How to Ensure Safety and Promote the Permanence of School Streets?

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Abstract. In recent years, research has focused on innovative solutions to ensure the safety of road users, with a particular emphasis on vehicular traffic, pedestrian mobility and the habits of vulnerable users. Among these, school streets represent a highly relevant topic, especially for their ability to combine safety, social interaction and play in proximity to schools.

This study analyses potential scenarios for the permanent implementation of school streets in the Italian context, evaluating their positive and negative externalities, particularly in terms of traffic management, safety and urban livability. The adopted methodology includes a preliminary literature review aimed at identifying international experiences and classifying key variables that influence the development of progressive solutions for managing vehicular and pedestrian flows. A case study is then presented, focusing on a school street located in the *Oltretorrente* neighborhood of Parma (Italy). Analysis through GIS (Geographic Information System) tools and multimodal transport simulation models using the software VISSIM have been developed to analyze the morphological, social and functional characteristics of the area, in order to assess its suitability for experimental interventions.The results of the study provide a basic framework of the essential characteristics for the success of future traffic management scenarios aimed at the permanent adoption of school streets. It emerges that the integration of social and modal analyses can promote more conscious actions that effectively balance the needs of safety, accessibility and urban sustainability.

Keywords: School streets · Street experiments · Traffic simulation · Scenario analysis · Sustainable mobility

1 Introduction

The concept of School Streets as it is understood today, dates back to the 1990s and was already mentioned in Italy with the first interventions in Bolzano and Milan. They are currently referred to as 'school zones'. According to the New Italian Road Code (from Italian "Nuovo Codice della Strada"), a school zone is defined as an "urban area in the proximity of buildings used for educational purposes, in which a special protection

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of pedestrians and the environment is guaranteed, delimited along the access paths by appropriate start and end signs" [1]. In this context, an integrated urban and transport planning plays a key role in bringing together all the socio-spatial variables that influence strategies related to urban mobility infrastructure and services [2–4]. Promoting walkability, safer environments, and social interaction within the sustainable mobility framework can lead to the creation of new, more efficient solutions for school spaces [5–7]. One of the most well-known negative externalities is traffic congestion, which is a common problem in school environments and typically results from the heavy reliance on the private cars by parents accompanying their children to school [8]. Among the factors leading to these issues, fragmented urban sprawl has certainly had an impact, generating difficulties with longer distances and leading users to feel safer when using a private car. The fragmentation of urban areas has also led to the emergence of monofunctional areas of the city that discourage walking and do not promote adequate accessibility. Promoting active mobility for children would solve many of the problems associated with delayed learning and perception of urban space [9, 10]. For this reason, academics and administrators now point to the need to invest their resources in road safety, an enabling environment and accessibility [11–14]. Among the strategies to promote walkability and accessibility in the surroundings of schools, School Streets have emerged as a valuable measure. These interventions temporarily restrict motorised traffic near school entrances during pick-up and drop-off; times, aiming to create safer, healthier, and more child-friendly environments. As highlighted in the literature [15, 16]. these schemes are typically implemented as pilot projects, and and the transition from temporary to permanent street reallocation is frequently complicated and slowed down by various institutional, social, and technical barriers [17]. Within this context, the present study investigates the processes of permanence of School Street through online and in-field investigations and then performing quantitative and qualitative analysis of the street space through the implementation of a microsimulation model. While school street programs are not new in themselves, what makes this study stand out is its emphasis on the conditions for permanence, rather than just the implementation or short-term outcomes of such interventions. The paper is structured as follows (Fig. 2): Sect. 1 briefly illustrates a collection of the main guidelines adopted at the international level, also applied at the neighbourhood level, concerning the management and localization of School Streets. Section 2 presents the methodology and tools used to analyze the case study. Section 3 identifies the tools and analyses necessary to complete an initial classification of factors supporting possible traffic management scenarios. It also presents the study of the area through the definition of thematic maps of physical elements and study of vehicular and pedestrian flows through field surveys. Section 4 concludes with a discussion of the results obtained and the critical points identified.

2 Methodological Approach

The methodology adopted in this study is articulated in multiple phases and combines both theoretical and empirical components (see Fig. 1). It is designed to investigate the conditions that influence the permanence of School Street interventions through a structured sequence of analyses. The first phase consists of a literature review, aimed at identifying international experiences and classifying the key variables that influence the development of progressive solutions for managing vehicular and pedestrian flows (as further detailed in Sect. 3). This step enables the identification of the main characteristics that may favour or hinder the transition from temporary to permanent interventions.

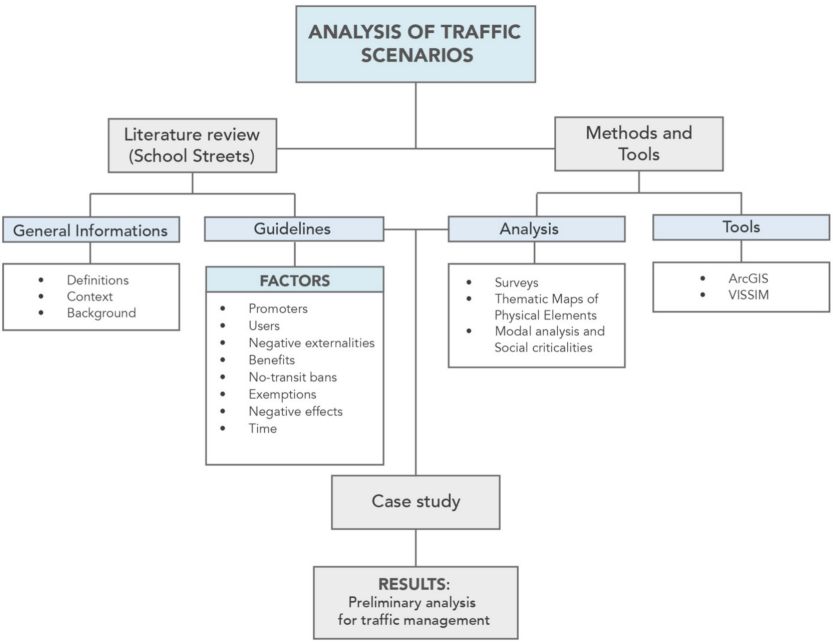


Fig. 1. Workflow and methodological steps. Source: authors elaboration.

Building on this foundation, the methodology included:

- The identification of the tools and analyses needed to make an initial classification of the factors supporting possible traffic management scenarios, as discussed in Sect. 4;
- The analysis of the study of the area through the definition of thematic maps of physical elements and a study of vehicular and pedestrian flows through on-site surveys, as detailed in Sect. 5.

3 School Street Applications and Guidelines at International Level

The main characteristics of the location of School Streets are different and all closely related to sociability and road safety. As already mentioned in the previous paragraphs, this global phenomenon spread rapidly after the COVID-19 pandemic [18–20], with a general increase between 2020 and 2024. Each country has contributed significantly, albeit in different ways, to the management of road space for the protection of vulnerable users. Some of them with measures such as Open Streets, which promote multifunctional spaces to improve the quality of life. Others, instead, have invested more in School Streets, focusing their interventions on the relationship between local authorities and educational institutions. For this reason, a comparative analysis has been carried out between the best practices analysed in literature and the guidelines developed by administrations in mostly local areas [22 – 33]. Among those analysed, a subdivision has been then made according to: (i) the scope of the study, (ii) the type of intervention (e.g. Open Streets or more specific interventions such as Play Streets or School Streets) and (iii) the level of action (global or neighborhood). This activity served to identify potential common factors that could later provide a preliminary framework for studying modal analysis and the degree of success of these interventions for their permanence and sustainability. The study highlighted that most of the guidelines for the establishment and management of School Streets have been defined in the years during and after the pandemic [33]. This aspect is particularly important because, although school zones have been present in the urban landscape for several years, administrations are now more involved through the development of efficient tools for territory management.

In addition, the involvement of school communities and local authorities is interesting, as some guidelines emphasize the process and timelines, and allow for citizens' approval and legitimization of school interventions within the strategic actions of the regional area. One of the most successful cities is certainly London.

As a result of the study, the following key variables have been identified as determinants for the implementation of School Streets:

- **Promoters** - Those who are actively investing in the promotion of school streets or wider urban space redesign processes, often through guidelines or strategic actions. These include local transport authorities, school communities, local government and EU initiatives.
- **Users** - People who regularly use the school environment and are therefore the most exposed to potential hazards. This includes children, parents, and school staff.
- **Negative externalities** - The main negative impacts on school areas, such as traffic congestion, air pollution, road accidents, and low levels of physical activity.
- **Benefits** - All the positive outcomes that result from the implementation of School Streets. These include creating safe and attractive places for vulnerable users, improving social interaction and inclusion, providing training for cyclists and pedestrians, reducing the use of private cars and decreasing air pollution.
- **No-transit bans** - Refers to those who are prohibited from driving during school street closures, i.e. parents/guardians dropping off or picking up students, school staff or other unauthorized drivers.

- **Exceptions** - Categories of vehicles that are allowed to travel during the road closure despite the ban. These include residents, commercial vehicles, emergency and assistance services, bicycles, scooters, refuse collection vehicles and school buses.
- **Negative effects** - Challenges and criticality caused by the road closure, such as traffic congestion in surrounding roads.
- **Time** - The duration of the road closure. This includes whether the closure is total (24 hours) or temporary (e.g., 15–30 min before and after school). In most cases, the time period selected will target congestion around school start and finish times.

Based on the analysis, the international School Street implementation process includes the following key steps (Fig. 2):

1. **Location and use**: the first step is to analyze the factors that influence the location of School Streets. These include the street typology, the level of traffic, the level of air pollution, the local mobility habits of citizens and the most common transport modes in the area. Another necessary action is to identify the traffic devices and road layouts that provide a framework for road safety. The other aspect to be considered in this first step is use, defined as the determination of the predominant type of use of a given area. In this case, it is necessary to interact with the school community, as these are sensitive areas used by vulnerable users such as children. This step is very important as it guarantees an intervention in line with extra-curricular activities that could also be increased or included in educational programs (e.g. outdoor learning, after-school programs etc.).
2. **Identify the stakeholders involved**: closely linked to the users, this step concerns the identification of stakeholders involved in the promotion of School Streets. These include, of course, the local transport authorities, who could guarantee greater protection and legitimacy for the intervention, as well as, in the same way, the school communities. Indeed, gaining local support could guarantee the permanence of the measures adopted. Furthermore, at this stage, it is also necessary to define the methods of communication with the various stakeholders to ensure greater efficiency and promotion of these interventions.
3. **Installation and management**: traffic signage, whether horizontal and/or vertical, is an essential tool for establishing road closures. For example, many guidelines refer to the time needed to prepare for the closure by means of appropriate signage such as barriers and school signals. In addition, during the closure it is necessary to have people who are responsible for traffic management in other areas, or simply to ensure that the orders issued are complied with (e.g. local police, etc.).

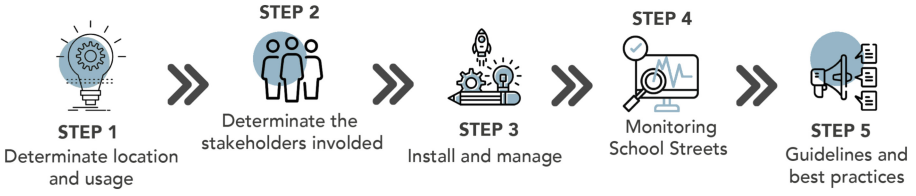


Fig. 2. Scheme of the Schools Streets permanence process. Source: authors elaboration.

4. **Monitoring School Street**: this is a fundamental step in determining the permanence of School Streets, as it includes a maintenance plan for interventions and the collection of feedback from users. Il also guarantees the possibility of establishing a degree of efficiency of the intervention, considering its replicability or improvement within the territory.
5. **Guidelines and best practices**: the last step of the permanence process concerns the use of an appropriate toolkit to educate citizens and encourage greater participation by local communities. The aim should be to ensure clear documentation that allows the promotion of practices for the redesign of public space and to provide evidence of other successful projects in the territory.

4 Traffic Survey: Preliminary Analysis

The section presents the activities carried out to collect data and analysis on the above case. Specifically, vehicular and bicycle/pedestrian flows in a neighbourhood were analysed to determine the impact of closing a street (to become a school street) has on surrounding streets. This scheme was followed for both the vehicular and bicycle-pedestrian traffic surveys. The scheme used for the survey is shown below (Tables 1 and 2) and included a division into categories of vehicles and, of course, their direction. The survey was carried out from optical cones corresponding to the focal points of the case study, as will be explained in the following section.

Table 1. Survey Scheme of Vehicular Flow.

	Survey objects	Description
Location	Optical cone	Represent the reference points
	Manoeuvres	Represent the directions
Typologies	Cars	
	Motorcycles	
	Bicycle	
	Bus	
	Trucks	
	Others	Special vehicles like firefighters trucks, ambulances, police etc.

Table 2. Survey Scheme of Pedestrian Flow.

	Survey objects	Description
Location	Optical cone	Represent the reference points
	Manoeuvres	Represent the directions
Typologies	Crossings	
	Pedestrian	
	Bicycle	
	Scooter	
	Others	Other transport means associated to soft mobility

5 Geometric-Functional Factors Analysis with GIS Software

From the field surveys, the geometric-functional characteristics of the study area were divided into road space and pedestrian space (Tables 3, 4 and 5). The latter are:

Table 3. Geometric-functional characteristics of cycle-pedestrian path

Cycle-pedestrian path
Width of cycle path Width of pedestrian path
Parklets

Table 4. Geometric-functional characteristics of pedestrian path.

Pedestrian Path	
Width Accesses Bike racks Speed Limit Carriageways Crossings Presence of on-street parkings for vulnerable users	Presence of on-street parkings Traffic calming devices Vertical signage Scooter parkings Parklet

Table 5. Geometric-functional characteristics of the road space.

Street	
Carriageways Crossings	On-street parkings Traffic calming devices
Speed Limit Width of the road space Parkings for vulnerable users	Vertical signage Motorbikes/Scooter parkings

6 Implementation to the Case Study of Parma

The proposed methodological approach has been implemented on a real-case study, focusing on the Oltretorrente neighbourhood in the city of Parma (Italy), and this section describes in details the study area and presents the results of applying of the methodology. Within the selected neighbourhood, some interventions have been carried out in recent years, but they are still temporary. The aim, as mentioned above, is to test the methodology to make these interventions permanent, and to be able to integrate them into planning strategies.

6.1 Case Study Overview

The chosen case study is the Oltretorrente district of Parma, an area located to the west of the Parma River and part of the city centre. It covers an area of about 1.1 square kilometres and has a population of about 8,496. The district is bordered by urban boulevards to the north, west, and south, while the Parma River forms its eastern boundary. It is divided into two main areas along an east-west axis by Via Emilia. The northern area contains mainly services and public facilities, including the Parco Ducale, while the southern area is predominantly residential.

Oltretorrente is a lively district with a high concentration of activities, particularly along its two main streets, Strada d'Azeglio (Via Emilia) and Via Bixio. Notably, it hosts a significant number of secondary schools located along the eastern edge of the district, near the Parma River. In addition, some poles of the University of Parma are located in the area, especially near the Parco Ducale.

In terms of transport accessibility, the district is largely accessible by car, except for Via Emilia and the area around Ponte di Mezzo, which fall within the Limited Traffic Zone (LTZ). Due to the characteristic narrow streets of the district, the infrastructure for active mobility is limited. However, pedestrian routes are widespread. The public transport system is well developed, ensuring easy access along the main roads, and several bike-sharing stations are also available.

Figure 3 shows some of the key elements within the neighbourhood, while Fig. 4 shows all the pedestrian paths and pedestrian crossings existing in the neighbourhood.

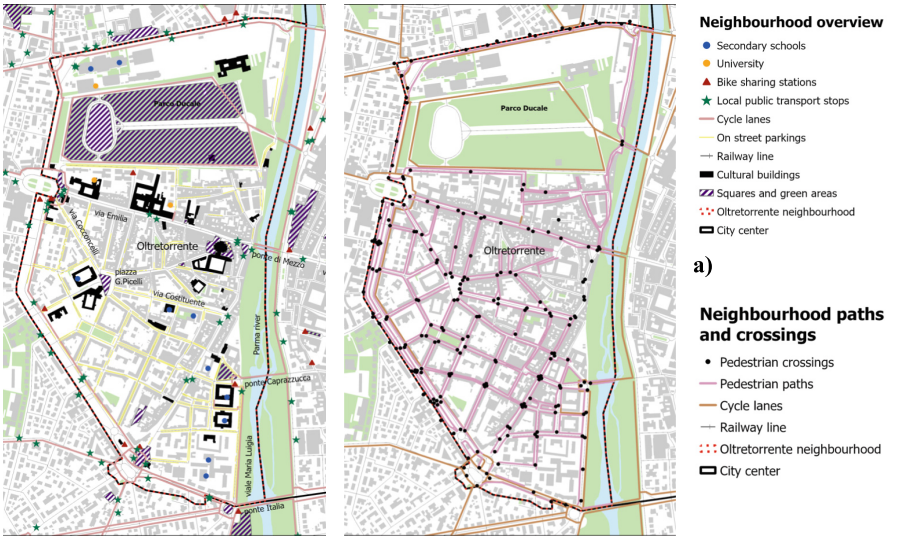


Fig. 3. Neighbourhood overview: a) identification of some important poles that characterized the area and b) pedestrian paths and crossings. Source: authors elaboration.



Fig. 4. a) First parklet (Liceo Scientifico Ulivi) and b) Second parklet (Liceo Classico e Linguistico Romagnosi. Photographs taken by the authors.

School Street: Viale Maria Luigia

To deepen the analysis, let's consider Viale Maria Luigia, the road that is already the subject of a 30-minute school street during school entrance hours. The road is bordered on the one hand, by a large traffic roundabout at Ponte Italia and, on the other hand, it extends to Piazzale Rondani near Ponte Caprazucca. The area is characterised by the presence of several educational institutions, including the Liceo Scientifico Statale

Giacomo Ulivi, the Liceo Classico e Linguistico Romagnosi, the Istituto Tecnico Economico ITA Melloni and the Istituto Tecnico Tecnologico C. Rondani. For this reason, following a municipal ordinance, it has become a School Streets, although this is not yet permanent. The ordinance in question was issued by the Mayor (No. 47) on 04/24/2015 and still in force, despite its initial temporary nature. In detail, the measure provides for a ban on motorised vehicles on school days, from 7:40 a.m. to 8:10 a.m., with the exception of authorised (e.g., emergency vehicles, residents or vehicles assisting users with disabilities). Over the years, schools in the area have promoted initiatives to improve the school street such as the installation of parklets, which help to promote greater sociality and sustainable mobility. The latter are located at two of the schools in the area (Fig. 4 a-b).

6.2 Preliminary Analysis of Vehicular and Pedestrian Traffic Flows

The following research provides the main factors that determine the possible impact of school streets in terms of negative and/or positive externalities through the study of vehicular and pedestrian flows (see Fig. 6 a-b).

Specifically, in-field surveys were conducted during the hour when the road section of Viale Maria Luigia is closed. Specifically, from 7:40 to 8:10 a.m. (when the road is closed to traffic) and from 8:10 to 8:40 a.m. (when the road is open to traffic).

The survey focused on the three main traffic junctions in the southern part of the district (Fig. 5) and on the whole Viale Maria Luigia. They are: Via della Salute, the first access point to the neighbourhood from the beltway to the south and west; the next intersection, and the traffic of the roundabout between the neighbourhood and Ponte Italia, to the south, an important access point to schools and services to the south.



Fig. 5. Location of survey important nodes. Source: authors re-elaboration from Google Earth view.

Numerical results of these traffic surveys will constitute the base for the implementation of a microsimulation model, in order to perform scenario analysis according to the evidences emerged from the following Geometric-functional analysis.

The detected maneuvers and related optical cones are shown in Fig. 6 a-b.



(a) (b)

Fig. 6. (a – b). Detected vehicles and cyclist/pedestrian detected maneuvers and related optical cones. Source: authors re-elaboration from Google Earth view.

6.3 Results from Geometric-Functional Analysis and Discussions

This section presents the results of the geometric analysis of Viale Maria Luigia. This is useful to identify already positive features and critical elements that can be further improved. Table 6 deals with the Cycle-Pedestrian Path on Parma river side (East side).

Table 6. Important features of the street with photographic survey. Acquisition date: 29/11/2024. Tools: Laser distance meter.

Geometric-functional elements	Description	Photo
Width of cycle path	2.50 meters	
Width of pedestrian path	2.68 meters The pedestrian space is extremely compromised by obstacles which do not guarantee spatial continuity and accessibility	
Parklet	• Parklet (Liceo Scientifico Ulivi) • Parklet (Liceo Classico and Linguistico Romagnosi) Occupied space = 2 parking spaces per parklet	

Table 7 is about the pedestrian path on the west side of the school (West side).

Table 7. Important features of the street with photographic survey. Acquisition date: 29/11/2024. Tools: Laser distance meter

Geometric-functional elements	Description	Photo
Width	4.78 meters (3.08 meters of pedestrian accessible section + 1.70 metres of space occupied by flowerbeds and/or obstacles)	
Accesses	In correspondence with the accesses of all schools or residential buildings. They are subdivided as follows: • Two residential carriageway accesses • Two residential pedestrian • Four school carriageway accesses • Five school pedestrian accesses	
Bike racks	They are placed at school entrances.	

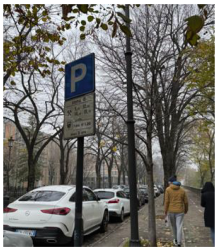
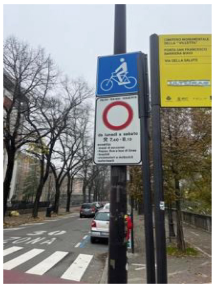
Table 8 is about both sides of street (whole street).

Table 8. Important features of the street with photographic survey. Acquisition date: 29/11/2024. Tools: Laser distance meter

Geometric-functional elements	Description	Photo
Carriageways	1 carriageway (Traffic direction: From Ponte Italia towards Piazzale Rondani)	
Crossings	5 Crossings No obstacles identified that restrict accessibility to the crossing	
Speed Limit	30 km/h (30 Zone)	
Width of road space	7 meters (considering parkings)	
Parkings for vulnerable users	4 On-street parkings: • 2 - ITE Melloni - Istituto Tecnico Economico • 1 - Liceo Scientifico Ulivi • 1- Liceo Classico e Linguistico Romagnosi	

(*continued*)

Table 8. (*continued*)

On-street parkings	Difficult to identify the exact number since they are not individually identified. All car parks are parking fees except those for vulnerable users	
Traffic calming Devices	Two traffic calming devices: • Roundabout (Ponte Italia) • Road hump (Crossing)	
Vertical signage	• Pick-up point • Bicycle crossing • Closure to vehicle traffic from 7:40 am to 8:10 am except for authorised vehicles • Pedestrian crossings • 30 Zones • No-parking zone • Road hump • Transit prohibited for vehicles with a laden mass exceeding a specific weight except authorised • Parking fees (times: 9 a.m.-12.30 p.m./14.30 p.m.-7 p.m. and fees: € 1.20)	
Motorbikes/Scooters parkings	• At the school entrance	

7 Discussion

Among the dangerous elements identified, the traffic roundabout represents an inconvenience that increases traffic congestion and affects with the pedestrian road safety. In addition, it would be useful to measure the number of vehicles parked in the area, which are usually parents pick-up and drop-off their children off at school.

Also, near the roundabout, it is difficult to detect the pedestrian crossing, as it is obstructed by the different traffic flows, which do not provide safety and visibility for the pedestrian and significantly increase the travel time to cross from one side of the roundabout to the other. In general, a high number of vehicles was observed between the 7:40 a.m. and 8:10 a.m., while in the second time slot the number of vehicles decreased by more than 50%.

Among the most common problems are parents' cars struggling to get into the school zone to drop off their children. In fact, there are no parking spaces to facilitate the flow of traffic.

In addition, a large number of bicycles use the road space for transit because of the obstruction of the cycle and pedestrian paths are blocked by students before entering the schools. Given the closure of the road section, this should not pose a danger to cyclists but given the reopening of the school road at different times (8:00/8:05/8:07), it is difficult to predict the transit risk.

During the opening of the road (8:10–8:40 am), almost all the bicycles observed used the cycle-pedestrian path, in contrast to pedestrians, who often cross diagonally despite the presence of 5 pedestrian crossings along Viale Maria Luigia.

Finally, the parklets are not always used at times when the school street is closed, in contrast to other times when the frequency of use is much higher.

Furthermore, direct observations showed that, many vehicles belonging to parents accompanying their children to school, or those needing to reach services further into the neighbourhood, are often not stopped by the traffic officers (who are monitoring the road closure all the time). This is dangerous because it is no longer possible to determine which and how many vehicles actually have permission to enter, and when instead the transit restriction is simply not respected.

8 Conclusions

It can be highlighted how the presence of a school street aims to improve the internal situation of the road, in this case by providing greater safety and allowing social interaction and freer mobility for students. However, it still lacks compensatory measures, and its impact on adjacent streets remains significant and negative.

This research analyses and validates possible solutions for the feasibility analysis study of the intervention, and to hinder the emergence of possible negative externalities from users.

The proposed methodology is considered to be particularly effective in an urban context at a neighbourhood scale, since the size of the neighbourhood itself is appropriate for a specialised analysis, which therefore implies particularly precise analyses and observations. Nevertheless, it is easily replicable in all medium-sized cities, such as Parma. In metropolitan cities, which are much more complex and articulated in terms of school location, it will be necessary to delimit a neighbourhood, or part of it, to performed effective analysis.

Future developments of this research will focus on the development of a micro-simulation model including both current movements of pedestrians and vehicles and

perform scenario analysis to qualitative and quantitative assess the impact of interventions such as streets experiments ensuring their permanence. In addition, the analyses of ex-ante and ex-post configurations will consider the analysis of pedestrians behaviours in response to these interventions.

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