All-round walkability condition to primary school in Milan

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Abstract (up to 125 words)
As part of the wider debate on social justice and the right to the city, the research addresses the fundamental and everyday issue of accessibility to services, through slow mobility, for the most vulnerable populations, and highlights how certain inequalities take shape in public space. Therefore, an analysis of the accessibility of a specific and prototypical service, primary schools, is proposed in three exemplary cases located in different districts of the city of Milan, studying the accessibility at different scales and for different user profiles (in particular, a comparison was made between vulnerable and able-bodied people).

Keywords
Walkability assessment; profiled pedestrian network; accessibility of primary schools; disabled people; Milan

Main text

Schools' accessibility

The issue of 'access' to the school, or rather of its reachability, has been the subject of much debate. This is not understood from the point of view of criteria and policies enabling student enrolment, but considered in relation to the spatial dimension, and thus assessed as the necessary movement to reach the school complex. This has been addressed for some time and studied in different ways.
The first issue to consider is the ideal distance between home and the service itself. This is a dimension that falls within the sphere of proximity, or even the 15-minute city.

Service proximity

When discussing the proximity of services, it is essential to consider the findings of several major studies that have examined their role. In this paper, we present a hypothesis that attempts to integrate various aspects of planning that may have influenced these concepts.
In the planning of Barcelona, Cerdà had identified the modular structure as the key to composing the relationship between inhabitants and their services[1]. It began with the distribution of services with respect to residential lots and somehow indirectly hypothesised an ideal distance between them. The engineer defined the radius of action for each type of service (including green spaces) across the entire city, and then defined the corresponding catchment area, starting from the minimum unit of the city, i.e. the neighbourhood[2]. For example, the plan was to have at least one school in each neighbourhood. Since the second half of the 19th century, there have been other experiments that have refined the concept. However, we can already

[1] In Italy, the relationship between inhabitants and their services was established by urban standards. They were defined with Law 1444/68, through an ideal ratio of square meters of services, divided by type, per inhabitant.
[2] In his design, the city was structured with an orthogonal grid divided by a few large infrastructural axes. The structure included square-shaped blocks with rounded corners, with a side length of 113 meters. In its logic, a neighbourhood consisted of 25 blocks.

identify a precursor of what is known today as the 15-minute city in Carlos Moreno's theory in this hypothesis. The theory rethought planning by focusing on the proximity relationship between home and services. This was done to improve quality of life and reduce environmental impacts, with an increase in cycling and walking. From this core concept, various theories of chrono-urbanism developed.

School

Among the fundamental services to be considered in the conceptual field of proximity is schooling. The school plays a role in our lives at different stages, from the early years as students to adulthood as a waiting place for children/grandchildren, and also as the hub of a community of citizens that is structured around the school building object. The school has evolved into a hub for community interaction, serving as a gathering point for parents and neighbourhood residents of all ages. This is due in part to the introduction of extracurricular activities. It should be noted that this is not a uniform phenomenon across all schools. However, the introduction of non-educational activities, in the extracurricular time, is already having a significant impact on the role of schools, even if it is not yet at the same level as in the open schools network in Rome, where schools are becoming true civic centres with the community at the centre as the in the Di Donato primary school.

In light of the above, this contribution, the result of a master's thesis, addresses the issue of walkability conditions in the city of Milan, intending to understand them in the most inclusive sense possible. It considers the role of school routes in offering opportunities to the city's population.

In Italy, two fundamental regulations concerning schools and their relationship with the built-up area must be considered when contextualising the relationship between home and school.

Until the 1990s, the obligation to attend a specific school (usually corresponds with the nearest school) according to address of residence was in place, in line with the division of the territory into catchment areas. The definition of catchment areas, as areas of redistribution of inhabitants between the different school centres, resulted in the direct relationship between parts of the city and neighbouring educational institutions. The abolition of catchment areas allowed students to choose their preferred school. In addition, the introduction of school autonomy (law 59/1997 and D.P.R 275/1999) led to the delegation of criteria for accepting student applications to school boards and gave schools the opportunity to customise their educational offerings. This also created a system of competition between individual educational institutions. (Pacchi, Ranci, 2017)

In 1962, with the implementation of Law No. 1895, middle school became part of the compulsory education system. To meet the increased demand for space and classrooms, new schools were constructed in urban areas. At the same time, the most significant internal migration was occurring, with people moving from southern regions to northern Italy and to cities. This migration resulted in an immediate need for new housing. To meet these demands, new neighbourhoods were often constructed, often autonomous or self-sufficient, in which the educational service was also present. In other words, neighbourhoods were planned in a unified manner, not only providing new residential volumes but also different kind of services within the new neighbourhoods (educational, religious, commercial, etc).

Finally, in 1975, Decree Law 18 established the optimal location of schools in relation to their context, defining the ideal distance and maximum time to be used to reach the school according to different modes of transport. The regulation stipulated that the maximum distance to be covered on foot to reach primary schools was 500 metres, while the maximum distance for secondary schools was 1,000 metres. In the case of public transport, the times were approximated to a maximum of 15 minutes and 30 minutes respectively.

It is evident that these values are indicative of an optimal condition and not representative of reality. Therefore, it would be prudent to consider additional dimensions for assessing spatial dimensions and distances of access to school. As school choice is more freely available, it cannot be assumed that enrollees are resident only within the catchment area, let alone within 500 metres. Therefore, it is necessary to consider a proximity dimension that can be evaluated in relation to the time required to reach the service. The isochrones of 5, 10 and 15 minutes, respectively, should be considered with different modes of travel depending on the school grade in question, as this provides further support to the argument. It can be reasonably assumed that students in lower grade schools (kindergarten and primary) are more likely to walk to school than those in higher grade schools. Nevertheless, there are numerous instances in which the selection of an educational institution is influenced by factors such as familial convenience, often determined by the parents' commuting route, or other considerations related to the specific type of school, such as private institutions or other factors. This can result in children not attending schools that are geographically closer to their residences. In addition, at middle and secondary level, the increasing autonomy of students contributes to the choice (especially at the high school level) of schools further away from their homes and consequently the mode of travel may be by bicycle, public transport or private car.

Walkability

With regard to the issue of walkability, a number of proposals and forms of analysis have been put forward. One can discern a number of components that are more objectifiable, relating to the design of the space and the degree of effectiveness or efficiency with respect to the type of uses for which it is intended. In contrast, there are other components that are more subjective, strongly linked to individual experience. It is evident that both dimensions must be considered when analysing walkability. The objective components encompass all aspects pertinent to the design of the street section, which facilitates the use of the space by the widest possible range of users and citizens. Additionally, they include aspects related to the context, such as the elements facing the latter, not only in relation to the function they host but also to the design of the façades, among other considerations.

One challenge is determining which elements are to be assessed in the field of walkability and which can be quantified. It is also necessary to determine which of these aspects contribute to making a street ‘walkable’. This should be done not only to facilitate the route, but also to favour an all-round, wider and more comfortable use, thus mobilising and arranging the elements that potentially make a street lively, comfortable, safe and so on. In this context, the assessment of walkability is a complex issue that requires the development of a variety of measuring instruments. Furthermore, to consider the various aspects listed above, it is necessary to move from a broader scale of analysis to a micro-level scale, which allows all the components involved to be considered. (Boyce 2010, Blečić et al 2015)

The objective of this research was to assess walkability within the Milanese urban context, with particular emphasis on the objective component. The aim was to verify its usability by all, starting from an analysis of the conditions of the street space object and its characteristics.

It is clear that this is only one of the aspects that could be investigated when talking about walkability. However, it is important to evaluate how this infrastructure performs in terms of the most relevant aspects of movement, which must allow a plurality of people to move from one point to another in the city or territory. In this context, we will focus on aspects of street space use that are easy, comfortable and accessible. We will exclude contextual elements that allow the space to be inhabited, as well as those that only allow it to be used.

In this sense, when designed from the perspective of universal design, the street object represents an instrument of inclusion, or rather a potential instrument of integration, in several respects. If its use is guaranteed for all, the pedestrian space represents an area in which real

social inclusion can be established. In fact, it's the infrastructure on which various positive practices (such as the possibility of physical activity or community building) are based, but above all, it is the infrastructure that accommodates the most democratic and inclusive - theoretically within everyone's reach - and at the same time sustainable mode of transport: walking. For this to be feasible, however, it is necessary to ensure that the space is designed in such a way that people with different disabilities can enjoy the public space independently, without having to rely on other people. It can therefore be said that the design of the space is fundamental and necessary, but not sufficient for true inclusion, which only occurs under certain conditions. (Azzolino Lacirignola, 2011 and Conti, Garofalo, 2013)
In this study, the term 'walkability' is used to refer to a broad concept that encompasses the design structure of the space in order to ensure that it can be used by all, safely and comfortably. However, it also extends to certain contextual conditions such as the attractiveness and vitality of spaces, which depend not only on the conformation of the road infrastructure but also on what is around it.

All-round walkability in Milan
In light of the above, the Milan survey proposes an analysis that addresses walkability in relation to the school service and approach routes. It also examines all those aspects of space design that represent limitations to use by all users, with a focus on those with disabilities or the most fragile populations. We therefore adopted the perspective of universal and inclusive design, and then deepened the study, taking the same phenomenon to a finer scale.
Although a limited view of the phenomenon has been adopted (ignoring the context with regard to the attractiveness and vitality of spaces) and an attempt has been made to define the relationship with neighbouring services solely on the basis of pedestrian accessibility, it is possible and useful to identify those elements that may represent problematic elements in the movements of persons with disabilities, based on the data available at the various scales. For instance, the presence of accessible crossings, wide pedestrian paths, and signage for users with sensory disabilities are examples of elements that may require attention.
The municipal level analysis was represented by the construction of a walkability graph, weighted on a number of factors. This was done in the wake of the evaluation of the IAPI indicator developed by Pucci, Lanza and Carboni within the research EXTRA - Experimenting with City Streets to Transform Urban Mobility. This aimed to improve accessibility through forms of active mobility. The initial investigation within this evaluation focused on the elaboration and evaluation of walkability according to different indicators. Some indicators were related to the technical performance of routes, while others were related to the relationship with vehicular spaces (number of lanes, limited traffic zones).

A new and distinct version of the analysis model is proposed here, which focuses solely on the characteristics of pedestrian spaces. The list of factors taken into consideration has been modified and implemented with new parameters characterising the space, with the objective of enhancing usability and sharing for all. In addition to evaluating certain aspects of the space that are important in the walkability of able-bodied people, such as width, lighting, the presence of trees, etc., other fundamental elements for use by disabled users were identified from the literature and interviews conducted with experts who deal with disabilities. For instance, the presence of steps at crossings, the width of pavements, their paving, the existence of posts or vertical signs that can reduce the useful width, whether they are positioned in a central location, and so on.
It was therefore decided that the walkability of the area should be assessed in two different ways: for those who are able-bodied and for those who have mobility difficulties.

Two user profiles were therefore selected for assessment: the able-bodied and the mobility-impaired. The following table (Table 1) highlights the selected factors, including those that were included precisely to recognise accessible routes. Each indicator is assigned a value, which is either positive or negative. This reflects the relative ease or difficulty of the route compared to others. The values were selected from certain ranges or from the selection of certain performances considered to be good or average. For example, as far as the width of pavements is concerned, the reference value indicated is 2 metres, a value that greatly increases the quality of the space. This is a value that can be used by two disabled people at the same time. With regard to street furniture and orientation for people with disabilities (such as street lamps and trees), their presence or absence was simply recorded. However, account was taken of the different relevance of the conditions highlighted during the interviews or deduced from scientific texts. For example, the obstacle constituted by steps as opposed to ramps is a more relevant element than the presence of trees or road markings.
In each arc of the graph, a different value, between 0 and 1, was associated with each indicator: low the value, higher the impact on our experience of walking. If the indicator did not affect the conditions of the space, the value assigned was 1. Once all 11 elements considered had been evaluated[3], the average of the indicators was multiplied by a different average speed, depending on the profiles evaluated. The average speed used for the first profile (able-bodied) was around 3 km/h, while with reference to frail or disabled users, a speed of 2 km/h was chosen. The values selected were derived from existing literature, which typically exhibits somewhat elevated values (around 4 km/h for walking). Additionally, the necessity to halt and recuperate or to terminate at an intersection was also considered.

[3] The values chosen were derived from some information in the literature and then verified empirically through some interviews. A calibration of the impedance factor on the basis of user preferences would have been important and would have added more detail to the survey. In the IAPI index, for example, these values are determined from information provided by the residents themselves, for different profiles, through a questionnaire. In addition to the greater relevance of the data to the conditions and habits of the inhabitants, this information can be read in different contexts. In fact, if one imagines that the same questionnaire is proposed to different neighbourhoods in cities with different orography and morphology, it will be possible to identify variations in values depending on the context. Think trivially of the slope data in cities near headlands, or the difference in the assessment of certain obstacles (such as the high presence of bicycles leaning against the wall in some cities).

Urban elements	Indicator	Explanation	Source	Impedance factor - profile 1	Impedance factor - profile 2
Quality and performance of pedestrian path	Width of the sidewalk	The width of the sidewalk affects the walkability of spaces, particularly if it is less than 2 meters	DBT Milano Municipality	0,25	0,25
	Sidewalk material	The type of pedestrian path material (asphalt, cobblestone) affects the ease and continuity of walking	OSM	0,5	0,5
	Absence of trees	The presence of trees can be an element that brings environmental comfort	DBT Milano Municipality	0,5	0,5
	Absence of lighting systems / streetlights	The absence of lighting may affect the perception of safety.	DBT Milano Municipality	0,5	0,5
	Presence of tunnels or bridges	The presence of tunnels or bridges represent elements of potential insecurity and obstacles	OSM	0,25	0,25
	Presence of steps	The presence of stairs or steps makes movement more difficult and is a potential obstacle	OSM	0,25	0,25
Impact of the road	Hierarchy of the road	Roads with increased traffic may represent an element of discomfort	OSM	0,5	0,5
Quality and performance of path	Presence of dehor on sidewalk with width less than 4 meters	Dehors that occupy sidewalks less than 4 meters wide make the usable width of the sidewalks less than a comfortable condition.	DBT Milano Municipality and open data municipality	1	0,25
Zebra crossing	Absence of regulatory systems for crossings	The absence of regulation systems at intersections could be a reason for unsafe conditions.	OSM*	1	0,5
	Absence of ramps (kerb)	The absence of ramps could be such an obstacle as to make it impossible to use the pathway	OSM*	1	0,25
	Absence of podactyl systems	The absence of podiatric systems could be such an obstacle as to make it impossible to use the pathway	OSM*	1	0,25
	Absence of vibration systems	The absence of vibration systems could be such an obstacle as to make it impossible to use the pathway	OSM*	1	0,25

Table 1 - Indicators of walkability and related impedance factors. Highlighted in blue are the most important indicators for assessing walkability conditions for people with disabilities, the elderly, care givers, etc.
Source: author

Alongside the analysis of walkability for frail persons, the investigation of the quality of the space for a hypothetical normally able-bodied user was carried out, thus considering a generic

user with no particular needs. In this case some of the information previously evaluated, i.e. those describing performance qualities that make the use of the pedestrian space more pleasant, but do not condition its use, have assumed different weights depending on the relevance of the factors for the users considered. For example, the presence of a ramp for a person without motor or sensory difficulties is as indifferent or as relevant a factor as the width of pavements or the presence of trees providing shade. Certainly this image is reductive from the perspective of inclusive design, but it is important in order to have a term of comparison in relation to the state of the art and a touchstone for comparing the two profiles.

This hypothesis does not consider the subjective preferences of inhabitants with different needs who live in the city. This aspect is fundamental and should be juxtaposed with the objective conditions of space (density of obstacles), since inhabitants with different needs and in different territories perceive the same elements differently. For example, one factor that could not be considered in this study concerns the continuity of natural guides (walls) for people with visual impairments.

However, it is important to point out that certain circumstances that are common to all cities, such as the presence of lamp-posts and other obstructions, can be accompanied by other elements - just think of the bicycles that lean against walls in many cities in Emilia - which can become obstacles of a certain weight. Or, to take another example, the presence of cobblestones in a city like Milan, where the pavement outside the historic centre is almost entirely asphalt, is secondary to other obstacles. Narrow pavements or pavements without ramps at the ends make walking difficult.
The assessment of walkability according to these parameters allows us to study its possibile usability, at least in terms of the design aspects of the space, for the entire population. This could therefore be a useful tool for the municipality in order to identify priorities for intervention in public space, starting from a study of the physical conditions of pedestrian areas, which could be flanked by other levels of analysis (taking into account subjective perception, level of accessibility and some socio-demographic evalutation). It is also important to consider the needs of vulnerable groups, including people with disabilities, older people living alone, and those with income issues. Indeed, it is crucial to assess accessibility and accessibility to different services, including transportation and the buildings themselves. This is particularly important when identifying clusters of services for different populations.

Walkability toward primary schools
This analysis yielded an initial general cognitive picture of the walkability condition within the Milanese municipal territory. Based on this overall picture of the city of Milan, it was decided to focus on a specific service and study its walkability in the traditional 5, 10 and 15 minutes for one and the other user profile (figure 1 and figure 2), taking into account the characteristics of the pedestrian space. All public primary schools in the territory of the municipality of Milan were therefore examined.
A visual analysis allows us to identify the most problematic areas of the city. The resulting graph is therefore no longer 'neutral', as it is marked by the parameters selected above. Instead, it can be considered a weighted graph, in which catchment areas are considerably reduced. Put another way, a comparison between the isochrones developed on a clean graph and those calculated on the weighted graph shows a clear shrinkage in the size of the different isochrones, which are a reflection of the numerical data (walkable metres). As Pileri (2023) notes in his essay, echoing Socco's insight, the ‘small pervasive problems’ that arise in cities become more widespread over time, conditioning those who live in them from an early age. For this reason, it is crucial to consider the safety and quality of the routes people take from an early age, as

well as the construction of an imaginary of the city's spaces, which makes the inhabitants aware of the criticalities and opportunities it offers. Additionally, this approach aims to enhance the liveability of the locations frequented by the public.
It should not be concealed at this point that, although it was essential to obtain a snapshot on an urban scale of the current condition of walkability (also in order to provide a tool to be included in that list of toolkits that the administration uses to decide where to intervene), this is not sufficient to describe the public space in an exhaustive form.

Figure 1 illustrates the accessibility of primary schools in terms of the time required to reach the service. From the images, it is evident that profiles with varying needs, in terms of speed of travel and factors to be considered in the practice of walking, result in a more or less limited ability to reach a certain number of spaces. It can be reasonably concluded that the primary factor is the variation in walking speed. However, the reduction in catchment area is more pronounced due to the multitude of variables that must be taken into account.
Furthermore, the image illustrates the significant variation in the size of the isochrones across municipal boundaries. In the outermost contexts, the catchment areas are reduced due to either lower population density or the presence of substantial physical barriers, such as transportation infrastructure or significant green spaces.

In fact, it should be pointed out that the data available on a municipal scale are only partly representative of urban mobility conditions. It would be beneficial to conduct further research through the implementation of targeted surveys at the municipal level. This could involve integrating data on population density and the vitality of contexts, among other factors. Additionally, some aspects may only be discernible through field studies, which could serve to enhance the accuracy and reliability of the research.

And in order to test this more concrete perspective, a finer-grained survey was juxtaposed to the large-scale analysis, which also involved the redesigning of a number of pedestrian routes approaching a service, within a radius of 500m, routes selected from the assessments of catchment areas.

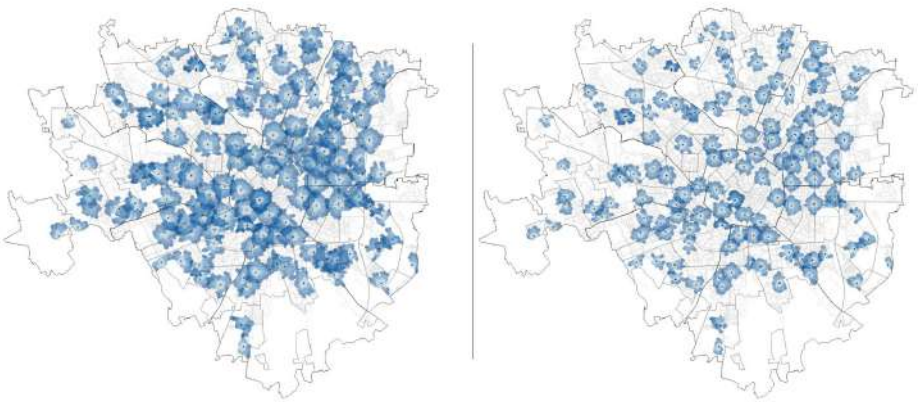

Figure 1 - The catchment areas were delineated at five, 10, and 15 minutes from the school, within walking distance for an average speed for the two profiles: the left profile represents an able-bodied individual and the right profile represents a profile with a fragile constitution. The first profile is

evaluated at a speed of 3 km/h, weighed against the conditions of walkability on the left. The second profile is evaluated at a speed of 2 km/h, weighed against the conditions of walkability from the access of primary schools on the right. The different shades of blue indicate the different thresholds of the walking isochrones: light blue 5 min, light blue 10 min, dark blue 15 min.
Source: author

Precisely in view of these conclusions and the important role that schools play, and could play in the future, with more flexible opening hours and increased activities aimed at the closer community (e.g. hosting services 'scattered' around the city), it was decided to focus on the presidia of education, particularly primary schools.
In order to sample varied and exemplary situations, three schools located in very different contexts were chosen; and three stretches of approximately 500 metres were obtained (by redesigning the public space, figure 2), the ideal average distance to travel to school from home or back. This operation made it possible to lay bare the limits of the analysis at an urban scale, due to the lack of detailed data, but also to highlight the presence of certain customs that are difficult to map, since they vary over the course of the day or in the short to medium term. Through redesigning, in fact, it was possible to record the presence of obstacles not highlighted at the urban scale. To give just a few examples, the placement of vertical signs, positioned in such a way as to make it difficult to pass, the existence of arches at driveways, but also the presence of street furniture placed in the pedestrian context by nearby businesses (figure 2).
This type of investigation, carried out at different times of the day, makes it possible both to witness social practices taking place in public spaces, and to record illicit uses of the pedestrian environment, linked to the illegal parking of cars on pavements, green spaces or pedestrian crossings, as well as the high use of outdoor areas at certain times of the day. These are all situations that make passing very difficult.
Finally, it should be considered that - as Pileri also discloses - a careful examination of this type makes it possible to study the frequency of appearance of obstacles or crossings encountered, and to identify their average value (Pileri, 2023) From these measurements, it is in fact possible to identify every how many metres the attention threshold must be activated to dodge an obstacle or to cross a road. The greater the distance, the better the perception of the space that the user will be able to enjoy in its continuity, in various activities and dimensions (chatting with friends, observing the landscape, etc.); if, on the other hand, this were very low, the enjoyment would be partial.
This line of reasoning, applied by Pileri to home-school routes, identifying critical points in children's walkability, can also be developed in relation to people with disabilities and highlight conditions that make walking fatiguing and frustrating (Pileri, 2023). If on an urban scale one can therefore measure the density of obstacles along an arc of a route, but without having information on their concentration, moving to the micro level one can perceive the weight of certain objective conditions: when walking through a certain space one is preoccupied by its conditions, to the detriment of other actions that the user could or would like to carry out at the same time (chatting, calling, etc.) and that could be disturbed or impeded.
In the case of schools, the elaboration carried out on a municipal scale, by means of isochrones, on the reachability of schools, could or, better, should be coupled with the consideration of other data (the number of students present in the school, the coexistence of several schools or other services in the same lots, the effects of interventions already carried out on the public space), and in this way one could better define the routes on which to intervene as a priority.

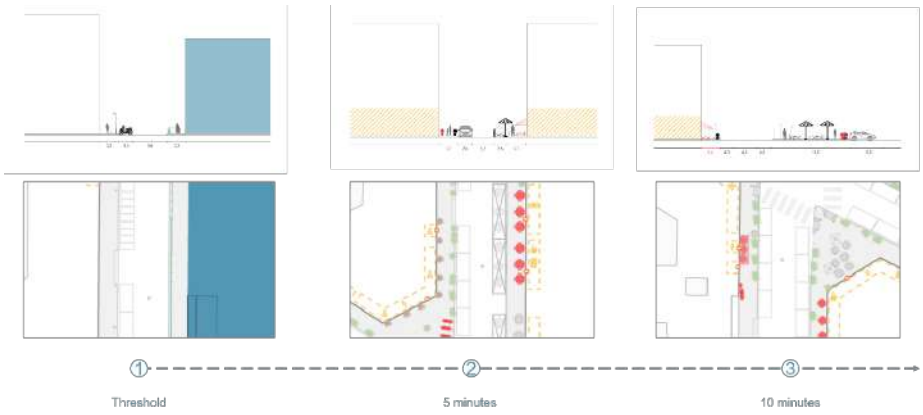

Figure 2 - Analysis of pedestrian conditions in the 500-metre approach, in an example case, the Stoppani primary school. All obstacles that can be seen along the route and that are not registered on the municipal scale are marked in red.

What's next

This type of research, which is increasingly being carried out on several user profiles, see the STEP UP project - Walkability for Women in Milan, is becoming an important resource for guiding interventions in public spaces. Indeed, depending on the profile and the service in question, they make it possible to assess its accessibility and also to identify, by theme, the spaces on which to intervene. One could also hypothesise the juxtaposition of this information with others related to the conditions of the service, the internal and relevant spaces of the latter, as well as others. Imagine, for example, in the case of schools, intervening in those contexts where the school has few spaces dedicated to the courtyard, restoring some of them by working on the threshold spaces. However, if these are mainly spatial aspects, there are other equally important aspects that could be taken into account. As explained by Paola Savoldi (2024), when choosing where to intervene from the point of view of proximity and spatial justice, it is also right to take into account other information, such as the socio-demographic conditions of the context or of the school's own users.

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