

The mobility for the elderly population encompasses different dimensions of urban life including housing, transportation, work-related activities and social interactions. The initiatives for the elderly are mainly undertaken in the areas of health while in reality, this is only a part of the overall picture that might be considered while planning urban accessibility strategies.

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**ELDERLY MOBILITY**

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## Elderly Mobility

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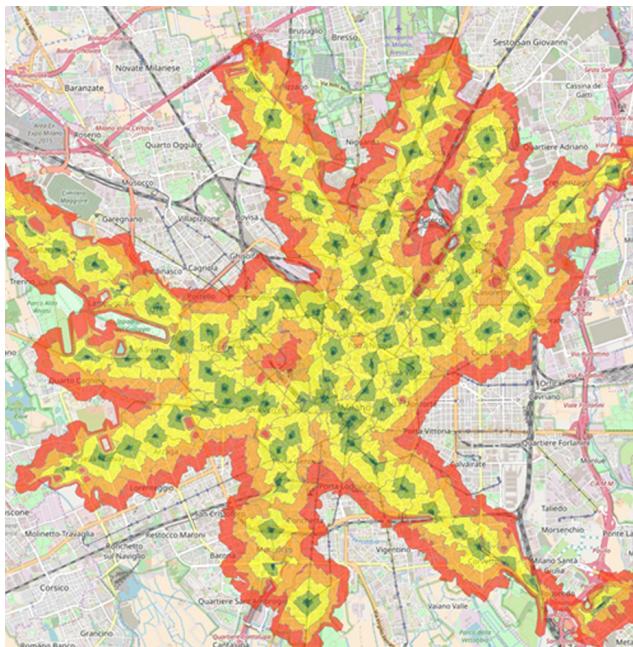
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## MEASURING SPATIAL ACCESSIBILITY FOR ELDERLY

AN APPLICATION TO SUBWAY STATIONS IN MILAN

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### ABSTRACT

This paper presents a method for mapping and measuring accessibility to subway stations for elderly. The methodology measures pedestrian accessibility by means of isochrones to specific urban functions, for quantifying the total amount of elderly people living within each isochrones and for evaluating the presence of services around each station. In particular, a real application on Milan city is carried out with the most updated available data.

Main aim is the identification of neighbourhoods that present more accessibility problems. The number of inhabitants, and in particular of aged persons living in less accessible areas are therefore quantified, such as the number of activities located within walking distance are counted.

The methodology can be applied to other spatial contexts and can be furtherly improved by integrating other information in the model. Accessibility analysis has an increasing role in policy making and evaluation for policies targeted towards social inclusion. because poor pedestrian infrastructures can hinder the potential movement of an increasing amount of urban population.

### KEYWORDS

Accessibility; Public Transport Services Elderly; Milan

## 1 INTRODUCTION

According to OECD (2015), cities in advanced economies are growing older more quickly than rural areas. In these countries, the populations are ageing as a result of low fertility, low immigration, and long lives. There is evidence that people are living longer without severe disability (Christensen et al., 2009) also thanks to technological and medical development. WHO (WHO, 2015) defines Healthy Ageing "as the process of developing and maintaining the functional ability that enables wellbeing in older age". The ability to be mobile is included among the functional abilities that policy should improve for all older people.

This relatively new condition raises novel demand of knowledge about the accessibility to relevant urban functions and services for elderly in cities.

Within health and medicine studies (Fernández-Mayoralas et al., 2000), urban and geographic studies (Fobker & Grotz, 2006; Forbes, 1964), transportation science (Lin et al., 2014; Mayo et al., 2012; Metz, 2000; Zielstra & Hochmair, 2011;), spatial sciences (O'Sullivan et al., 2000) many methodological and conceptual research projects have been carried out on accessibility issues for specific groups of people and, among these, for elderly. Accessibility measures and maps are useful in helping to identify social groups and locations with poor levels of access to services and facilities (Achuthan et al., 2010). Accessibility has been analyzed and mapped for different mean of transport (car, train, public transport, foot), for different destinations (foods, health services, public transport, job places) and in different urban and regional contexts.

In this general framework, the research MOBILAGE, Mobility and aging: daily life and welfare supportive networks at the neighborhood level, supported by Fondazione Cariplo, is aimed at investigating which role local public transport (LPT), and welfare and community services play in improving the quality of life of elderly and at providing the public administration with a GIS decision support tool to find out the most appropriate forms of governance to improve and integrate care services for the elderly and urban policy and mobility measures in the city of Milan.

The project involves three partners: Politecnico di Milano – DASTU as principal investigator, University of Naples – DICEA TeMAlab and University of Groningen – Faculty of Spatial Science.

Within the MOBILAGE project, an analysis of the supply and demand of local public transport (LPT), and of welfare and community services concerning the elderly living in the municipality of Milan, is carried out. In particular, this paper refers to a specific task assigned to DASTU concerning data analysis and mapping of accessibility issues in Milan.

## 2 METHODOLOGY

The paper presents a methodology for measuring spatial accessibility to subway stations in the city of Milan. The methodology integrates several spatial data analysis techniques performed with geographical information system tools aimed at calculating the number of elderly living at different time breaks walking distances around existing subway stations in the city of Milan.

The analysis is based on the following steps:

- Acquisition of the road network and construction of the pedestrian road network (May, 2018) for the city of Milan;
- Acquisition of the point subway station dataset for the city of Milan;

- Generation of the 2, 5, 10, 15, 20 minutes isochrones based on the pedestrian road network around each subway stations;
- Acquisition of the polygon census blocks dataset with socio-demographic variables (2011) and transformation of the census blocks in points;
- Quantification of inhabitants and of elderly people living within each isochrones;
- Acquisition and geocoding of the commercial activities related to food and beverages in the city of Milan, integration of this dataset with the isochrones spatial dataset, analysis of the number of activities around each station.

In the following paragraphs we will present and comment the previous activities. In particular, sub-paragraph 2.1 deals with the construction of the pedestrian road network, sub-paragraph 2.2 with the methodology for calculating accessibility by means of isochrones and sub-paragraph 2.3 with the methodology for counting the number of elderly living within each isochrone.

## 2.1 THE CONSTRUCTION OF THE PEDESTRIAN ROAD NETWORK

The first methodological issue was related to the identification of a correct and reliable source for the road network. The AMAT Agency (Agenzia Mobilità Ambiente e Territorio) is the official agency devoted to support the Milan administration in analysing mobility, developing maps and analysis, models and simulations, developing planning tools and projects for transport and mobility. Among these activities it provides to the municipality the official road graph for Milano. In 2014 AMAT started a project aimed at integrating its own road graph with OpenStreetMap (OSM) road graph.

OSM was chosen because of its quality, its continuous updating by a community of volunteers, its spatial coverage that goes beyond administrative boundaries and its open licence. OpenStreetMap recently improved dramatically in terms of the quantity and quality of available data and is currently more and more used in different field of research (VGI, digital cartography, urban studies, modelling) (Hacklay, 2010; Mooney & Minighini, 2017; Ramm et al, 2011).

OSM is a collaborative project aimed at creating an “open source” and editable map of the world. The data are grouped into different features, described by a numbers of tags such as amenity, buildings, highway and many others. Thanks to this source, it is possible to realize maps according to the distribution of infrastructures (street hierarchy), the presence of points of interests, the connection with public transport, etc. OSM features can be easily integrated in GIS packages and can be extracted through web based data mining tools (Overpass Turbo). In this context, an extraction of OSM road network has been performed by February 2018 selecting some specific tags.

Since our aim was the evaluation of the accessibility to specific locations by foot, we cleaned the road network in order to remove high speed roads and motorways from the network. For the same reason, we added to the network, pedestrian footways and paths collected through specific queries in OSM (Tab. 1). Tab. 1 shows the complexity of the pedestrian OSM road network and its articulation in different categories according to the different types of roads.

Finally, we extracted the nodes for all the intersections of the network in order to guarantee the pedestrian connections among roads. With this last operation, we developed an updated OSM pedestrian network composed by several road categories (Fig. 1). This network could be further modified or improved by adding or removing specific types of roads.

PRIMARY FEATURES	VALUE	NUMBER OF EDGES
highway	footway	58,249
highway	service	44,760
highway	residential	43,041
highway	unclassified	33,714
highway	tertiary	19,377
highway	pedestrian	10,020
highway	cycleway	9,186
highway	secondary	8,820
highway	path	5,839
highway	track	5,186
highway	primary	4,943
highway	steps	1,784

**Tab. 1 Main map features for the construction of the pedestrian road network. Source:** elaboration of the authors of OSM data

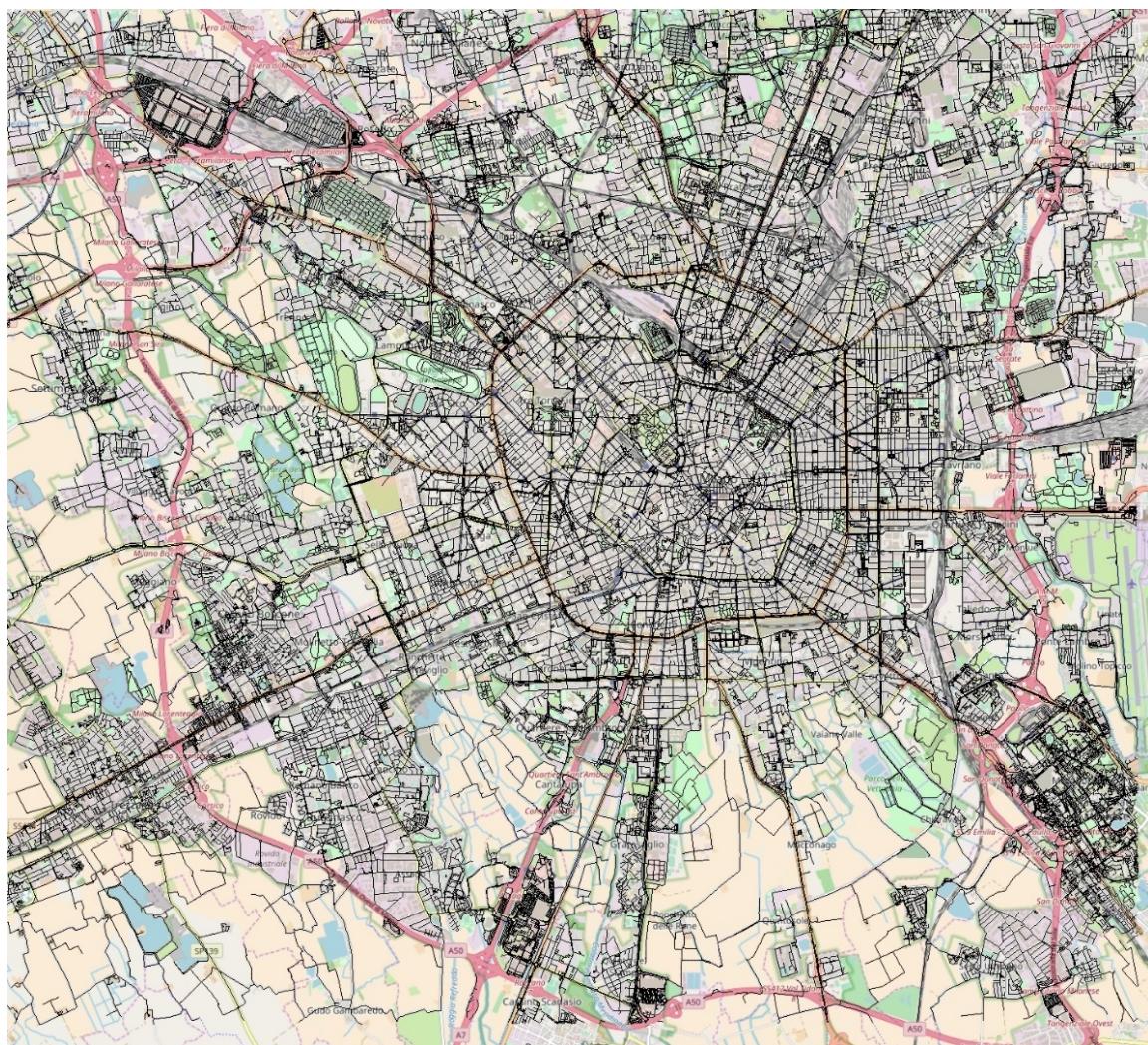


Fig. 1 Map of the pedestrian road network. Source: elaboration of the authors of OSM data

## 2.2 CALCULATING THE PEDESTRIAN ISOCHRONES AROUND SUBWAY STATIONS

Once we obtained the pedestrian road network, we integrated in our model the spatial distribution of subway stations collected through the open data portal of the Milan Municipality in order to calculate the isochrones around each subway station.

In this context, subway stations, other than specific destinations are a gateway for accessing other services for elderly, related to leisure, free time, culture, health issues, visiting friends and family.

Since we were interested in the analysis of accessibility for elderly people by foot we defined a simplified average pedestrian speed of 1 m/sec despite the walking speed depends on several and complex factors (age, health condition, weather conditions, pendency, characteristics of the ground surfaces).

This average speed has been added to the network segments as a prerequisite for the application of the Dijkstra's algorithm used for the generation of the isochrones within ArcMap Network Analysts.

The algorithm finds the shortest path within a road network for reaching specific locations, i.e. the subway stations and generates the polygons according to a time or length cost function. Isochrone maps are commonly used to depict areas of equal travel time.

We specified 5 break values that identify the different isochrones (2, 5, 10, 15 and 20 minutes). Each isochrone defines the urban area from which it is possible to reach the destination based to its value and to the real pedestrian network. Fig. 2 shows the isochrones around existing subway stations and highlights which parts of the city, at 1 m/sec average speed, are closer to subway stations.

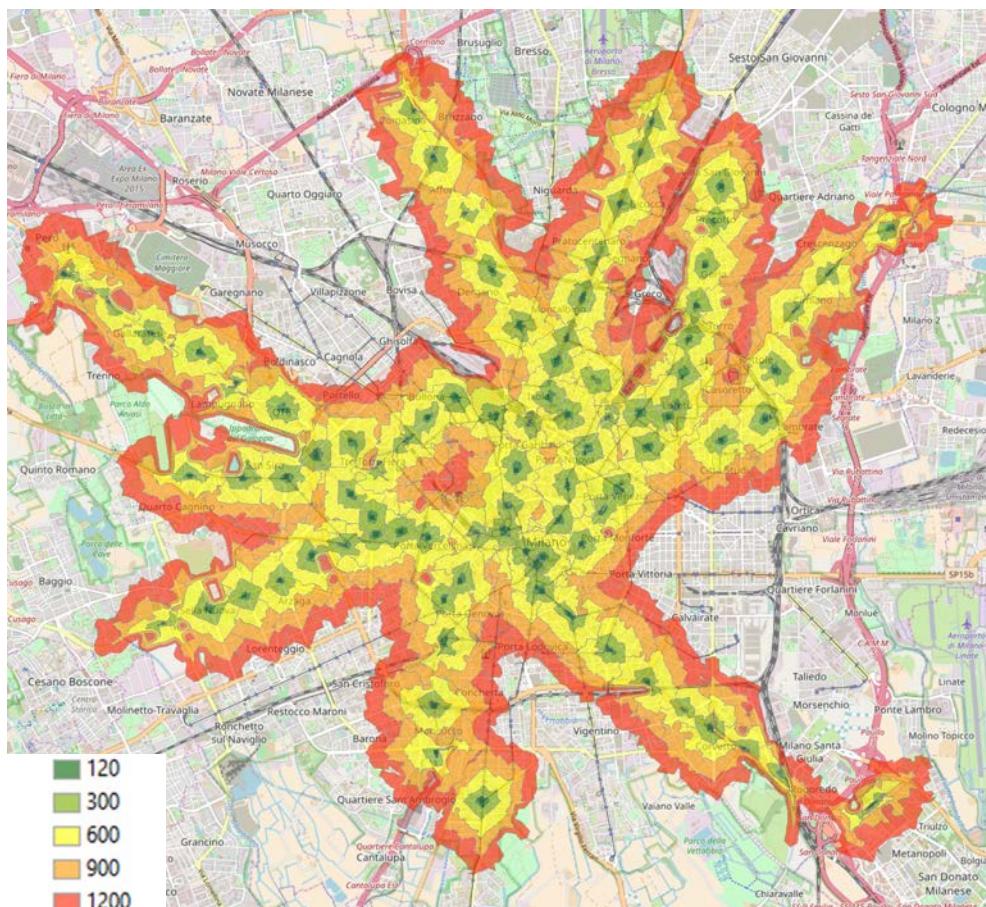


Fig. 2 Isochrones around existing subway stations: seconds for reaching the nearest station - time breaks in seconds. Source: elaboration of the authors

### 2.3 THE QUANTIFICATION OF ELDERLY PEOPLE ACCORDING TO DIFFERENT LEVEL OF ACCESSIBILITY TO SUBWAY STATIONS

The subsequent step was the quantification of elderly people living in the city of Milan according to different levels of accessibility to subway stations in order to identify not only which neighbourhoods are more far away from subway station but also how many elderly live in census tracts included in the different isochrones. Our aim was to measure the number of elderly people with potential problems of accessibility to public transport service.

For this purpose, we acquired the 2011 Population and Housing Census dataset provided by Istat at the spatial resolution of census tract which is the smallest statistical unit available in Italy. In cities, a census tract corresponds to a city block. For each census tract dozens of census variables are available. For this reason, the Census statistics based on city blocks can be very useful for analysing and mapping spatial phenomena at a very detailed scale, despite they are updated every ten years.

We transformed the 6085 city blocks of Milan in point and we summarized the overall number of inhabitants and of elderly people included in each isochrone in order to quantify the number of elderly people living around each subway station. This conversion of polygon census tracts to points was aimed at finding a univocal criterion for the attribution of the population living in each census tracts to a specific isochrone. More precisely, when the point is located within the isochrone polygon, its population value is attributed to the same polygon. Fig. 3 represents, as coloured points, the census blocks belonging to the different isochrones. In black are depicted the areas of Milan from which it is possible to reach a subway station only by more than 20 minutes walking. These neighbourhoods therefore present some serious issues of accessibility not only to relevant

nodes of the public transport network but also to dozens of destinations that can be reached through the subway system.

Tab. 2 presents some basic statistics on the overall number of inhabitants and elderly people (aged 65-74 and over 74) living in the different isochrones in the year 2011.

ISOCHRONE	INHABITANTS	ELDERLY (65 - 74)	Elderly (>74)	Elderly > 65 (%)
< 2 minutes	8,613	995	1,141	24.8%
2 - 5 minutes	116,531	14,188	14,664	24.8%
5 - 10 minutes	323,252	39,716	41,483	25.1%
10 - 15 minutes	238,384	29,589	30,904	25.4%
15 - 20 minutes	169,643	20,243	21,510	24.6%
> 20 minutes	385,700	46,994	48,679	24.8%
Total	1242,123	151,725	158,381	25.0%

Tab. 2 Overall number of inhabitants and elderly people in the different accessibility areas  
 Source: elaboration of the authors on Istat data

Over 385.000 people live at more than 20 minutes walking distance from a subway station. Of this value, more than 94,000 are aged over 65, around 30% of the overall number. This means that, even in the Italian city with the most extensive public transport network, there is an accessibility issue both for the general population and, in particular, for elderly.

A further methodological step concerned the integration between the spatial dataset on food and beverage shops provided by the Municipality of Milano and the isochrone in order to highlight the stations with lack of

this kind of services around them. Moving from the consideration that the more the foot path toward the subway station offers possibilities to stop and to have a short rest in a bar or coffee shop, the more it can be easy to reach the destination for urban populations in general but for elderly in particular, we calculated the number of activities related to supply of food and beverage, collected through the open data website of Milan within the 15 minute isochrone for each subway station. Tab. 3 shows that around 15% of the subway stations is characterized by lack of services related to food and beverages. From the perspective of healthy and active ageing this condition can discourage people from moving by walking to their destinations especially under specific conditions (weather, health and mobility issues just to cite some).

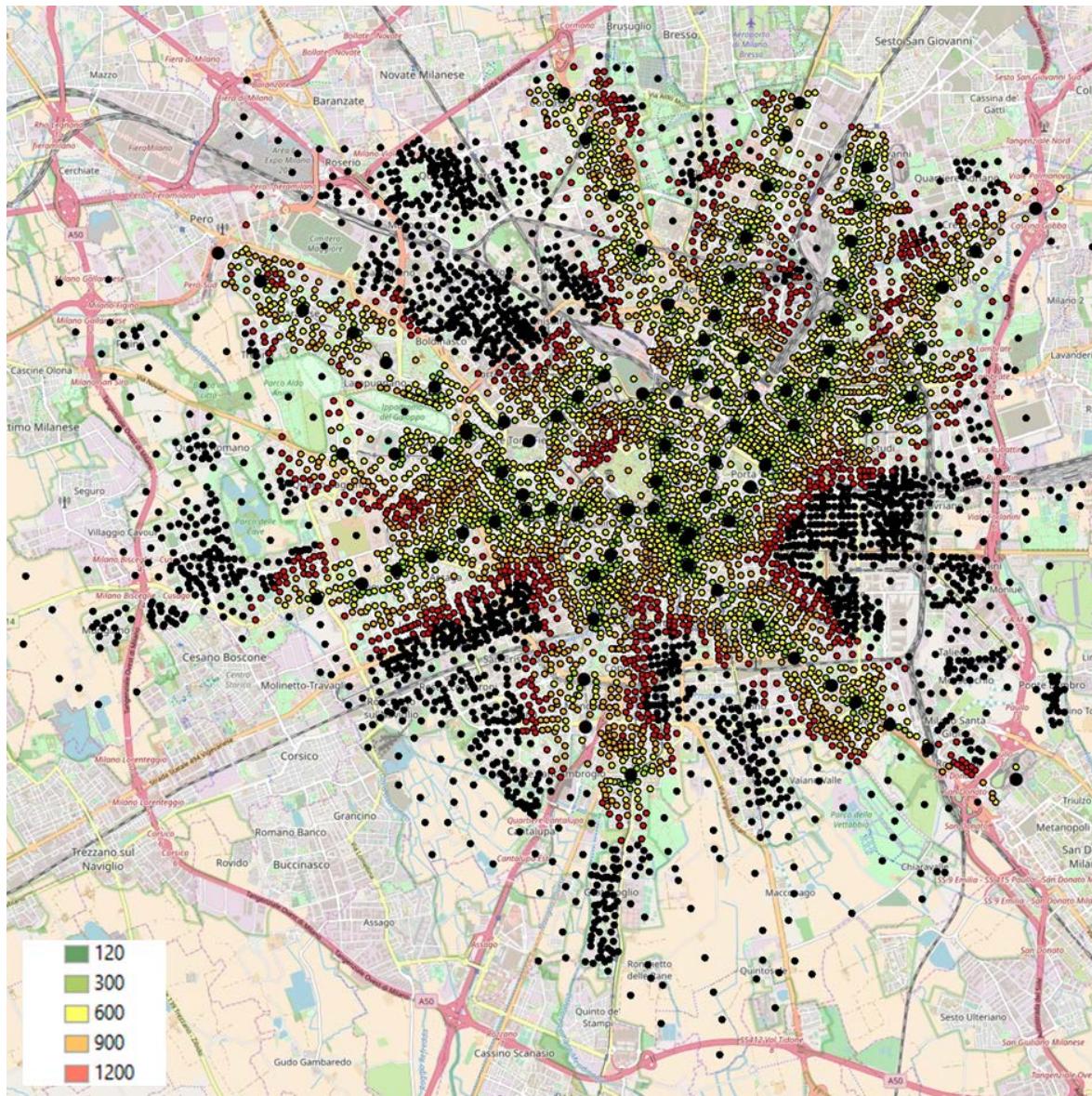


Fig. 3 Census blocks as point features according to the different Isochrones -time breaks in seconds. In black color, are depicted the census blocks located more than 20 minutes walking from subway stations. Source: elaboration of the author

NUMBER OF ACTIVITES (FOOD AND BEVERAGES)	NUMBER OF SUBWAY STATIONS	PERCENTAGE OF SUBWAY STATIONS
< 20	9	10.1%
20 - 60	15	16.9%
60 - 100	14	15.7%
100 - 200	27	30.3%
> 200	24	27.0%
	89	100.0%

Tab. 3 Food and beverage shops within the 15 minute isochrones. Source: elaboration of the authors

### 3 COMMENTS AND FUTURE WORKS

This paper discussed the development of a methodology aimed at mapping accessibility for elderly. We applied a methodology for measuring accessibility by means of isochrones to specific urban functions, for quantifying the total amount of people living within each isochrones and for evaluating the presence of services around each function. In particular, we tested the method to subway stations in Milano. The methodology is based on data publicly available such as OpenStreetMap, dataset on the public transport services that are easy to find in other international and Italian contexts.

The methodology can be certainly improved, extended to other spatial contexts and applied to other services (LPT services, schools, cultural facilities, commercial facilities, etc.) in order to provide different analysis of accessibility related to more complex and articulated urban functions. Daconto et al. (2018), for example, analysed elderly's people accessibility to food opportunities in Milan which is another relevant issue for guaranteeing wellbeing and quality of life dealing with the potential difficulties to walk and move in the city for reaching food shops and similar activities. The effect of micro-level barriers, road pendency and their impacts on pedestrian accessibility can also be integrated in the model in order to evaluate also some ground level issues, such as obstructions in pavements, that can be very relevant for reducing mobility opportunities of specific groups of population.

The methodology can also be improved by using different criteria for the identification of a correct average pedestrian speed in order to take into account differences in physical capabilities and mobility levels and can also be used to provide different scenarios according to the development of new urban transformation and new urban functions (i.e. new subway lines). Furthermore, it could be possible to integrate more specific information on the socio-demographic characteristics of elderly living in the different isochrones and on their mobility behaviours in order to recognize different mobility profiles and needs. The specific access to services can be better incorporated in the model by adding some specific information to the subway stations such as the presence of physical barriers, the presence (or absence) of mobile chairs or other elements that can make it difficult to reach not only the station but also the mean of transport. Accessibility analysis can also have an increasing role in policy making and evaluation for policies targeted towards social inclusion because poor pedestrian infrastructures can hinder the potential movement of an increasing amount of urban population.

Within the MOBILAGE project further experimentations will be carried out in order to understand better the dimension and the development of accessibility issues for elderly and to provide policy makers new tools for identifying and promoting targeted actions aimed at improving opportunities of mobility for elderly.

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## WEB SITES

Istat – Italian National Institute of Statistics - <https://www.istat.it/>

OVERPASS TURBO – web based tool for OSM data extraction <https://overpass-turbo.eu/>

OPEN DATA COMUNE DI MILANO – open data portal of Milan Municipality <https://dati.comune.milano.it/>

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