ($N = 299$ children from nine classes).

3.2. Data sources

Questionnaires were completed by the caregivers in three stages: i) two weeks before the beginning of the PwC sessions (T1: pre); ii) at the end of the inquiry sessions and outdoor activities (T2: post, four months after T1); and iii) after winter school break (T3: follow-up, six months after T1), covering a set of socio-demographic variables, the adopted transport modes by children and caregivers, and descriptive social norms towards active mobility as informed by the caregivers. The questionnaires were filled out by parents during the project presentation sessions throughout the school semester (65% of the questionnaires delivered) and were sent home to parents who were unable to attend these meetings (35% of the questionnaires delivered). In these presentation sessions no reference was made to a specific transport mode, even though a minor proportion of the caregivers in the initial phase of the project tended to associate the study with the lack of free school buses offered by the municipal government. The project was named "Study on

the influence of the built environment on children's mobility in São Paulo" in official documents and *pytá* ("stay" in the Tupinambá Tupian language) in short for children and schoolteachers. A more detailed description of the variables collected in the questionnaires is provided in Table 2.

In the case of data collected with children, the transcription of the inquiry sessions originally yielded a text corpus with 27,943 segments of text. The comments of the participants during the PwC sessions (before and after the first outdoor walking activity, T1 and T2) encompasses both children and adults (school staff and participating researchers) and can vary from short comments to long contributions to the discussions at stake. Approximately one third (28%) of such segments were associated to children whose caregivers answered the questionnaires, and 7% of them ($N = 1909$) could be joined to the AFINN sentiment lexicon, which estimates the polarity of pieces of text by classifying terms in integer values between −5 and − 1 for negative words and between 1 and 5 for positive words, with a predetermined prevalence (65%) of negative terms (Nielsen 2015). This includes polarity values for children's statements between −3.000 and 4.000 once terms are reassembled in the corresponding segments and divided by the segment of text's word count. In this sense, positive (or less negative) polarity values indicate children's statements with rather positive sentiments, and *vice-versa*. A detailed description of the sentiment analysis used in this manuscript is provided by Humberto et al. (2020a).

In order to supplement the data provided by caregivers (questionnaires) and children (transcripts of inquiry sessions), information about the nationality of children and their caregivers was obtained using school documents as provided by school staff. The description of these variables is also presented in Table 2, as follows.

The data on transport mode use (children and caregivers, as reported by caregivers) were subsequently processed to represent the adoption of active transport modes (walking or cycling) and motorized transport modes (car or motorcycle) as a nominal variable, for instance adoption of active transport (1) and non-adoption of active transport (0). As they are derived from multiple response questions, these variables are not mutually exclusive and therefore cannot be combined. The nationality of the children surveyed originally contains ten different nationalities, but for the sake of simplicity only native and non-native children are presented as alternatives in Table 2. Finally, the georeferencing of the children's households as provided by the caregivers enabled the association with public datasets about the housing conditions, including the determination of low, moderate and high levels of social vulnerability (SEADE, 2012).

The data collection and processing were approved by the Research Ethics Committee of the Institute of Psychology at the University of São Paulo (CEPH-IPUSP) on December 2018 (No. 3.092.675, CAAE: 03318918.0.0000.5561). The first author was part of the group of four researchers that coordinated the data collection and the implementation of the intervention types (inquiry sessions and outdoor walking activities) in the analyzed schools.

The methodology previously described is summarized schematically in Fig. 1.

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, p. 4). 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.

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

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.

Table 2
Type, description and sources of data of variables collected (caregivers, children, and school staff).

Source of data	Variable	Description	Type	Stage of study
Quest. to caregivers	Transport mode (caregiver)	Which transport mode(s) do you (caregiver) commonly use during the week? 1) Walking; 2) Car; 3) City bus; 4) Bicycle; 5) Subway; 6) Suburban train; 7) Motorcycle; 8) Other.	Nominal. Multiple response question. 8 options available	T1, T2, T3
	Transport mode (child)	Which transport mode(s) does your child commonly use to go to school? 1) Walking; 2) Public school bus; 3) Private school bus; 4) Car; 5) City bus; 6) Bicycle; 7) Subway; 8) Suburban train; 9) Motorcycle; 10) Other.	Nominal. Multiple response question. 10 options available	T1, T2, T3
	Descriptive social norms	In your opinion, children generally walk to school: 1) Never; 2) A few times; 3) Many times; 4) Always.	Ordinal. Integer values between 1 and 4	T1, T2, T3
	Age of caregiver	What's your age (caregiver)?	Integer	T1
	Household size	How many people live in your house?	Integer	T1
	Location of residence	Home address	Text	T1
Inquiry sessions	Polarity of statement	Polarity of children's statements during the inquiry sessions (AFINN sentiment lexicon)	Continuous	T1, T2
School staff	Gender of child	1) Native; 2) Non-native	Nominal. 2 options available	T1
	Nationality of child	1) Girls; 2) Boys	Nominal. 2 options available	T1

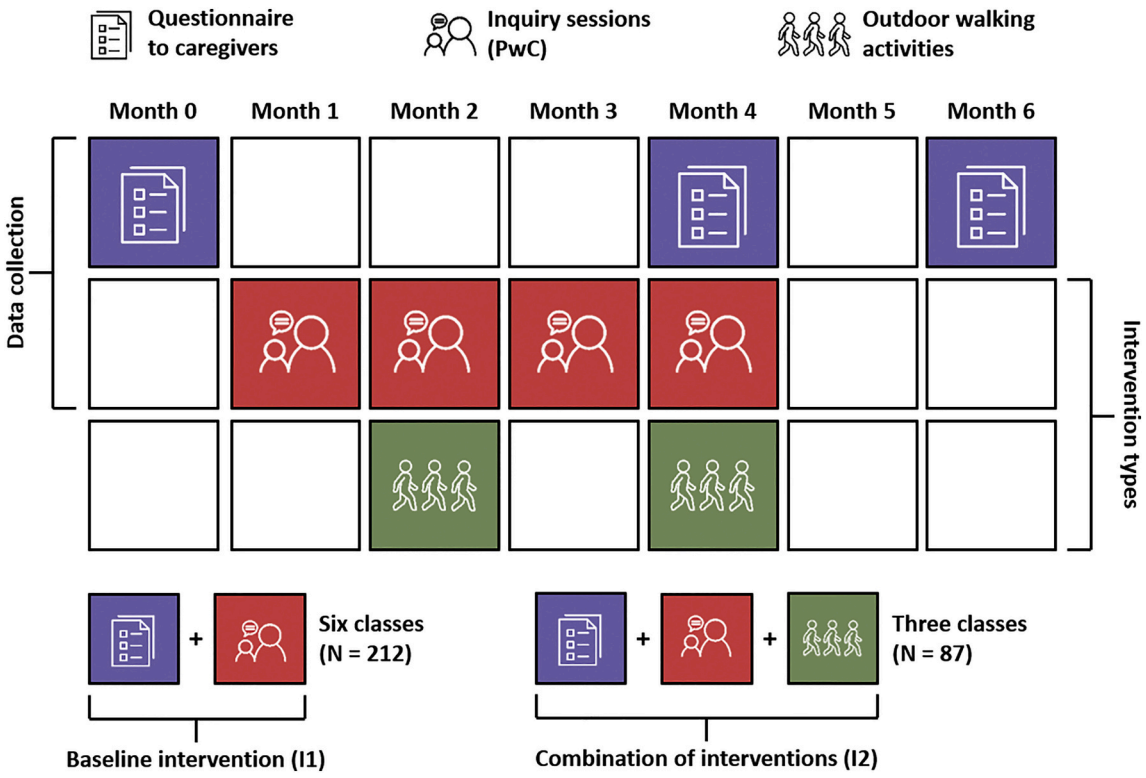

Fig. 1. Schematic representation of the adopted methodological steps (intervention types and sources of data).

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

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 Fig. 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 Grolemund 2017).

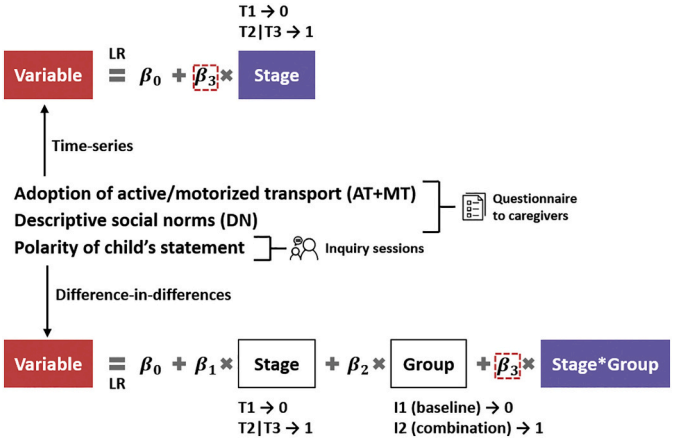

Fig. 2. Schematic representation of the adopted analytical approaches (time-series and difference-in-differences). The interest coefficient for assessing the impact of interventions is highlighted (β_3). LR: Linear Regression model; AT: Active Transport (walking or cycling); MT: Motorized Transport (car 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 location of the analyzed schools and children's households can be found in Fig. 3, which indicates a context with a high share of active travel by younger children to and from school, coupled with a situation of precarious housing in the regions where most of children and caregivers surveyed live. The lower shares of active trips in the other zones within the Expanded Center are noticeable, which seems to point out to spatial inequalities related to children's mobility that are found in the interplay of the analyzed region with its surroundings, where better transport services and employment opportunities overlap with the spread of slums and squatter settlements. Similarly, a more detailed contextualization of schools and the location of children's households is provided as supplementary materials, namely regarding the location of other public preschools (Fig. SM-1), the location of rapid transit stations (Fig. SM-2), the share of motorized school trips of preschoolers and primary school-aged children (Fig. SM-3), the share of active and

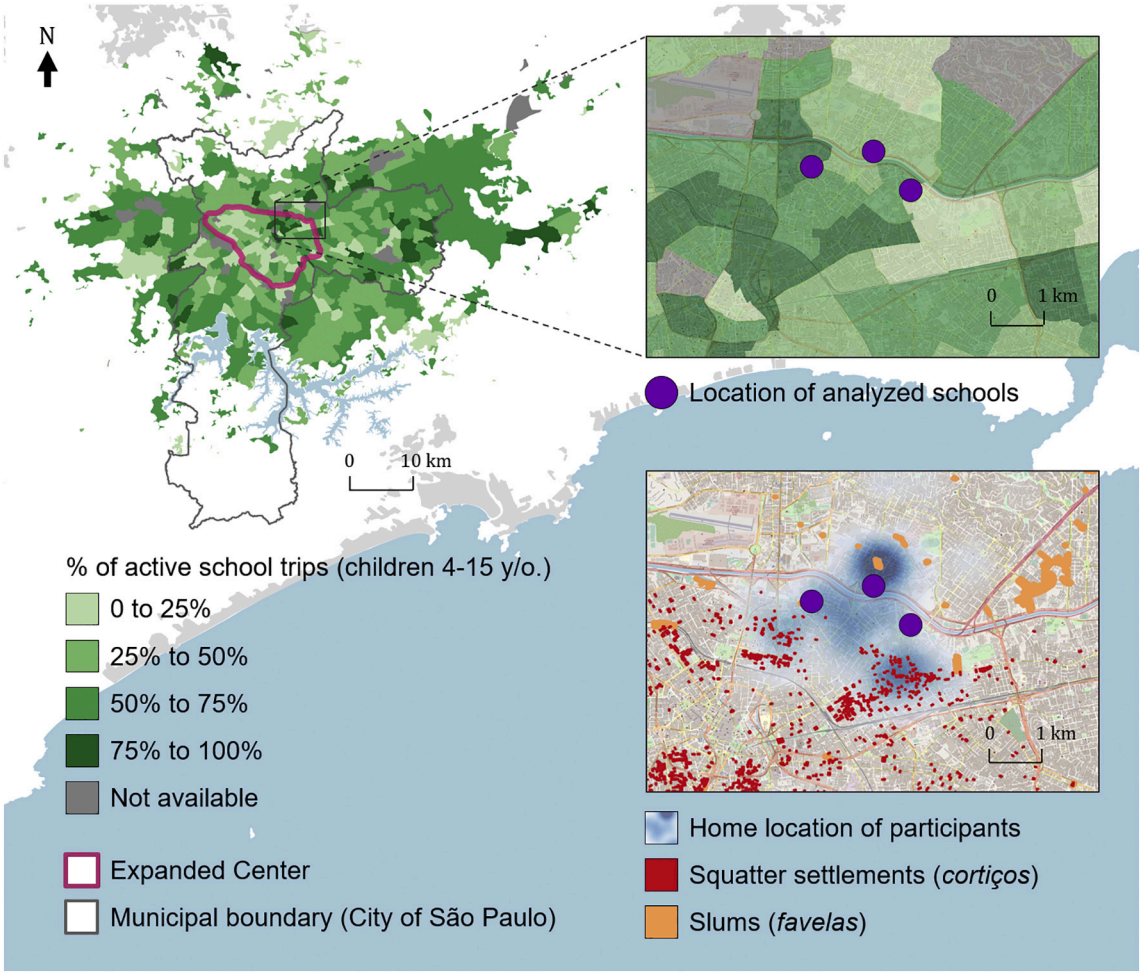

Fig. 3. Context of analyzed schools in Metropolitan São Paulo regarding the share of active school trips (walking or bicycle) of preschoolers and primary school-aged children (aged 4–15 y/o.) and association of participating children's households with the presence of slums and squatter settlements. Both public and private schools were considered. Adapted from CET (2013), GeoSampa (2018), HabitaSampa (2019), IBGE (2005), and METRÔ-SP (2018).

motorized trips of their caregivers (Figs. SM-4 and SM-5), the average monthly household income (Fig. SM-6), and the location of slums and squatter settlements across São Paulo (Fig. SM-7). The descriptive statistics of the collected data can be found in Table 3.

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 4. On the other hand, the percentage of motorized school travel (car or motorcycle) is also above the city's average in the households analyzed, which may indicate a lower adoption of other transport modes, such as the school bus, railway and the city bus to access schools, notwithstanding the greater availability of public transport facilities in the region in relation to Metropolitan São Paulo as a whole (*cf.* Fig. SM-2 in Supplementary materials). In contrast, the children's caregivers present

Table 3
Descriptive statistics of collected data.

Source of data	Measure	T1 (pre)	T2 (post)	T3 (follow-up)
Quest. to caregivers	% AT (caregivers)	28	73	72
	% MT (caregivers)	47	34	39
	% AT (children)	61	64	64
	% MT (children)	22	20	18
	Descriptive social norms	1.9 (0.9); 1 < 2 < 3; Min: 1; Max: 4	2.2 (1.0); 1 < 2 < 3 Min: 1; Max: 4	3.0 (0.7); 3 < 3 < 4 Min: 1; Max: 4
	Age of caregivers	33.4 (8.9); 26 < 32 < 38; Min: 15; Max: 72	–	–
	Household size	5(2.6); 3 < 4 < 6; Min: 2; Max: 18	–	–
	% in low social vuln.	87	–	–
	Response rate	78	65	53
Inquiry sessions	Polarity of statements (x100)	−10 (63); −40 < −14 < 20; Min: −300; Max: 400	9 (54); −20 < 8 < 33 Min: −150; Max: 400	–
School staff	% of boys	53	–	–
	% of natives	75	–	–

AT: Active Transport (walking or cycling); MT: Motorized Transport (car or motorcycle). Standard notation for non-categorical variables: Mean (SD); 1st quartile < Median < 3rd quartile; Min: Minimum value; Max: Maximum Value.

Table 4
Stratification of statistics of selected measures according to 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 (caregivers)[b]	28	29/27	29/23	29/27	29/25	38[c]
	% MT (caregivers)[b]	47	46/48	46/50	50/32	44/52	32[c]
	% AT (children)[a]	61	57/64	59/68	61/73	54/75	45[c]
	% MT (children)[a]	22	20/24	24/11	19/18	24/17	12[c]
	% AT (caregivers)[b]	28	29/27	29/23	29/27	29/25	38[c]
	% in low social vuln.	87	85/89	84/96	–	81/94	56[d]
Inquiry sessions	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	–
School staff	% of boys	53	–	51/59	50/58	53/54	51[c]
	% of natives	75	72/78	–	72/92	82/61	–

AT: Active Transport (walking or cycling); MT: Motorized Transport (car or motorcycle); I1: Baseline intervention; I2: Combination of interventions. [a]Share of AT/MT in the usual transport modes during the week (T1); [b]Share of AT/MT to/from school (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).

lower share of active trips and higher share of motorized trips when compared to the whole municipality. 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.

Regarding the modal shifts throughout the implementation of the intervention types (pre, post and follow-up), no major changes can be detected in the way children access schools, as shown in Fig. 4. 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. None of the modal shifts related to children's transport were statistically significant when comparing the periods analyzed, as indicated in Table 5. On the other hand, the reported 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. Similarly, the modal shifts reported by the caregivers were statistically significant in the decrease of motorized transport use between T1 and T2 and in the increase of active transport use for both T1-T2 and T1-T3, as indicated in Table 5. Both effects seem to be more pronounced among caregivers whose children attended both outdoor walking activities and inquiry sessions.

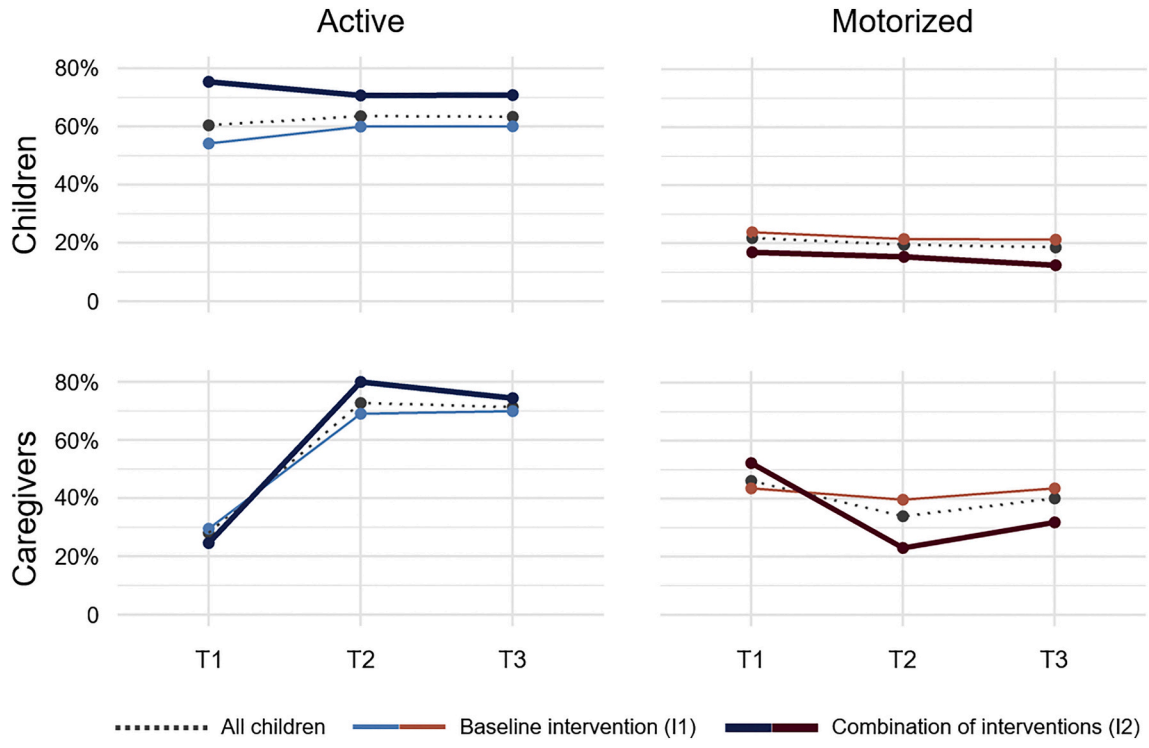

Fig. 4. Modal share of trips (active and motorized) of children and their caregivers throughout the implementation of the intervention types (pre, post and follow-up).

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 Fig. 5). 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. Positive changes in children's perceptions (polarity of statements during inquiry sessions) were statistically significant between T1 and T2, whereas the increases in the descriptive social norms (by caregivers) were significant when comparing the follow-up measures with the other periods analyzed (T1-T3 and T2-T3), as indicated in Table 5.

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.

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. In this sense, a set of variables related to children (polarity of children's statements during the inquiry sessions) and caregivers (share of active/motorized transport and descriptive social norms) is examined more thoroughly in Table 6, following the analytical approaches employed: time-series analysis and difference-in-differences. Accordingly, the statistical significance of the changes shown in Figs. 4 and 5 can be observed in column "All children" of Table 6 and Table SM-1 (Supplementary materials), which were evaluated between the periods analyzed (Time-series) and also considering the differences between both groups (I1 and I2) and periods (Difference-in-differences).

For time-series analysis, significant modal shifts towards active modes were found among caregivers 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

Table 5
Average values of modal shares and perceptions of children and caregivers throughout the stages of the study (T1, T2, and T3) and respective two-sample Wilcoxon test effect sizes (r values) and *P*-values. Fields whose estimates are statistically significant at the 10% level are highlighted (in gray).

Measure		T1 vs. T2 (pre to post)	T1 vs. T3 (pre to follow-up)	T2 vs. T3 (post to follow-up)
% AT (caregivers)	Mean (modal share)	**28 / 73**	**28 / 72**	73 / 72
	Wilcoxon test	**.450 (<.001)**	**.435 (<.001)**	.011 (.829)
% MT (caregivers)	Mean (modal share)	**47 / 34**	47 / 39	34 / 39
	Wilcoxon test stat.	**.133 (.006)**	.075 (.134)	.058 (.272)
% AT (children)	Mean (modal share)	61 / 64	61 / 64	64 / 64
	Wilcoxon test stat.	.039 (.416)	.034 (.503)	.005 (.923)
% MT (children)	Mean (modal share)	22 / 20	22 / 18	20 / 18
	Wilcoxon test stat.	.026 (.584)	.048 (.337)	.022 (.665)
Descriptive social norms	Mean	1.9 / 2.2	**1.9 / 3.0**	**2.2 / 3.0**
	Wilcoxon test stat.	.118 (.015)	**.543 (<.001)**	**.428 (<.001)**
Polarity of statements (x100)	Mean	**-10 / 9**	-	-
	Wilcoxon test stat.	**.174 (<.001)**	-	-

AT: Active Transport (walking or cycling); MT: Motorized Transport (car or motorcycle).

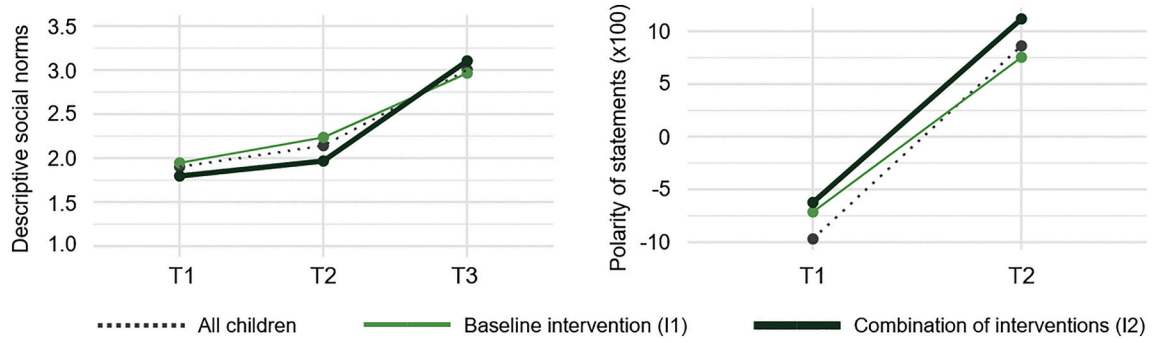

Fig. 5. Changes in social norms and polarity of children's statements during the inquiry sessions throughout the implementation of the intervention types (pre, post and follow-up).

Table 6
Changes in selected measures following the implementation of the intervention types (coefficient β_3 and respective *P*-value). *Refers to the variables related to the caregivers (%AT, %MT and DN), whereas † indicates variables referring to and collected with children (polarity of children's statements). Fields whose estimates are statistically significant at the 10% level are highlighted (in gray). The results for the other measures collected are presented as supplementary material (Table SM-1).

Analysis			All children	Boys	Natives	Low vulnerability
Time-series	T1 to T2 (pre to post)	%AT*	**+44.7 (<.001)**	**+41.3 (<.001)**	**+41.8 (<.001)**	**+40.1 (<.001)**
		%MT*	**-12.1 (.012)**	**-12.5 (.067)**	**-9.8 (.073)**	**-13.6 (.041)**
		DN*	**+0.2 (.010)**	**+0.3 (.028)**	**+0.2 (.055)**	+0.1 (.394)
		Pol.†	**+18.3 (<.001)**	**+15.1 (.001)**	**+14.8 (<.001)**	**+14.0 (.001)**
	T1 to T3 (pre to follow-up)	%AT*	**+43.3 (<.001)**	**+35.1 (<.001)**	**+38.9 (<.001)**	**+35.6 (<.001)**
		%MT*	-6.0 (.245)	+0.1 (.988)	-3.0 (.609)	-7.6 (.268)
		DN*	**+1.1 (<.001)**	**+1.0 (<.001)**	**+1.1 (<.001)**	**+1.1 (<.001)**
Diff.-in differences	T1 to T2 (pre to post)	%AT*	**+15.8 (.097)**	**+24.1 (.083)**	+15.4 (.188)	+12.6 (.314)
		%MT*	**-25.3 (.015)**	-19.1 (.200)	**-29.2 (.020)**	-15.9 (.233)
		DN*	-0.1 (.559)	-0.2 (.394)	-0.3 (.243)	-0.1 (.667)
		Pol.†	+2.7 (.719)	-0.7 (.945)	+4.1 (.624)	+7.3 (.427)
	T1 to T3 (pre to follow-up)	%AT*	+9.3 (.367)	**+27.4 (.064)**	+5.3 (.683)	+10.1 (.438)
		%MT*	**-20.4 (.072)**	-24.3 (.126)	**-27.0 (.056)**	-6.2 (.658)
		DN*	+0.3 (.126)	+0.1 (.729)	0.0 (.987)	**+0.4 (.083)**

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).

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.

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 (inquiry sessions) and practicing urban mobility (outdoor walking activities) 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 reported 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 (Teixeira et al. 2019, p. 13). However, both inquiry sessions

and outdoor walking activities here analyzed over a five-month period seem to have contributed to alter the reported 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). In this sense, they seek to bridge the gap of previous research on the influences on travel behavior intention, which has "relied heavily on eliciting information via survey questionnaires and interviews using the researcher's words" (Line et al. 2010, p. 239).

The major role of the intervention types identified here does not preclude nevertheless the effective role of physical changes in the urban environment in changing and shaping sustainable mobility behaviors, which require a "high degree of political involvement and support" (Christiansen et al. 2014, p. 180) and may be well combined with soft interventions. The integration of initiatives focused on perceptions and attitudes into transport projects might therefore be effective in: i) changing "car use intentions and willingness to accept car restrictions" (Sigurdardottir et al. 2013, p. 1); ii) mitigating "gender inequities in transport cycling" (Bourke et al. 2019, p. 64); and iii) promoting "well-planned natural experiments focusing on AST [active school transportation]" 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, p. 180). 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 most prominent 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? Could a reinforcement loop towards more active mobility be triggered by such school-based interventions?

This debate is convergent with the positive impacts on the family environment and the social-emotional development of children that are promoted by the Philosophy for/with Children inquiry approach by increasing "organic and sincere dialogue between parents, teachers and students" (Papathanasiou 2019, pp. 22–23). It is also in line with 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, p. 243). This points out that even children this young, who still rely on their caregivers for many activities, have agency and constitute a culture of their own to discuss relevant transport-related aspects, besides having the potential to promote behavior change in their households. This indicates the significant role of children as social actors and of childhood as a social category, which resonates with Sarmento et al.'s (2018) critique on the "ideas about 'vulnerability' and 'innocence' usually attributed to childhood", whose acknowledgment might endorse a "renewed vision of childhood such as those related to agency, childhood cultures, public policies for childhood and social practices, and institutional settings for children" (Sarmento et al., 2018, p. 136).

These considerations suggest possible lessons for the evaluation of child-centered interventions in the transport domain, particularly with regard to the role of perceptions and early childhood in behavioral changes involving school-based interventions towards sustainable transportation. First, the perceptions seem to indicate triggers for behavior change and might be the starting point for future measures, converging with the suggestion brought by Gutierrez et al. (2014) regarding the "prioritization towards engaging in and acknowledging safety before physical activity" (p. 116) to promote active transportation with children. Furthermore, the participatory and pragmatic aspect of combining discussion and practice with children may overcome the challenges found in shifting parental attitudes, such as the ones found by Ducheyne et al. (2014) in cycle training with children, where "multiple efforts might be needed to change parental attitudes" (p. 59). In this manuscript, changes in both descriptive social norms and travel behavior were identified in the caregivers, even though they were not the direct beneficiaries of the proposed interventions.

In addition, although no significant increase in active modal share has been identified among children to access schools, this positive impact has been detected in the reported travel behavior of caregivers. This observed effect may unravel intra-household interactions beyond the monodirectional influence of adults on children and indicates potential pathways for the impact assessment of school-based interventions on sustainable habits. Furthermore, this may also disclose the possible impact of parental behavioral changes on children, such as the primary focus on "attitude and behaviour change among parents to grant children more freedom" suggested by (Vlaar et al. 2019, p. 8) to design "future interventions to increase children's territorial range" (*Ibid.*). Finally, the context of Brazilian public schools analyzed in this study may also contribute to the yet under-studied research agenda on the Global South with regard to the travel behavior of children and their caregivers.

Evidently, it is difficult to claim (nor was it the objective of the present research) that long-term effects may persist in this group of children and caregivers involved in these interventions, particularly in a context of large-scale economic and social repercussions brought by the COVID-19 pandemic in 2020. Still, it would be of particular importance to assess the persistence of the gaps identified between children from different nationalities and social vulnerability levels, as well as to verify whether the impact of these interventions at an early stage are somehow correlated with permanent changes in behavior, such as the significant influence of school-age physical activity on adult physical activity identified among 9 to 18 year old children (Telama et al. 2005). In addition, the quarantines enforced by the spread of the novel coronavirus might prompt long-lasting changes in the travel behavior and social norms related to urban mobility, since the COVID-19 pandemic has implications in many spheres relevant to transport issues, including school closures, occupation of public places, changes in work routines, family organization, and isolation, leading to feelings of insecurity and avoidance of crowds (Brooks et al. 2020; Ornell et al. 2020).

5.1. Limitations and further research

Nevertheless, this study presents some limitations and 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 distinct role of walking and cycling within active mobility was not considered, which may have overlooked possible singularities associated with the population groups analyzed. Finally, this study draws on the caregivers' statements to measure the modal shifts identified, which may present some limitations regarding the accuracy of these measures, possible biases (for instance literacy level), and the comparison of effects between children and caregivers, as the variables related to transport use that are collected throughout the study (T1, T2, and T3) refer to school trips for children and "during the week" for caregivers. 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. (2020a, 2020b). Still regarding the analytical approaches adopted, this study could benefit from the adoption of other statistical tests such as hypothesis testing, odds ratio, and structural equation modelling. 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).

Finally, several factors relevant to pedestrian travel behavior were not considered in this study, in which the association with walkability measures might be of considerable value. These might comprise traditional measures in the field such as land use, sidewalk width, traffic safety, existence of meeting places, and vigilance perception by pedestrians (Bradshaw 1993; Moura et al. 2017), as well as other relevant measures relevant to cities in the Global South, including public lighting conditions, existence of vacant lots and narrow passages (for instance stairways and alleys), and pedestrian flow density (Harkot et al. 2017).

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) consider the effects of the proposed intervention types concerning the mode of transport (rather than only active/motorized) and the nationality of children (instead of aggregating non-native nationalities into a single group); iii) evaluate the effects observed through other statistical tests such as hypothesis testing and odds ratio; iv) conduct follow-up measurements one year later; v) inclusion of treatment and control groups in further applications using a randomized controlled trial; vi) test the impact of the intervention types in schools with lower shares of active mobility; vii) include other under-researched age groups, principally adolescents in secondary school settings; and viii) assess the combined impact of interventions directly addressing the engagement of parents.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jtrangeo.2020.102922.

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