Age Inequalities of Accessibility to Essential Urban Services. The Case Study of Primary Health Care in the City of Milan for Older People

Gerardo Carpentieri and Carmen Guida

Abstract The population in urban areas is getting older because of a significant demographic change. In 2019, the OECD indicates that the share of people aged over 65 reached 17.8% and is expected to climb to 25.1% in 2050. Older people present age-associated limitations that influence mobility capacities with the occurrence of social isolation, loneliness, and depression. Moreover, aging is associated to an increased vulnerability and dependence on medical care services. Since everyone should have the opportunity to access to essential services equally, especially people who need them the most, to accomplish practices and maintain relationships that people take to be necessary for normal social participation. Hence, more age-friendly approaches are needed to shape ageing cities. In this study, a GIS-based procedure was developed in order to assess accessibility to primary healthcare services and to support decision-makers to better allocate resources, for local welfare policies restructuring. The accessibility measure considers the local healthcare provision, the land use structure and the characteristic of the multimodal transportation network. The methodology was applied to the city of Milan, considering its Health Protection Agency (ATS) that provides healthcare assistance to the elderly dwelling in the city. The outputs show that entire neighbourhoods' elderly population suffers from very poor accessibility to primary health services, especially in the city suburbs, and that the methodology could be effective in urban planning strategies to promote better quality of life for the elderly.

Keywords Urban accessibility · Healthcare provision · Elderly

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1 Introduction

Cities are ageing because of demographic change and economic and social consequences are expected to be comparable to the industrial revolution. In Europe, the share of people aged 65 and over is expected to increase from 19.4% in 2017 to 30% of the total population in 2060 and for the first time in human history, in 2050, the number of older people will be greater than the number of children under the age of 15. As far as for the Italian context, the combination with a significant reduction of the total population, from over 60 million people in 2018 to 46 million in 2065, and a noteworthy increase of the population aged 65 and above (from 22.7% in 2019 to 30.5% in 2065), would make Italy an even older nation. The elderly represent an essential group of interest: due to improvements in nutrition, sanitation and medical care older people are healthier than the previous generation but, at the same time, aging is also associated to an increased vulnerability and dependence on medical care services. Since everyone should have the opportunity to access such services equally, local authorities should prioritize the implementation of policies to promote higher life-quality standards for this increasing amount of population and the accessibility approach can be useful to achieve this aim. Therefore, the study of spatial distribution of urban activities, efficient use of resources (economic and environmental) and a good level of accessibility to different services are crucial challenges to promote more sustainable cities (Kompil et al. 2019; Rossetti et al. 2015). The accessibility paradigm takes into account both the land-use system, consisting of the amount, quality and spatial distribution of supply and demand of activities, and the transport system, considering individual needs, abilities and opportunities (Geurs and Van Wee 2004; Papa et al. 2018). This contribution proposes a GIS-based procedure to measure accessibility to medical care services, considering the supply of transport network. The aim is to identify elderly people living in areas that suffer of poor accessibility to healthcare provision. The procedure was applied for the health service provision in the city of Milan, Italy.

2 Materials and Methods

Due to the increasing political and scientific interest on the topic, several methods and approaches were produced to determine healthcare accessibility in urban areas and, based on the application context, these measures vary a lot in terms of theoretical basis, operationalization, interpretability and communicability (Geurs and Van Wee 2004). In order to fill the hiatus between scientific theories and real practices and to take into account the main spatial, individual and transport variables, gravity-based methods have been developed and one of the most commonly used methods is the 2SFCA (2 Steps Floating Catchment Area). It is a special application of a gravity model proposed for the first time in 2000 (Luo and Wang 2003); since then, the 2SFCA method was modified and improved several times (Xing et al. 2020;

Kibambe Lubamba et al. 2013). In this study, a GIS-based procedure to evaluate the level of accessibility for the elderly to primary health services is explained, considering the main characteristics of potential users and the multimodal transport service (walking street, frequency of service and localization of urban transport stops). The proposed GIS-based procedure is organized in the following three phases: Data collection, GIS analysis and, finally, Visualization of results. Methodologically, this approach integrates the use of open data (spatial and alphanumerical) and organizational capability, analysis, and representation by Geographic Information Systems (GIS) software. In the procedure first phase, it is necessary to create a geodatabase using a GIS software, containing different types of data (spatial and alphanumeric). To improve the data output accuracy of the GIS-based procedure, we used a regular spatial grid to divide the area of analysis into small spatial units, with hexagonal shape. In literature, the use of a hexagonal cell rather than a square one is best advised for dealing with areas that have problems related to the connectivity of different space units and the identification of shorter paths for calculating travel distances (Kwan 1998). For this GIS-based procedure, we used as a regular hexagonal unit with a side length of 50 m that provides greater aesthetic attraction but above all a greater accuracy in the calculation and visualization of results (Carpentieri and Favo 2017). A proportional function is used to assign the census tracks socio-economic data to the hexagonal cells of the grid, taking into account the buildings footprint located in each cell (Kwan 1998). In the second phase, the geoprocessing stage, joint data and network analysis operations elaborate the data to evaluate the travel time and accessibility level to urban services for the elderly people. In order to evaluate travel times from each hexagonal cell to the main local health buildings, we created a multimodal transport network, which is the combination of both walkable streets and local public transport lines (bus and metro), to better simulate elderly mobility habits. The ArcGIS Network Analysis tool was used to compute the OD (Origin – Destination) travel matrix. We run three different simulations during morning peak-hour (9:00), for a 65–69-aged person, for a 70–74-aged person and for an over-75-aged person, considering three different walking speeds (Radke and Mu 2000). According to literature review, a modified two Step Floating Catchment Area (2SFCA) method was used to measure the accessibility to primary health services. It is a special application of gravity models but with an improved interpretability, that takes into account the equilibrium of supply and demand, both of healthcare facilities and transport. The theoretical basis behind this method are described in greater detail below: the first step is to compute, for each health urban centre j (Milan Local Health Agency facility), a ratio R_j (Eq. 1) between the available services (S_j) during the network time travel simulation (9 a.m. of ordinary week day), and the sum of the population (dived in three age ranges) at location i, P_i, weighted considering a time-distance-decay function, $\mathrm{W_{ij}}$; for the second step, $\mathrm{A_i}$, the accessibility of each hexagonal cell was obtained (as reported in Eq. 2) summing the supply-demand ratios of the j health centres serving the i cell, multiplied for the impedance function coefficients W_{ij}, to take both into account the spatial distribution of health centres and population.

$$R_j = \frac{S_j \cdot \left(\frac{S_j}{S}\right)}{\sum_{\text{i}} P_i \cdot W_{ij}} \tag{1}$$

$$A_i = \sum_{j=1}^{n} R_j \cdot W_{ij} \tag{2}$$

The distance-decay function W_{ij} was introduced to reflect elderly people mobility habits: a Gaussian Impedance function was used, whose values vary between 1 and 0 and its main characteristic is that it quickly decreases when time travel is close to 30 min (Bauer and Groneberg 2016).

$$W_{ij} = e^{-dij^2/\beta} \tag{3}$$

The coefficient β was set equal to 180 in order to best represent elderly mobility attitudes, according to scientific literature outcomes (Loo and Lam 2012). For our application, a further step was needed since we simulated the urban public and pedestrian network for three different elderly classes. Accessibility for each cell, A_i, was computed for the three different age groups, 65–69, 70–74 and people over the age of 75. Then, the total accessibility was obtained summing the three different accessibility values for every cell of the grid. Since the main objective of this methodology is to focus both on under and surplus-served areas in order to identify possible improving measures, such as spatial relocation of existing resources or physical improvements to reduce access to primary health centres, in the third phase, maps and tables are produced to visualize and quantify the results of the GIS-based procedure and support the planning process of decision-policy makers. The results can also have another significant application: deciding a more comfortable neighbourhood where to reside in, elderly people can consider how primary health services are distributed in the city area and how accessible they are. Hence, further development of the methodology would concern economic and social issues to take into account these potential applications.

3 The Case Study

The proposed GIS-based procedure is applied to the city of Milan to evaluate the urban accessibility at public primary health services for the elderly. We selected this case study because it represents one of the most ageing cities in the Italian and European panoramas. Milan is the second Italian city for population, after Rome, with 1,378,689 inhabitants in 2019 (ISTAT), on a surface equal to 181.81 km^2. The city is divided into eighty-eight neighbourhoods and nine boroughs authorities. The city developed along radial axes and for concentric circles. In more recent decades, it has grown inconstantly incorporating and connecting pre-existing settlement areas, which are rich both from a physical and social point of view. In 2019, 23% of the total population (314,873 inh.) were aged 65 years old and above and they are mainly located in the suburban neighbourhoods. According with the proposed methodology, we consider three elderly age groups: the young elderly (aged 65–69), the medium elderly (aged 70–74) and the oldest elderly (aged over 75). The Health Protection Agency of Milan (ATS—Agenzia di Tutela della Salute) is responsible for the primary healthcare supply within the Metropolitan City of Milan. It is the main provider of primary healthcare services, both public and private. About the spatial distribution of accessibility, the peripheral areas of the city are particularly penalised as in some neighbourhoods in the North-West and South-East. We created a multimodal transport network for the city of Milan, using ArcGIS tools to add mobility data to a network dataset and to estimate the travel times. Firstly, Open Street map data was used to create the walking network, taking into account only walkable roads and their gradient. Then, GTFS (General Transit Feed Specification) data, from three transport companies working in Milan (Transport Company of Milan (ATM), Trenitalia (FS) and Trenord), was used to add bus and railway routes and stops in the transport network. Since public transport is not a continuous service, in space and time, additional modelling operations were needed to connect the pedestrian system to the public transit system. Once the multimodal network was ready, the ArcGIS Network Analyst tool was used to compute an OD matrix, containing in each cell the total travel time to get from a generic hexagonal cell to a certain healthcare center. Then, for what concerns the healthcare provision, the ATS website and official documents were consulted to model the city primary healthcare supply system, considering both district centers (whose access is available just for district citizens) and primary health centers.

4 Results

The numerical values shown in Table 1 highlight that the methodology is useful not only to map highly accessible locations, but also to quantify how many people dwell in these areas.

With the aim of filling the hiatus between rhetoric and real practices, the number of inhabitants, the average travel time and the number of accessible services, for each accessibility class, can be helpful to identify the main urban field of action in a G2C (Government to Citizen) point of view: public transport network performance, health services supply distribution, location of new health centers. The numerical results (see Table 1) of application of the methodology to the city of Milan evidence that the great part of elderly people is localized in areas with medium or poor accessibility to the primary health services. About the spatial distribution of accessibility, the peripheral areas of the city are particularly penalized as in some neighbourhoods in the North-West and South-East. This research application could give a further inspiration in terms of real practices: the multimodal transport

Table 1 Number of inhabitants per level of accessibility

Level of accessibility	Number of inhabitants			% of over 65 inhabitants
	65–69	70–74	Over 75	
Level 1 (Very good)	2,040 (2.8%)	2,106 (2.7%)	4,424 (2.8%)	2.8
Level 2	5,830 (8.0%)	6,318 (8.1%)	13,271 (8.4%)	8.2
Level 3	7,724 (10.6%)	8,346 (10.7%)	17,378 (11.0%)	10.8
Level 4	8,453 (11.6%)	9,048 (11.6%)	18,642 (11.8%)	11.7
Level 5	8,453 (11.6%)	9,048 (11.6%)	18,642 (11.8%)	11.7
Level 6	9,546 (13.1%)	9,984 (12.8%)	20,380 (12.9%)	12.9
Level 7	9,619 (13.2%)	10,374 (13.3%)	20,696 (13.1%)	13.2
Level 8	7,360 (10.1%)	8,112 (10.4%)	15,482 (9.8%)	10.0
Level 9	6,121 (8.4%)	6,396 (8.2%)	13,113 (8.3%)	8.3
Level 10 (Very poor)	7,724 (10.6%)	8,268 (10.6%)	15,956 (10.1%)	10.3
	72,869	78,002	157,984	

network, which is the background of the whole model, is made of two complementary elements, the public transit network, and the pedestrian network. While aging, people get more vulnerable and weaker and the street environment could be perceived as a risk factor for their wellbeing: poor pavement conditions, the lack of bench seats, exposition to vehicle traffic, missing crossroads, and ramps, etc.

Public administrations could invest in improving the city walkability, making the road context more pedestrian and elderly-friendly (Loo and Lam 2012). That measure would not directly decrease the average travel time, and neither increase the number of available services but it could work towards an urban environment perceived by elderly safer and more pleasant. Since the aim of our research is to fill the existing gap between scientific knowledge in accessibility field and real practices, another element needs to be taken into account: due to the topic multidisciplinary, different authorities, administrations and agencies, in transport and healthcare sphere, need to be engaged; that condition could be a strength's feature but, most likely, a weakness element because different political and managing tools would be needed to holistically model the urban setting. In Fig. 1, the spatial accessibility variation of the over 65 inhabitants to the primary health supply of the city of Milan.

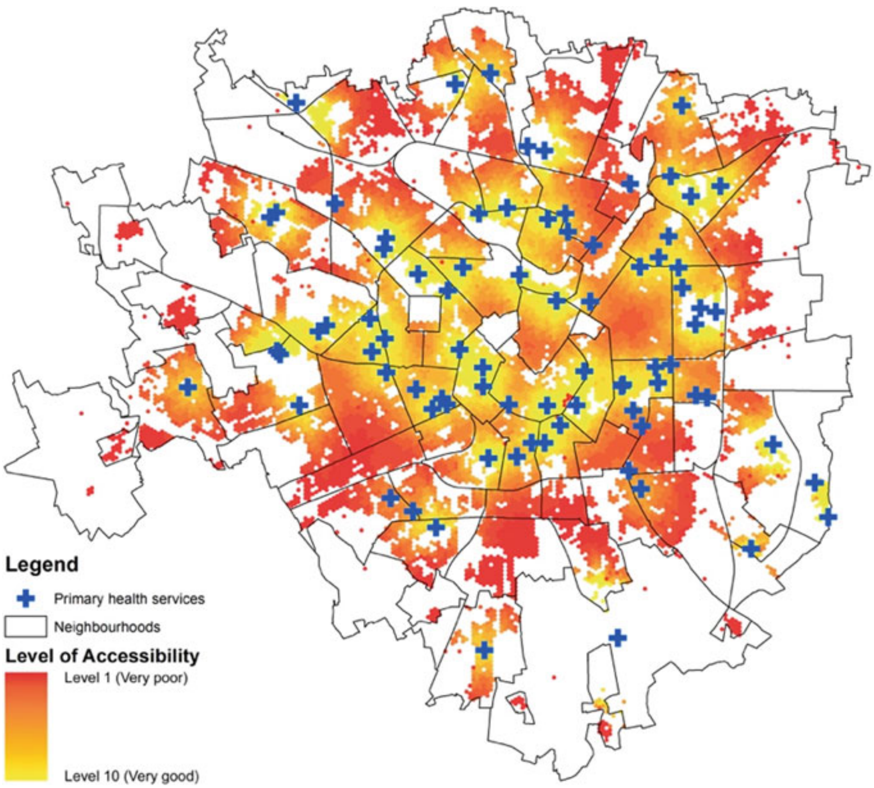

Fig. 1 The spatial accessibility variation of the over 65 aged inhabitants to the whole primary health supply of the city of Milan

5 Conclusions

Many studies and planning practices show that the evaluation of urban accessibility is a useful instrument to support transport and land-use planners in the localization and integration of different urban services to improve the quality of life for the different inhabitants' categories. Urban planning common practices lack some insights on the accessibility issue because of some noticeable critical aspects: due to the large amount of data needed, to the use of spatial analysis instruments and their interpretability. Accessibility measures and their potentialities may be difficult to understand and to be managed both by decision-makers and technicians. This study proposes a GIS-based procedure to evaluate the level of urban accessibility to primary healthcare provision system for the elderly, in order to identify urban areas with critical accessibility issues and quantify the elderly people underserved. The outcomes of the application of this methodology could be useful to improve the general and sectoral planning instrument as the general master plan, the mobility plan, the urban services plan, the territorial time plan, the health service plan or other sectorial plan. The application to the city of Milan was useful to validate the procedure and lead to some interesting and meaningful results. The results allow technicians to give policymakers some meaningful and interesting suggestions, related to the characteristics and the location of health services, to the mobility supply system and to the urban morphology. It must be said that such an approach needs a holistic and integrated attitude to the city context, in order to take into account both the land-use and the transport systems components defining urban accessibility. Bearing that in mind, it is clear how necessary the development of integrated policies and tools is, through the combination of all aspects influencing urban accessibility and that are easy to understand for the different actors, public and private, involved.

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