This paper presents the evaluation of micro accessibility in the surrounding area of a school located in a residential neighborhood in the city of Bauru, São Paulo, Brazil. Micro accessibility indicators related to the quality of both comfort and safety of users were used for this study as well as multi methods in order to assess the quality of micro accessibility in the vicinity of this area. The results show that the indicators used are effective to identify problems related to comfort and safety of students and school staff who use public transportation. These results may assist local managers in planning and monitoring the spatial quality of the sidewalks located around school areas and contribute to the formulation of municipal policies on this topic.

Keywords: urban mobility, micro accessibility, micro accessibility indicators, sidewalks, bus stops.

1. Introduction

In Brazil, contrary to what occurs in other countries, most journeys transporting children from home to school is held by parents or guardians using the motorized individual transport - the car. In some cases, these students use private school vans, urban public transport, or they walk to school when the distance to be covered is small.

Both the students who use public transport and those who go on foot may face some problems of accessibility during their commute between their starting point (home or bus stop) and their final destination (school). The issues related to infrastructure directed to the non-motorized modes, especially to the one “walking”, are still very recurrent in many Brazilian cities. Lack of accessibility, due to the presence of architectural barriers along school routes may bring insecurity to the users as well as be a cause of accidents.

According to Litman (2008) accessibility can be defined as the ability to reach goods, services, activities, or desired destinations. The author also notes that accessibility can be assessed through three levels: i) micro-scale, ii) regional scale and iii) inter-regional scale. The concept adopted in this article is the micro-scale, which is also known as micro accessibility.

Micro accessibility can be “affected by the quality of the physical conditions of pedestrians, the proximity and clustering of activities, and the road infrastructure offered” (LITMAN, 2008). Bianchi (2011) complements this definition stating that micro accessibility is related to the time spent to access destinations both by vehicle and walking. However, the author says that other complementary aspects should be analyzed to expand this assessment, such as the parking policy, the access points to public transport, the configuration of the circulation environment, and the comfort and safety in crossing the roads.

An accessible path or accessible route can be defined as a continuous path without any architectural barriers and with signaling. It must connect internal or external environments, spaces or buildings, allowing anyone to use it autonomously and safely. According to the Brazilian Standard of Accessibility (NBR 9050), an accessible external route can incorporate the areas for parking, lowered sidewalks, pedestrian crosswalks, ramps, etc. (ABNT, 2004)

According to Campelo (2011) “a route is classified as accessible if it presents, in addition to the features of continuity and signaling, the lack of barriers or impedances that characterizes the path clear of any interference in the movement of pedestrians”. In this sense, the floor of the sidewalks should not present unevenness, the surface should be even and regular, non-slip and without obstacles. The materials used in it should follow appropriate standards for traffic of people (ABNT, 2004; Magagnin, 2009).

As regards the safety of routes in the vicinity of school areas, both national and international literatures have shown that there are few studies that consider the child and the adolescent the target audience in the evaluation of routes between the bus stop and the school building.
Among the relevant national and international researches that analyzed the route of the child to school using different modes of transport are: Müller and Arruda (2013); Mendoza et al. (2012); Collins & Kearns (2005); Stewart et al. (2012); Yeung et al. (2008); Ipingbemi & Aiworo (2013). However, these studies are related mostly to the definition and implementation of new safe methods to take and pick up children to/from school or analyze what are the factors that determine the choice of a transport mode to perform this route. These studies do not seek to assess the comfort and security of infrastructure of the routes home-school.

In this context, this work aims to contribute to the definition of indicators of micro accessibility that can be used to evaluate the micro accessibility in the vicinity of school areas. This paper presents the evaluation of micro accessibility in the surroundings of a school area located in a residential neighborhood in the city of Bauru, São Paulo State, Brazil.

2. Study area

The study of micro accessibility was conducted in the vicinity of the Christino Cabral School; located in the southern region of the city of Bauru, a city of medium size located in the Midwestern region of the São Paulo State, Brazil (see Figure 1). This area was chosen for analysis because it has a large number of students who use public transport to make the journey home-school. Other factors contributing for this school having been chosen were: i) location and ii) the presence of nearby bus stops.

Currently, 1325 students are enrolled in this school, distributed in: junior high (students aged 11-14 years, totaling 543 students) and high school (aged 15 to 17 years, representing 782 students). The school has two entrances. The main entrance is on Avenue 2 allowing only access to teachers and visitors at school, it has a higher flow. The second entrance is on Street 3 (local street, but with a large flow of vehicles) and allows access only to students (see Figures 1a, b and c).

The area analyzed comprised the path between the school entrance to the bus stops. For the definition of bus stops and routes to be studied, a radius of approximately 300m distance from school was adopted (see Figure 1a). For the definition of the routes to be analyzed, consultations were held at the site of Company of Urban Development of Bauru (EMDURB), the body responsible for urban mobility area in the municipality.

3. Methodology

The formulation of the urban micro accessibility indicators for evaluating the spatial quality of the surrounding sidewalks of school areas had reference to the studies carried out by Frum (1987), Sarkar (2003), Magagnin et al. (2014), Ferreira and Sanchez (2007), Keppe Junior (2007), Brazil (2007), Miranda & Cabral (2005 cited in Brazil, 2007); Brazilian Technical Standard NBR 9050 (ABNT, 2004); Ipingbemi & Aiworo (2013); Mitchell, Kearns & Collins (2007); Pires (2009); Rudner (2012). These indicators relate the comfort issues and pedestrian safety regarding the conditions of the sidewalks.
Comfort Quality of the Sidewalk (Effective width, Floor type - slippery, Conservation status of the floor surface, Longitudinal slope, Transversal slope, Unevenness); Safety Quality of the Sidewalk (Street Furniture and vegetation - clogged sidewalks by street furniture or vegetation, Horizontal signs, Vertical signs, Ramp, Vision of approaching vehicles on the crossing, Traffic light for pedestrians, Traffic light time, Minimum free height 2.10m).

For this evaluation, qualitative methods and techniques have been adopted for the collection and analysis of data. Data collection involved field work, by conducting observations “in loco” and photographic and metric study.

4. Results and Discussions

In this section, the analysis of the results obtained by applying the micro accessibility indicators is presented. The analysis began with a study of the location of existing bus stops surrounding the State School Christino Cabral and the definition of the bus lines that target these points (Figure 2).

Figure 2 - Location of the school entrances for teachers, students and the location of the surrounding bus stops. Source: Adapted from Google Maps, 2014.

In the school surroundings there are four bus stops (see Figure 2), and two of them (Bus stops 3 and 4) are located on Avenue 1, and two other ones (Bus stops 1 and 2) on two streets which are perpendicular to Avenue 1. These four bus stops are served by eight lines of urban public transport system: Line L1 feeds Bus stop 3; Lines L2 and L4 feed Bus Stops 3 and 4; Lines L3, L5, L7 and L8 feed Bus Stops 1 and 2; and the Line L6 feeds Bus Stop 2.

When analyzing the data of eight lines that pass by the four bus stops, it was found that half of the bus lines that target this area of the city, has as intermediate stop or final stop, Bus Stops 1 and 2. One of the lines has as its final Bus Stop 2 and the remaining lines are associated with Bus Stops 3 and 4. In all cases, the same line has two bus stops near the studied School area.

From this initial information, a survey was conducted to identify along the path of each public transport line which bus stop was closer to the school for embarking and disembarking of students and thus examine the micro accessibility in these routes.

Figure 3 - Routes of the lines of the public transport system in the school surroundings: (a) L1; (b) L2; (c) L4 (yellow - arrival and purple - departure) and (d) L6 and (e) L3, L5, L7 and L8. Source: http://tdmax.transurbbau.com.br/ITSInformativo/Home/Index
The first group of public transport lines analyzed corresponded to Lines L1, L2 and L4 (Figures 3a, 3b and 3c). In Lines L1 and L2, Bus Stop 3 is accessed prior to Bus Stop 4, and the first is the nearest point to access the school by the walking mode. In Line L4, Bus Stop 4 is accessed for the arrival of a route (in yellow, Figure 3c), while Bus Stop 3 is accessed at the departure by another route (in purple, Figure 3c). As Bus Stop 3 is the closest stop to the school, it is the busiest for embarkation and disembarkation of passengers when compared to Bus Stop 4, thus, the latter will not be considered for this analysis.

The second group analyzed consisted of Lines L3, L5, L7 and L8 (Figure 3e). In this group, Bus Stop 1 is always an intermediate stop and previous to Bus Stop 2, as the latter acts as the final stop point in most of the analyzed lines, including Line L6. Due to the fact that Bus Stop 2 is closer to the school, it was considered in the analysis while Bus Stop 1 was disregarded. Owing to the above analyses, which were based on the proximity of the bus stops in relation to school, only the bus stops 2 and 3 will be analyzed below.

The first route, called Route R1, covered the path between the Bus Stop 2 and the School (Figure 4). From that point, the user of public transport must cross the Avenue 1 to get to the sidewalk that accesses the school. The route called Route R2 is between Bus Stop 3 and the school (Figure 4). In this route, the user of public transport must use the same sidewalk to get in front of the school and only then make the crossing of Street 3.

In the typology, the two routes were analyzed individually with reference to the themes and indicators presented in the Methodology item.

![Figure 4 - Analyzed paths: From Bus Stops 2 and 3 to the school. Source: Adapted from Google Maps](image)

The analysis of the theme "Comfort Quality of the Sidewalk" on Route R1, with respect to the effective width indicator (free path), showed that the sidewalks are very narrow along three of the six blocks belonging to that path. The minimum widths were 0.60m (Figures 5i and 5j) or 0.80m (Figure 5h) and, therefore, unsuitable for pedestrian traffic. According to the Accessibility Technical Standard - NBR 9050 the recommended width is 1.50m and the minimum allowable width is 1.20m (ABNT, 2004). Regarding the types of flooring analyzed along the path, they are made of different materials (hexagonal block, hydraulic tile, paving stone and concrete) and most of them have rough surfaces with only a small strip of slippery cobblestone. The evaluation of the sidewalk conservation status was considered reasonable. Two sections of the street flooring have their surface broken and with holes due to tree roots, Figures 5i and 5k. It is worth mentioning that the hydraulic tile sidewalk has been renovated recently and that its situation is degradable in periods of rain by floods account. The longitudinal slopes are within the standards. The transversal slopes showed inclinations above 3% (Figure 5i and 5k) in two sections. Regarding the unevenness, the whole path is leveled.

Regarding the "Safety Quality of the Sidewalk" on Route R1, in the item street furniture and vegetation, the corridors of the sidewalks were considered inappropriate because they had vegetation in the middle (Figures 5i and 5j). There are pedestrian crossing markings on the street crossing of Avenue 1 (horizontal signs), but there are neither road signs (vertical signs) nor access curb ramps along the way. The view of approaching vehicles is hampered by vegetation and there are no traffic lights. The minimum ceiling height of 2.10m is hampered by lack of maintenance of the trees (Figures 5b, 5e e5f). Although Street Safety Quality is not among one of the pointed indicators, it is worth noting the lack of security for crossing Avenue 1, which despite the large influx of people accessing the school is not equipped with traffic lights. The traffic light with button would be ideal to request signal lock for cars allowing the passage of pedestrians.
The second path, called Route R2, corresponds to the axis: Bus Stop 3 to school, as shown in Figure 4.

Regarding the theme "Comfort Quality of the Sidewalk" on Route R2, the effective widths of most sidewalks on Route R2 are slightly larger than the ones on the previous route, reaching up to 1.05 m wide. However, they do not meet the minimum width allowable by the NBR 9050 which is 1.20m (ABNT, 2004), as shown in Figures 6c, 6d, 6e and 6f. Only the last sidewalk of this route, Figure 6f, the one in front of the wall painted red, has the effective width within the Accessibility Technical Standard, with 2.50m.

Regarding the types of flooring, these are in general not slippery, because most have concrete lining, only one lot is cobbled which makes it part of the slippery path. Regarding the conservation status, the surfaces of this route are a bit better than on Route R1, but also have irregular and poorly maintained surfaces as shown in Figures 6d and 6e. The longitudinal slopes and transversal slopes are appropriate.

Only one gap was found shortly after Bus Stop 3 (Figure 6b).

On the theme "Safety Quality of the Sidewalk" on Route R2 - street furniture and vegetation - the furniture is considered regular, because there is a very wide strip of 6.50 m for the furniture, with the exception of the point shown in Figure 6d, where the trunk of a tree is taking up half of the available free area of the pedestrian corridor. There are pavement markings, but the street signs do not exist. There is a ramp for the sidewalk on the opposite side of Route R2, that is, on Route R1, with uneven surface. The vegetation and the lamppost hinder the visualization of approaching vehicles and there are no traffic lights for pedestrians. Both road signs and markings are present, warning the proximity of the school area, Figure 7a and 7b. There are problems with vertical clearance of 2.10m only at the end of the route Figure 6f.
Figure 6 - Photographic Study - Route R2

(a) (b)

Figure 7 - Markings (a) and street signs (b) at the school proximity

Table 1 presents a summary table showing the situation of each of the indicators for each analyzed route.

<table>
<thead>
<tr>
<th>Micro accessibility indicators</th>
<th>Route – R1</th>
<th>Route – R2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective Width</td>
<td>Inadequate</td>
<td>Inadequate</td>
</tr>
<tr>
<td>Type of flooring - slippery</td>
<td>Inadequate</td>
<td>Inadequate</td>
</tr>
<tr>
<td>Pavement surface maintenance</td>
<td>Inadequate</td>
<td>Inadequate</td>
</tr>
<tr>
<td>Longitudinal slope</td>
<td>Adequate</td>
<td>Adequate</td>
</tr>
<tr>
<td>Transversal slope</td>
<td>Inadequate</td>
<td>Adequate</td>
</tr>
<tr>
<td>Level</td>
<td>Adequate</td>
<td>Inadequate</td>
</tr>
<tr>
<td>Urban furniture and vegetation – sidewalk obstructions</td>
<td>Inadequate</td>
<td>Inadequate</td>
</tr>
<tr>
<td>Pavement markings</td>
<td>Adequate</td>
<td>Adequate</td>
</tr>
<tr>
<td>Traffic signs</td>
<td>Non-existent</td>
<td>Non-existent</td>
</tr>
<tr>
<td>Ramp</td>
<td>Non-existent</td>
<td>Inadequate</td>
</tr>
<tr>
<td>Visualization of the approaching vehicles in crossings</td>
<td>Inadequate</td>
<td>Inadequate</td>
</tr>
<tr>
<td>Traffic lights for pedestrians</td>
<td>Non-existent</td>
<td>Non-existent</td>
</tr>
<tr>
<td>Time of traffic lights</td>
<td>Non-existent</td>
<td>Non-existent</td>
</tr>
<tr>
<td>Free minimum height of 2,10m</td>
<td>Inadequate</td>
<td>Inadequate</td>
</tr>
</tbody>
</table>

According to the results of the evaluation process of public space for the pedestrian in the vicinity of school buildings - Table 1, it was possible to determine that with regard to "Comfort Quality of the Sidewalk", both routes R1 and R2 have 66.66% of items considered inappropriate. The evaluation of the two routes was a draw in this regard, and 33.33% of each one of the routes was considered adequate. However, the same items are not suitable for both routes, only the longitudinal slope is, while the transversal slope is inadequate on route R1 and adequate on route R2, and the unevenness is appropriate on route R1 and inappropriate on route R2.

On the "Safety Quality of the Sidewalk", Route R2 (with 50% of inadequate items) had its evaluation slightly worse than Route R1 (37.50%). The adequate items had numerical draw and are also the same for both routes: the street signs. It is noteworthy that 50% of Route R1 did not present any elements that could be analyzed and on Route R2, 37.5% of it had no elements for analysis. Overall, Route R1 (50% inappropriate) is more appropriate than the Route R2 (57.14%), but both have serious problems, mainly related to the effective width of the sidewalk corridors, furniture location/vegetation and canopy maintenance, as well as vehicle approaching visualization and lack of accessibility of ramps at the major crossings.

In addition to the problems identified in these two routes, another problem relates to the identified student access to school building is carried out by stairs.

These results indicate that for this area to be considered accessible to all users, it is necessary that the council adopts some urban interventions to solve the problems identified above, which resulted in an extremely negative evaluation for safety and comfort of pedestrian who get to school by public transport.
5. Final Considerations

The application of indicators of urban accessibility to evaluate environments of school areas allowed the identification of various urban problems related to micro accessibility to both the public space and the building and which are interfering with the spatial, comfort and safety qualities of the users.

Considering these results, the conclusion is that the proposed indicators are intended to contribute to similar analyses by offering elements for: i) the composition of a system of Urban Accessibility Indicators for surroundings of school areas, which can assist local managers in making decision, planning and monitoring of these areas, ii) conducting a broad diagnosis of the surroundings of school areas in order to propose guidelines that can be implemented in the short and medium term, and thus make this space more accessible and safer, iii) the formulation of programs, projects and municipal policies, aimed at providing a better quality of life for pedestrians.

For a more comprehensive assessment of school surroundings, the inclusion of other Urban Accessibility Indicators may be needed in future studies, although the methodology applied in this study has shown to be relevant to its assessment as it accurately portrayed the problems associated with pedestrian infrastructure found in this place.

6. References


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