Quality of life in the urban environment and primary health services for the elderly during the Covid-19 pandemic: An application to the city of Milan (Italy)

Carmen Guida, Gerardo Carpentieri [*]

Department of Civil, Architectural and Environmental Engineering at University of Naples Federico II, Italy

ARTICLE INFO

ABSTRACT

The outbreak of the Coronavirus during the first months of 2020 completely reshaped urban lives because of the need to limit the spread of the disease and ensure essential services to the most vulnerable city users, such as elderly people. The urban population in European is ageing at unprecedented rate; at the same time, ageing is associated with increased vulnerability and dependence on medical care services. Age-friendly approaches are consequently necessary in urban planning strategies to ensure equal accessibility to essential services, not least in view of coronavirus pandemic. This article aims at defining a methodology for measuring urban accessibility to healthcare services as indicative of quality of life for the elderly within the city of Milan — affected by Covid — both in ordinary working scenarios and during the pandemic. The outputs show that entire neighbourhoods' elderly populations suffer from very poor accessibility to primary health services, especially in the city suburbs, and their condition deteriorates even more because of limited services and activities. The methodology would be effective to suggest policy recommendations to distribution of public services in urban areas and to reduce the potential effects of the Covid-19 pandemic on old people's health and quality of life.

1. Introduction

The beginning of 2020 marked the worldwide spread of a new strain of Coronavirus, Covid-19, discovered in 2019 and previously unidentified in humans. First detected in China, it has now spread in more than 100 locations internationally, such that on 11 March, Covid-19 was defined as a global pandemic by the World Health Organization (WHO).

National and local authorities at every level have had to promptly react in order to limit the spread of the disease and avoid the collapse of healthcare supply systems. Europe, and the world more generally, is presently experiencing a real emergency that is indisputably playing a role in shaping our cities, which are the most vulnerable places for health emergencies, due to the high density of people and activities (De Falco, 2018).

While the authorities are working on strengthening the provision of healthcare — which is the most urgent need in a short-time period — they are also working on improving the resilience of urban areas, in order to limit economic and social issues on the medium- and long-term scale. In managing any public health crisis, a city has two overall tasks, namely dealing with the sudden large number of sick people and keeping city life as normal as possible for everyone else (World Health Organization, 2008) — especially for the most vulnerable residents, such as the elderly, in order to provide to them sufficient healthcare and social assistance. Both the Covid-19 pandemic and the increasing European ageing population are the main issues of our research, which comprises a part of the project "MOBILAGE. Mobility and ageing: daily life and welfare supportive networks at the neighbourhood level". Funded by the Fondazione Cariplo and involving the University of Naples Federico II, the University of Groningen and the Politecnico di Milano, the project targets the development of strategies to support decision-making tools in urban planning practices, in order to improve the accessibility to essential urban services for the elderly.

Indeed, the number and proportion of people aged 65 years and over in the global population is increasing at an unprecedented pace and will accelerate in the coming decades, particularly in developing countries (World Health Organization, 2020). The ageing of the population will affect all aspects of society, including labour and financial markets, the demand for goods and services (such as education, housing, health, long-term care, social protection, transport, information and communication) as well as family structures and intergenerational ties. The consequences

---

* Corresponding author.

E-mail addresses: carmen.guida@unina.it (C. Guida), gerardo.carpentieri@unina.it (G. Carpentieri).

of this phenomenon are comparable to those of the Industrial Revolution (Arup, 2015). This issue has been even more stressed in recent times due to the spread of Covid-19.

Solutions to improve the lives of older people, their families and the communities in which they live are so urgent that the World Health Organization (WHO) delineated the 2020–2030 period as the Decade of Healthy Ageing, in order to bring together governments, civil society, international agencies, professionals, academia, the media, and the private sector for ten years of concerted, catalytic and collaborative action. By the end of the Decade of Healthy Ageing, the number of people aged 60 years and older will be 34% higher, increasing from 1 billion in 2019 to 1.4 billion. By 2050, the global population of older people will have more than doubled, to 2.1 billion. Moreover, 2018 will mark the first time in human history that people aged 60 years or over will outnumber children under 5 years (UN, 2019). The UN Population Division of UN (2019) estimated that at 2050 there will be more than twice as many people above 60 as children under 5, and the former will outnumber adolescents and young people aged 15–24 years. Furthermore, there is little evidence that older people today are in better health than previous generations (Clarfield, 2018; Cutler, 2001; Smith et al., 2014; WHO, 2017) and that implies more potential opportunities arising from increasing longevity; however, if ageing is dominated by poor health, social isolation or dependency on care, the implications for older people and society are much more negative, especially during times of crisis, such as the one the entire world is currently experiencing.

The individual's ability to gain access to opportunities and activities depends on intrinsic capacities (i.e., the combination of all of the individual's physical and mental capacities), the environment in which they live (understood in the broadest sense and including physical, social and policy environments) and the interactions between these factors.

According to Article 9 of the United Nations Convention on the Rights of Persons with Disabilities (2007), every person has the right to live independently, participate fully in all spheres of life and equally access physical environments, transport, information and communications — including systems and technologies, as well as services and facilities open to the public — both in urban and rural areas. Due to economic and geographical issues, achieving such levels of equity could be challenging for decision-makers on every territorial scale (Taleai, Sliuzas, & Flacke, 2014). In fact, the most important factor in causing inequality is the lack of access to public services, because it affects people's living quality and well-being, both directly and indirectly (Papa et al., 2018). Local authorities, through welfare policies, should prioritise the implementation of practices to promote higher quality-of-life standards for this increasing demographic, and the urban accessibility approach is essential to achieving this aim (Gaglione et al., 2019; Gu et al., 2016; Pan et al., 2018).

The concept of accessibility is broad and manifests in various aspects, including physical, psychological, economic and financial accessibility, which can be strongly dependent on per capita land use and transport networks. Therefore, the study of the spatial distribution of urban activities, efficient use of (economic and environmental) resources and sufficient level of accessibility to different services and facilities is crucial to promote more sustainable cities, both in terms of land use and urban form, as well as to support. Furthermore, Covid-19 is highlighting new inequalities among citizens mostly due to restrictions and limits for social activities and fear of public and crowded places such as public transports. Decision-making processes have to take into account these issues to pursue and support a good quality of life for older adults (Coppola et al., 2014; Papa, Angiello, & Carpentieri, 2017; Guida & Caglioni, 2020; Kompil et al., 2019).

According to more recent scientific definitions, accessibility cannot be defined as the number of facilities or services per random geographical unit; rather, accessibility depends on several heterogeneous factors, such as spatial externalities, the structure of transportation networks and choice behaviour of users, the frictional effects of distance, the features of the supply side and, of course, measurement issues related to large and multi-variable analyses (Masoumi and Shaygan, 2016; Papa et al., 2017). Since studies have indicated that mobility and accessibility trends of the elderly are a critical trial of mobility systems (Aceves-González et al., 2015; Buehler & Nobis, 2010; Currie & Delbosc, 2010; Voss et al., 2016) the provision of a sustainable transport system, designed for the elderly mobility needs, is both urgent and necessary (O'Neill, 2016). On the other hand, the activity system also needs to be shaped and organised in order to gain a uniform level of access within the same city.

It is crucial to provide decision support tools to local administrators to evaluate and assess the accessibility level to medical care services in urban areas (Papa, Carpentieri, & Angiello, 2018); this becomes even more urgent when facing emergencies and crises. In order to contribute to these debates in the literature, this paper proposes a GIS-based procedure to measure accessibility to essential services — and thus the quality of life — of the elderly, taking into account the restrictions due to the very first stages of the coronavirus pandemic and the co-existence phase. The methodology aims to measure accessibility to primary healthcare services in an ordinary setting as well as according to municipal and regional dispositions for controlling the pandemic; it is based on the two-steps-floating-catchment-area (2SFCA), which is the most widely applied measure of spatial accessibility due to its operability (Tao & Cheng, 2019; Wang, 2015). Many improvements to 2SFCA have been made in recent studies. Our contribution is focused on some improvements for introducing distance-decay functions and modelling the transport network. The developed GIS-based methodology is a multi-mode 2SFCA that incorporates a mixed-mode transportation network that includes walking streets, bus lines and urban railway lines. This important issue depends on some significant considerations: elderly people are highly dependent on public transport, as they have relatively limited use of private cars and, more generally, of mobility capital. The 2SFCA was further developed within the Covid-19 scenario to consider the limits of the provision of healthcare services: in some cases, ordinary hospitals were converted in order to treat Covid-19 patients, limiting other essential medical assistance. Moreover, further considerations were needed to take into account issues related to the significant connection between urban characteristics and the transmission of the infection (Gargiulo et al., 2020; Liu, 2020). In fact, the urban environment provides the real background for the virus' transmission, with the high population density in the metropolitan area as well as the extensive levels of public transportation in the large cities having a "multiplier effect" for the virus' transmission. Therefore, one cannot ignore the urban context within the discussion of the transmission of a severe infectious disease (Cesaro & Pirozzi, 2020). At the same time, when dealing with urban planning matters, the new coronavirus and the still-uncertain ways (Holmdahl & Buckee, 2020) in which it can be transmitted cannot be disregard: territorial authorities at every level had to promptly react in the very first moments of the pandemic to strengthen healthcare provision and keep urban activities to a minimum standard, in order to limit the health emergency; now, and for the next months (or years), decision-makers will be more committed to preparing urban environments and services for a phase of coexistence with the virus, with the aim of reducing social and economic disparities and emergencies.

The developed methodology could prove an effective form of support for decision-making tools, enabling the optimisation of allocations and resources of healthcare and public transport services in policy-making — in ordinary conditions as well as during the spread of Covid-19.

This article presents an application of the developed methodology to the city of Milan, Italy. Milan (and the Lombardy region in general) was particularly affected by the new coronavirus — to such an extent that particular restrictions to the use of public transports and public or private health centres were required.

This article also offers some significant advances to previous research applied to the city of Naples, Italy (Carpentieri et al., 2020), by aiming to

measure urban accessibility to primary healthcare services both within an ordinary and emergency scenario in Milan. Hence, the main objective of our research is to provide a decision-making support tool for facing elderly people's needs in ordinary conditions as well as emergency scenarios, in order to provide an equal level of accessibility to essential urban services, such as primary healthcare.

The paper is organised into five different parts. Following this introduction, we propose a literature review of common measures for assessing accessibility to health services for elderly people. In Section 3, a GIS-based procedure is proposed in order to compute the urban accessibility in urban areas, both within the ordinary and Covid-19 scenario; in Section 4, we discuss the application of the methodology to the hard-hit city of Milan; in Section 5, the results are discussed, and comparisons between the two scenarios and further research developments are presented and proposed respectively.

2. Literature review

2.1. Quality of life and accessibility to healthcare services for the elderly

The availability of accessible healthcare services for the elderly is an essential requisite for a high quality of urban life (Khalil, 2012; Moroke et al., 2019). With little evidence that older people today are healthier than the elderly of previous generations (WHO, 2015), ageing is dominated by poor health, isolation and a strong dependency on medical care. In fact, while ageing people get inevitably weaker due to hearing loss, cataracts and refractive errors, back and neck pain and osteoarthritis, chronic obstructive pulmonary disease, diabetes, depression, and dementia that can all contribute to mobility problems (de Sousa Faria, 2020; Fredriksen-Goldsen et al., 2011; WHO, 2018). For instance, some studies have considered older people as a group with substantial healthcare needs by describing the variables of access to medical care provision (Du et al., 2020; Koh et al., 2015; Wang et al., 2020). Other researchers have meanwhile suggested that the quality of such services — characterised in terms of the number of available beds or physicians or number of square meters — plays a major role in users' behaviour when they have to cope with the choice of being in one healthcare structure rather than another (Bakimchandra et al., 2020; Cabrera-Barona et al., 2018).

Hence, a good level of accessibility to essential urban services has significant positive effects on elderly quality of life (Levinson et al., 2017; Linchuan & Xu, 2020), and the contribution of people aged 65 and above to society will continue, if not increase, in the future, so long as mobility options are maximised, for example increasing the numbers of buses, improving concessionary tickets for public transport use and the introduction of driverless cars. Some studies (O'Hern, Oxley, & Logan, 2015) proved that the car continues to be the prime mode of transport for older people, at least in high income countries, including those across America and Europe, but data suggest increase in the prevalence of the numbers killed or seriously injured as a result of frailty: older people are more likely to be injured or killed if involved in a collision (Lee & Lee, 2019; MacLeod et al., 2014; Manning et al., 2019). In the light of this, more interventions that help older people move between modes are needed, to try out new modes and new destinations; in addition to support a gradual process of giving-up driving, potentially reducing its negative consequences (Musselwhite & Shergold, 2013; Musselwhite et al., 2015). In fact, the use of bus or transit, above and beyond walking, keeps people connected to their communities, and essential urban services (Julien et al., 2015; Manfredini & Di Rosa, 2018; Shergold et al., 2015). When dealing with the needs of social and healthcare assistance of elderly people, some studies have conceptualised accessibility of healthcare services by developing an integrated geospatial approach to model medical care use for the elderly supported by transport features, hospitals and clinic proximity, as well as other quality parameters (Kim et al., 2018). This approach represents important progress in multidimensionally estimating accessibility to one of the more essential

supply systems for the elderly. The limited available data for these parameters could represent a barrier for research in several cities. Thus, as in some previous studies (Carpentieri et al., 2019; Wang et al., 2020; Xu & Yang, 2019), this study concerns the measure of spatial accessibility to primary healthcare services for the elderly proposing some improvements in modelling the mobility behaviour of these vulnerable users.

2.2. Accessibility measures

Due to the increasing political and scientific interest in the topic, several methods and approaches were generated to compute accessibility to essential services in urban areas; depending on the application context, these measures vary significantly in terms of theoretical basis, operationalisation, interpretability and communicability (Geurs & Van Wee, 2004). The simplest way to assess healthcare accessibility is to use contour measures (or opportunity measures), define catchment areas by drawing one or more travel time contours around a node, and measure the number of opportunities within each contour (Campbell et al., 2019; Sahitya & Prasad, 2020). This measure is easy to compute and understand but suffers from a poor theoretical basis, since different distances within the same area have no variable evaluating accessibility. Moreover, in a metropolis, where many alternatives exist, the distance to the service does not match the people's demand. In order to define catchment areas by measuring travel impediments on a continuous scale, gravity-based measures have been introduced; although the latter are more accurate representations of travel resistance than contour measures, they tend to be less legible and neglect the variation across individuals living in the same area (Scheurer & Curtis, 2007). Indeed, utility-based accessibility measures are the link between infrastructure provision and perceived individual and societal benefits — assuming that people select the healthcare alternative with the highest utility. Apart from the strong theoretical basis (Domencich & McFadden, 1975), it can be difficult to compute and interpret these measures. In the scientific panorama, the two-step floating catchment area (2SFCA) method is one of the most popular approaches for measuring spatial accessibility. The method is a special application of a gravity model, with its main positive aspects proposed for the first time by Radke and Mu (2000); since then, the 2SFCA method has been modified and improved several times, and has mostly been used in research on access to healthcare (Ahn et al., 2014; Ding et al., 2015; Hu et al., 2012; Tao et al., 2018), public transport (Kanuganti et al., 2016; Langford et al., 2012) and green areas (Dony et al., 2015). In fact, the method evaluates access to a service site in terms of provision (with variables describing the supply side) and need (considering the social features of the demand) — as well as the distance between them — to identify unserved areas. As a result, the method's limitations have yielded several developments and improvements thereof. The following paragraph aims to state some of the main improvements after conducting a systematic literature review.

2.3. Improvements of the 2SFCA method

The 2SFCA method was developed by Luo and Wang (2003) and was first applied in the Chicago area to define the service area of physicians by a travel time threshold while accounting for the availability of physicians by their surrounding demands. The methodology consists of two steps: the first aims to evaluate the balance of supply and demand, quantifying the stress level of services, while the second estimates accessibility as the sum of available services, weighted by their ratios and their distances from users. From its first application, the method was developed differently in order to better overcome its main limits. Table 1 below displays some of the studies that were selected because of the improvements they developed for the implementation of the 2SFCA method, which this study sought to adopt and further develop for its age-based 2SFCA method. These improvements are described in the following aspects, after a systematic literature review.

First, several studies have focused on distance-decay functions and

Table 1

Main studies on the evolution of the FCA family of metrics.

Authors	Service category	Demand feature	Contest of application	Territorial scale	Improvement
Xing et al. (2020)	Parks	Young people	Wuhan, China	Regional	Introducing quality index on the supply side with respect to youth characteristics
Guo et al. (2019)	Urban parks	Elderly people	Beijing, China	Regional	New data sources: mobile phone data
Ma et al. (2019)	Hierarchical healthcare facilities	–	Wuhan, China	Regional	Three-step FCA: multiple travel modes; arithmetic mean-based Gaussian weight algorithm
Bryant & Delamater (2019)	Public parks	–	Washington D.C., USA	Metropolitan	Micro- and macro-level population representations: modifiable areal units
Qiu et al. (2019)	Green areas	Elderly people	Yichang, China	Urban	Spatial distribution of population using mobile phone call data
Kiran et al. (2020)	Fire stations	–	Brisbane, Australia	Urban	Multiple decay functions
Wang (2018)	Hospitals	–	Florida, USA	State	Inverted 2SFCA (i2SFCA): used to measure scarcity of resource or intensity of competition
Kuai & Zhao (2017)	Healthy food providers	–	East Baton Rouge Parish, Louisiana, USA	Regional	Kernel Density 2SFCA for optimal threshold search
Bauer and Groneberg (2016)	Healthcare providers	–	Berlin, Germany	Urban	Variable distance-decay function (iFCA)
Fransen et al. (2015)	Day-care centres	Commuters	East Flanders, Belgium	Regional	Commuter-based 2SFCA to account for trip-changing behaviour
Luo & Qi (2009)	Primary care physicians	–	Illinois, US	State	Discretisation of Gaussian distance-decay function (E2SFCA)

their parameters. Luo & Qi, (2009) have proposed an enhanced 2SFCA (E2SFCA) method that discretises the weights obtained by a Gaussian function in order to divide the catchment area into multiple travel zones. Bauer and Groneberg (2016) have also introduced a variable distance-decay function in a 2SFCA method (iFCA); in order to take into account the frictional effect of distance, the decay function is shaped individually for every single population location by the median. Furthermore, Kiran, Corcoran, & Chhetri, (2020) have worked on the introduction of multiple decay functions in order to better estimate actual accessibility levels to fire stations in the Brisbane area. Meanwhile, in their application of accessibility measurements to healthy food stores, (Kuai & Zhao, 2017) have introduced a Huff-core distance-decay function which also considers the probability that certain populations visit certain groceries.

Second, some improvements have been explored in quantifying supplies and demands. Xing, Liu, Wang, Wang, & Liu, (2020) have studied the accessibility to parks in Wuhan (China) from young people's perspective, introducing a quality index on the supply side in order to give due weight to the needs and expectations of younger people. Guo et al. (2019) have developed an age-based 2SFCA considering mobility behaviours of the elderly through mobile phone data, with Qiu et al. (2019) adopting a similar application for the region of Yichang (China). Furthermore, Bryant & Delamater, (2019) have improved the 2SFCA method by introducing micro- and macro-level representations of the population in order to include variable areal units to compute accessibility to parks in the Washington, D.C. (USA) area. The inverted-2SFCA developed by Wang, (2018) represents an outlier application, since it uses the method to measure the scarcity of resources or intensity of competition for hospitals in Florida (USA).

Third, multiple travel patterns have been considered in some research. Ma et al. (2019) have differentiated the impacts of multiple travel costs on spatial accessibility outcomes, considering both private and public modes of transport. A commuter-based 2SFCA has been developed by Fransen et al. (2015) to estimate accessibility levels to day-care centres, taking into account changes in usual trip behaviours.

Given these limited considerations, this study proposes an age-based 2SFCA method that considers the network characteristics and mobility attitudes of older people to measure spatial accessibility to primary healthcare services. In terms of the pandemic that many cities are facing, the methodology introduces a limiting factor to take into account the restrictions of local authorities of transport and healthcare services.

Hence, this study aims to contribute to the scientific literature on the theme by: introducing three different distance-decay functions, one per age-group (people aged 65–69, 70–74 and 75 and over); developing a multimodal network for time travel analyses comprised of walkable roads and transit (bus and metro) lines; diversifying older people's walking speeds. Moreover, it also aims to support decision-makers in emergency conditions for providing a good level of accessibility to essential services for the elderly, who are the most vulnerable demographic.

3. Materials and method

In this study, a GIS-based procedure was developed to evaluate the elderly's level of accessibility to primary health services, considering the demographic characteristics of potential users and multimodal transport services (i.e., walking in the street, the frequency of service and the localisation of urban transport stops) (Makarewicz & Németh, 2018; Wang & Cao, 2017).

The proposed GIS-based procedure is organised in the following three phases: data collection, GIS analysis and, finally, visualisation of results. Methodologically, this approach integrates the use of open data (spatial and alphanumerical) and organisational capability with an analysis and representation by Geographic Information Systems (GIS) software. According to the GIS Model Builder tool of the ArcGIS Pro 2.2 software, we defined a geoprocessing workflow to execute operations that organise and analyse the alphanumeric and spatial data (Fig. 1).

In the procedure's first phase, it was necessary to create a geodatabase using a GIS software that contains 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. The use of a cell grid is very important in experimental and observational science, and also offers the most common framework for spatially explicit models (Jin, Liu, Luan, & Huang, 2007). The hexagonal cell — the minimum spatial unit in which the study area is divided — has a hexagonal shape, and each side may have dimensions previously selected by the user based on the area under analysis (Papa, Carpentieri, & Guida, 2018). In the literature, the use of a hexagonal cell (rather than a square one) is recommended 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 (Kibambe Lubamba et al., 2013). For this GIS-based procedure, we used a regular hexagonal cell as the spatial unit with a side length of 50 m that provides greater aesthetic attraction — but above all a greater
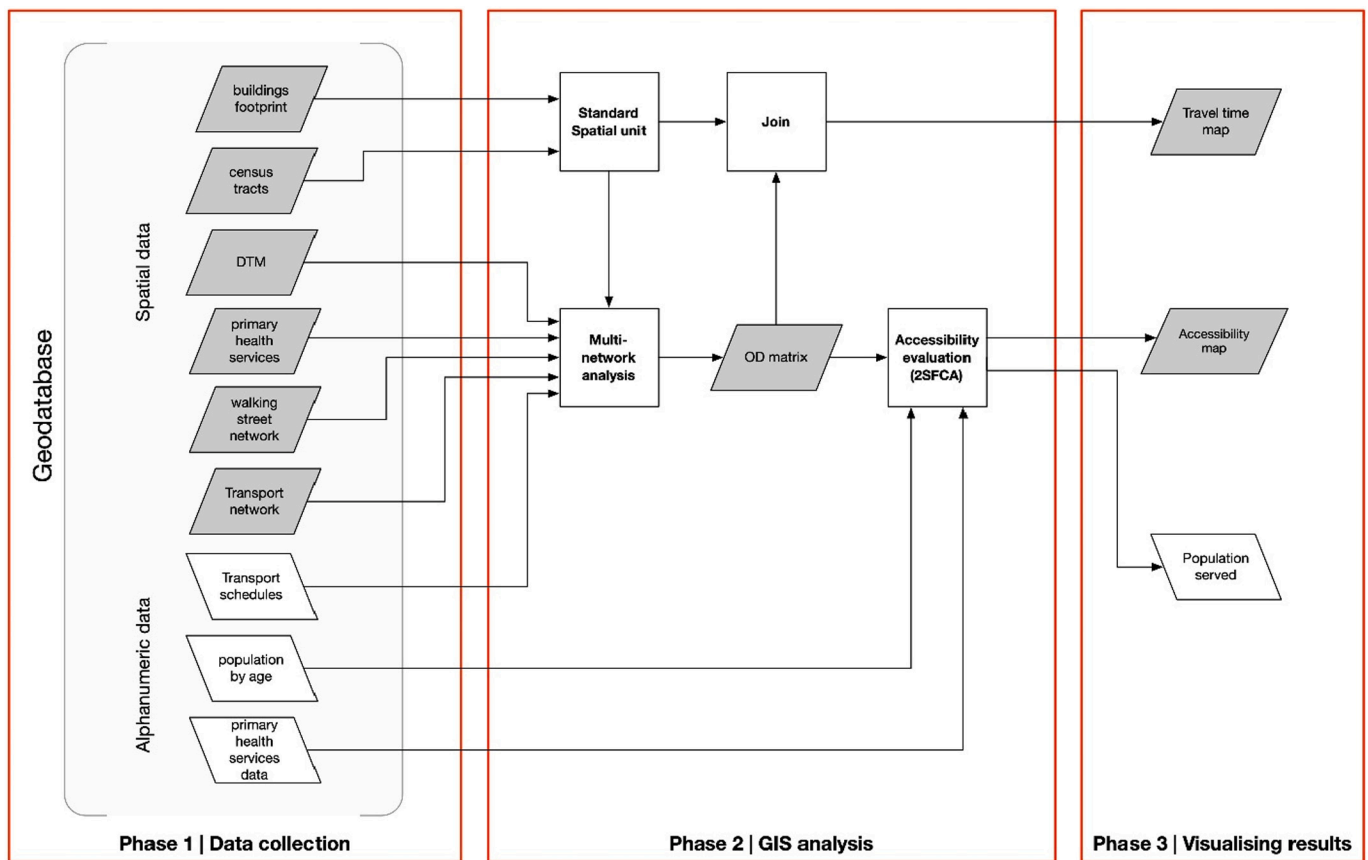
Fig. 1. The conceptual GIS-based procedure for evaluating the accessibility of urban services to elderly people.

accuracy — in the calculation and visualisation of results. A proportional function was used to assign the census tracking socio-economic data to the hexagonal cells of the grid, taking into account the buildings' footprint located in each cell (Carpentieri & Favo, 2017).

In the second phase, namely the geoprocessing stage, joint data and network analysis operations elaborated upon the data to evaluate the travel time and accessibility level to urban services for elderly people. In order to evaluate travel times from each hexagonal cell to the main local health buildings, we created a multimodal transport network. We considered the network as the combination of both walkable streets and local public transport lines (bus and metro) in order to better simulate elderly mobility habits. The ArcGIS Network Analysis tool was used to compute the OD travel matrix. We ran three different simulations during morning peak-hour (9:00) for a person aged 65–69, 70–74 and 75 and over respectively, accordingly considering three different walking speeds (Alshalalfah and Shalaby, 2007; Papa, Carpentieri, & Angiello, 2018).

According to the literature review, a modified Two-Step Floating Catchment Area (2SFCA) method was used to measure the accessibility to primary health services. The theoretical basis behind this method is described in greater detail below:

the first step is to compute, for each healthcare centre j (Milan Local Health Agency facility), a ratio R_j (Eq. (1)) of supply and demand. The supply of healthcare services is quantified by the number of available surgeons for each building (S_j); the demand is the sum of the population, potential users divided into three age ranges in location i, with P_i weighted to consider a time-distance-decay function, W_{ij}, which is a function of the total travel time. The travel times between residential locations i and healthcare structures j are estimated by Network Analyst and ArcMap, taking into account both walking and transit routes. Due to the Covid-19 pandemic, policymakers are now facing a further, more urgent challenge unprecedented in recent human history due to its rapid and dangerous expansion. In fact, an emergency such as the present one,

with its significant impacts on most urban activities, affects all the components of the urban system (economic productivity, socio-cultural life, communication — up to changing personal relationships), including the social subsystem (Allam & Jones, 2020; McKibbin & Fernando, 2020). Hence, in order to consider the limited supply of healthcare services during the spread of Covid-19, a k coefficient was introduced. It varies between 0 and 1, to highlight the variable availability of services for the elderly.

For the second step, A_i, the accessibility of each hexagonal cell was obtained (as reported in Eq. (2)) by summing the supply-demand ratios of the j health centres serving the i cell — multiplied for the impedance function coefficients W_{ij}, to take into account both the spatial distribution of health centres and the population.

$$R_j = \frac{S_j \cdot \left(\frac{S_j}{S}\right) \cdot k}{\sum_{65-69} P_i \cdot W_{ij}^{65-69} + \sum_{70-74} P_i \cdot W_{ij}^{70-74} + \sum_{>75} P_i \cdot W_{ij}^{>75}} \quad (1)$$

$$A_i = \sum_{65-69} R_j \cdot W_{ij}^{65-69} + \sum_{70-74} R_j \cdot W_{ij}^{70-74} + \sum_{>75} R_j \cdot W_{ij}^{>75} \quad (2)$$

The distance-decay function W_{ij} was introduced to reflect elderly people's mobility habits: a Gaussian impedance function, whose values vary between 1 and 0, was used; this function's main characteristic is that it quickly decreases when time travel is close to the maximum availability of minutes that each elderly age category requires (according to their physical capabilities) to access at the health service (Kwan, 1998).

$$W_{ij} = e^{-t_{ij}^2 \big/ \beta} \quad (3)$$

The coefficient β was set equal to 180 for people aged between 65 and 69, 160 for those between 70 and 74 and 140 for those aged 75 and

over, in order to best represent mobility attitudes of different elderly age categories according to outcomes in the scientific literature (Bauer & Groneberg, 2016). Fig. 2 below shows the Gaussian impedance functions used in our application.

The coefficient *k* was introduced to consider the variation of the number of available services in different scenarios: it represents the ratio between the available services S_j during emergency scenarios, instances when the supply of healthcare services could be reduced, and the number of services functioning ordinarily.

$$k = \frac{\sum_{j}^{n} S_j}{\sum_{j=1}^{m} S_j} \quad (4)$$

Since the main objective of this methodology is to focus on both under and overly-served areas in order to identify possible measures for improvement — such as the spatial relocation of existing resources or physical improvements to reduce access to primary health centres — in the third phase, maps and tables were produced to visualise and quantify the results of the GIS-based procedure and hence support the planning process of policymakers, even in the face of emergency scenarios, in assuring essential services for the elderly.

Table 2 provides the list of alphanumeric and spatial data (vector and raster) requests for the application of the GIS-based procedure.

4. Theory and calculation

The proposed GIS-based procedure was applied to the city of Milan to evaluate urban accessibility to primary public health services for the elderly. Milan was selected as the case study for the developed methodology because, according to the last national census of 2011, 25% of the residents of Milan are 65 years or older — against a national average of 20.8% — and it was the first major European city to experience the lockdown measures related to the Covid-19 pandemic. Although the city of Milan took part in the Healthy Cities Network[1] launched by the WHO in 1987, there has not been a clear attempt in recent years to generate a multidisciplinary response to the societal and demographic changes that are currently engulfing the city. Moreover, Milan is also the study area of the research project "MOBILAGE. Mobility and ageing: daily life and welfare supportive networks at the neighbourhood level", funded by the Fondazione Cariplo mentioned above.

The city of Milan has 1,242,689 inhabitants within 181.67 km^2 — the second-largest municipality in Italy by population.

The city is divided into eighty-eight neighbourhoods and nine boroughs. The urban structure of Milan significantly changes from the city centre to the peripheral areas. The city has developed along radial axes and in concentric circles (the circle of Navigli, the ramparts, the trolleybuses ring, the railway ring, the ring road). In more recent decades, it has grown sporadically, incorporating and connecting pre-existing settlement areas — rich areas from both a physical and social point of view. Milan is one of the largest Italian cities to have implemented sustainable mobility (see Comune di Milano, 2015 for the Urban Plan for Sustainable Mobility – PUMS), and it was awarded the 2016 Access City Award by the European Union for being the most accessibility-friendly city, particularly for people with disabilities (Mariottti et al., 2018). For these reasons, as well as the gradual increase in its elderly population — especially in suburban areas, as shown in Fig. 3 below — the city of Milan represents an interesting case study for investigating further the application in decision-making processes of the developed methodology. The application is based on 2011 census data (ISTAT, 2011); the

network analyses are run differently for the three age groups of the elderly: people aged 65–69 years, 70–74 years and 75 and over years.

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. The ATS was set up in 2016, as part of the implementation of Lombardy (Northern Italy) Regional Law 23/2015, and covers the provinces of Milan and Lodi, with their 194 municipalities, for a total number of users equal to 3,464,423 (ATS Milano, 2018). The ATS of the metropolitan area of Milan was formed through the merger of four ex-ASLs (Local Health Agencies) and represents the administrative joints of Lombardy in making healthcare services available and operative for citizens in different and heterogeneous territories. Considering the differences between territories of the metropolitan area, the ATS is divided into six districts: Milan; North Milan; Rho Area; West Milan; Melagrano and Martesana; and Lodi. They all have a significant role in the organisational logic of central and strategic management and have the same territorial extension of Territorial Healthcare and Social Agencies (ASST – Aziende Socio Sanitarie Territoriali). ASSTs are providers of primary healthcare services, including both public and private centres. In fact, the entire system of healthcare provision comprises both public structures and private contracted services: they respectively share 50% of the full demand for healthcare assistance. Considering the regional scenario, the supply from the public side is greater than the contract facilities of a private nature. More particularly, in 2017, according to the Lombardy region's statistics, the ATS of the Metropolitan City of Milan recorded 54.5% of access to private healthcare services, regardless of the number of available beds or the category of medical service provided.

Since the methodology described in the previous paragraph was applied to the Milan Municipality District, we considered all of those services — both public and private — dedicated to elderly healthcare within the city boundaries. Fig. 3 above indicates that healthcare centres managed by ATS Milan are spread across the whole city's territory and offer the following primary services to the elderly: cardiology, diabetology, neurology, ophthalmology, orthopaedics, otolaryngology, pulmonology, urology, rehabilitation, dermatology and gynaecology. Table 3 shows the number of available surgeries within each structure; it also highlights whether the healthcare structure is public or private.

For this application, we evaluated the accessibility to primary health services for the elderly before (base scenario) and during the Covid-19 pandemic emergency (Covid-19 scenario). For the first scenario, we considered the supply of services (transport and health) in the month of February 2020, during a morning weekday. For the Covid-19 scenario, we took into consideration for the primary health services the indications of the Lombardy region's decree (DGR Lombardy n° XI/2906 of 08/03/2020) that closed some primary health services located in the hospitals. In Table 3, we proposed a comparison of the reduction in primary health services for each surgery between the two scenarios. For transport services in the Covid-19 scenario, we took into account the reorganisation by the company of public transport (ATM – *Agenzia Transporti Milanesi s.p.a*) that reduced the number of operating lines and their frequency on weekdays. This reduction of transport services is comparable to the base scenario on a Saturday, according to the indication of the ATM,[2] as explained below (Fig. 4).

As soon as the first Covid-19 infection in the Milan area was confirmed, the ATM created a dedicated team that developed an action plan, scheduled on different levels and times, in order to promptly react during the emergency phase, on one hand guaranteeing a certain level of service, and to consequently get ready for the ongoing coexistence phase of the virus (Phase 2). In fact, during the lockdown weeks, the ATM maintained a level equal to 75% of ordinary operativity for those who needed to move for work or health needs — even though in Milan, as in
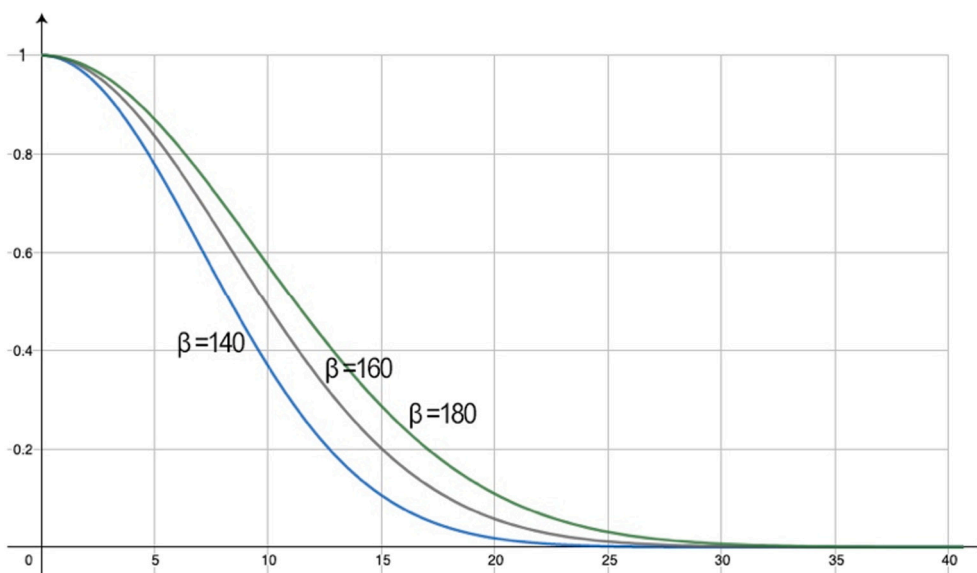

Fig. 2. The three Gaussian distance-decay functions.

Table 2
Alphanumeric and spatial input data.

Data	Category of data	Type of geometry	Source	Year
Population	Alpha-numeric	–	ISTAT	2011
Transport schedules	Alpha-numeric	–	Transport companies	2020
Primary health services	Vector/alpha-numeric	Point	Local Health Agency	2020
Walking street network	Vector	Polyline	Open Street Map	2020
Transport network	Vector	Polyline	Transport companies	2020
Census tracts	Vector	Polygon	ISTAT	2011
Buildings	Vector	Polygon	Geoportal	2011
Digital terrain model	Raster	–	Geoportal	2017

every European city, the usage of public transport declined up to 90%, as shown in the following chart (Fig. 5). The data shown in Fig. 5 below refers to the period between 15 January 2020 (more than a month before the first Covid-19 infection was confirmed in Italy) and 4 May 2020, the first day of Phase 2.

To encourage people's mobility in urban areas, the ATM worked to ensure a significant level of activity of public transport, as well as an intense and capillary cleaning of each vehicle. Among these safety measures, the company also provided travel tickets for people aged 65 and over for direct delivery to their residences (ATM, 2020). These polices show that, although people reduced their movements, transport companies continued to provide a satisfactory level of service, especially for those whose demand for certain services and needs — such as for health facilities — is unchangeable and inflexible. On the other hand, the elderly could be seriously discouraged from using public transport due to the particularity of the present health emergency; as such, our methodology takes into account this aspect through its distance-decay functions, which are different per age group, in order to limit people's mobility capitals.

In terms of the supply side, in order to apply the methodology to the Milan area case study, a multimodal transport network of the city was created using ArcGIS tools to add roads shapefile and GTFS (General Transit Feed Specification) data to a network dataset and to evaluate travel times. Firstly, OpenStreetMap data was used to create the pedestrian network, taking into account only walkable roads and their gradient. Then, GTFS data from the ATM 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 (Rossetti et al., 2020; Zecca et al., 2020). Once the multimodal network was ready, the ArcGIS Network Analyst tool was used to compute an OD (Origin and Destination) matrix, containing in each cell the total travel time to get from a generic hexagonal cell to a certain healthcare centre. Fig. 5 shows the structure of the multimodal network of the city of Milan. The variation of transport costs was not considered when computing generalised costs since these are flat within the Milan municipality, as travel fares do not depend on physical distances and public transport modality.

5. Results

The numerical values in Tables 4 and 5 highlight how multidisciplinary the accessibility issue is: undoubtedly it is scientifically advantageous, but when dealing with real-world practices, it represents a drawback. With the aim of bridging the gap between rhetoric and real practice, the number of inhabitants and their location within each accessibility group can be helpful in identifying the main urban field of action from a G2C (Government to Citizen) point of view, in terms of public transport network performance, health services supply distribution, and location of new health centres. For the Covid-19 scenario, measuring accessibility to essential urban services could be helpful for local authorities in keeping urban life as normal as possible during emergencies. The results of the methodology, presented in this paragraph, are mainly focused on the differences between the accessibility to primary healthcare services in an ordinary scenario and during the first phase of the coronavirus pandemic that severely affected Italy and, in particular, the Lombardy region and the city of Milan during March 2020. It is worth highlighting that the Covid-19 scenario, for the application of the methodology, takes into account the moment immediately following the pandemic's outbreak.

Fig. 6 below represents, on a chart, the number of potential users (people aged 65 or above) per level of accessibility. The accessibility levels' thresholds were chosen according to the quantile classification — a data classification method that distributes a set of values into groups containing an equal number of values (Bauer et al., 2018; Shah & Adhvaryu, 2016; Zhu et al., 2018). The attribute values are added up,
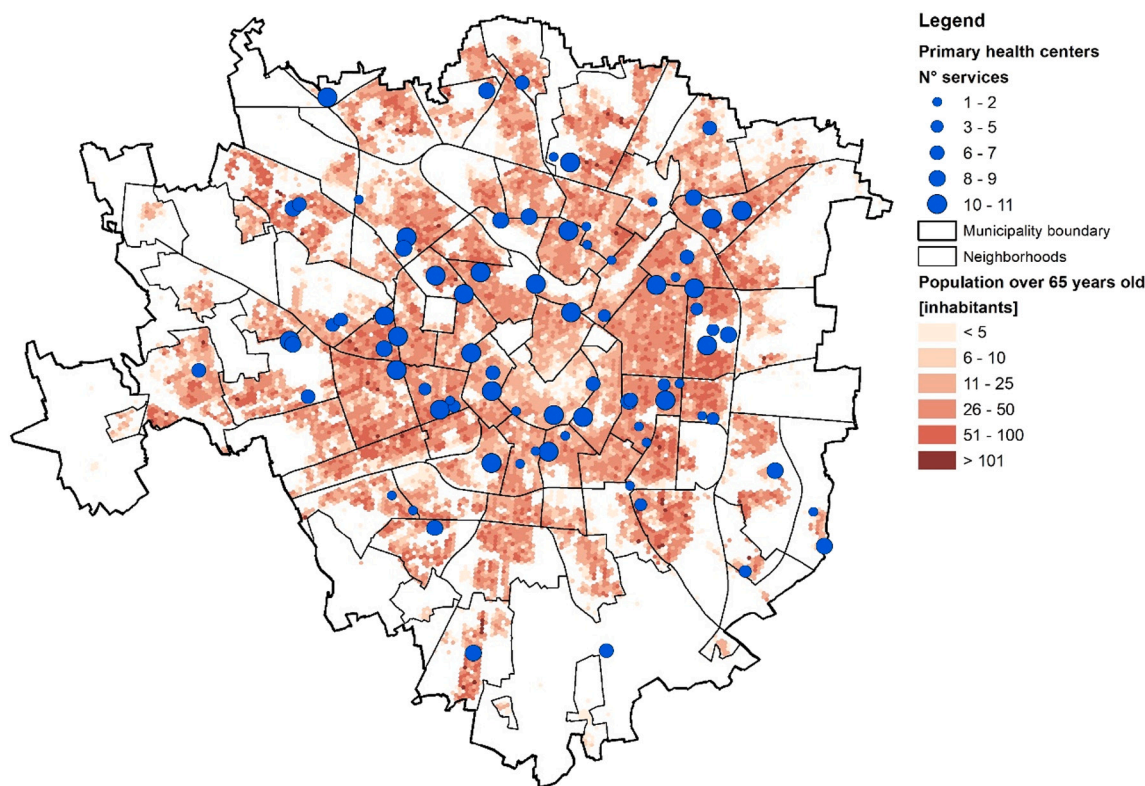
Fig. 3. The distribution of the adult population and primary health services (private and public) in the city of Milan.

Table 3

Available surgeries for health structure (public hospitals and polyclinics and private health centres) in the two scenarios. (*ORL stands for Otolaryngology).

Scenario	Cardio.	Diab.	Neuro.	Opht.	Ortho.	ORL*	Pulm.	Urology	Rehab.	Derma.	Gynec.	Total
Base	60	42	56	50	52	57	35	39	51	50	59	540
Covid-19	45	30	42	37	39	44	20	27	39	39	46	398
% Variation	−25%	−29%	−25%	−26%	−25%	−23%	−43%	−31%	−24%	−22%	−22%	−26%

then divided into the predetermined number of classes. In this application, ten accessibility levels were considered, ordered from greater to poorer accessibility (Carpentieri et al., 2020). Fig. 6 shows that, due to restrictions to healthcare services and transport, the people who benefit from higher accessibility levels (1, 2 and 3) are far fewer during the Covid-19 emergency than in ordinary working conditions. On the contrary, an inverse relation is highlighted for the lower accessibility levels.

Tables 4 and 5 below highlights the number of potential users, divided per age group (65–69, 70–74 and 75 and over). Focusing on the main differences — also proven by the above chart — the medium levels of accessibility underwent no significant modification, at least in absolute terms, while there are considerable changes for both the high and low levels of accessibility. Bearing in mind that, between the two scenarios, the demand of potential users is unvarying, levels 1 and 2 demonstrate considerable decreases (from 9% and 13% to 3% and 8%). This means that all of these users were re-distributed in lower accessibility levels: under the same quality-of-life standards, fewer people have had access to primary healthcare services during the Covid-19 disease outbreak in Milan.

The matrix shown in Table 6 focuses on how the framework of healthcare provision accessibility was rebuilt for the elderly. In the rows and the columns are the respective levels for the ordinary scenario and the Covid-19 scenario. Each element of the matrix represents the number of territorial units that changed their classification between the two conditions. On the diagonal are the percentages of cells that maintained the same level of accessibility. The matrix is an upper triangular matrix,

meaning that the whole territory of Milan underwent a significant decrease in accessibility to primary healthcare services during the very first days of the pandemic outbreak. No improvements in accessibility have been recorded, as there are no values in the lower triangle of the matrix.

The matrix representation was introduced to better evaluate how accessibility changed within the city of Milan due to the restrictions that deeply changed healthcare provision as well as the public transport system. The matrix focuses on how potential users were reallocated in terms of accessibility levels. The Table 6 and Fig. 7 represent these changes between accessibility classes.

The results data are interesting in understanding how the accessibility paradigm could be implemented both in base conditions and during emergencies: local authorities could introduce smart decision-support tools in ordinary planning practices to better allocate and distribute resources from the supply side. At the same time, this data could be actually useful only if associated with the territory and, hence, the base locations of potential users of primary healthcare services. Images below represent the levels of accessibility for the whole city of Milan, and how they were modified during Covid-19 restrictions.

In particular, Fig. 8 shows the spatial accessibility of the elderly to primary healthcare services in the base scenario. Fig. 9 refers to the Covid-19 pandemic scenario and to the changes made to healthcare provision at the beginning of the Covid-19 outbreak in Milan — and consequently in Italy, according to DGR Lombardy n°XI/2906 of 08/03/2020 — that designated some of the main healthcare centres "Covid
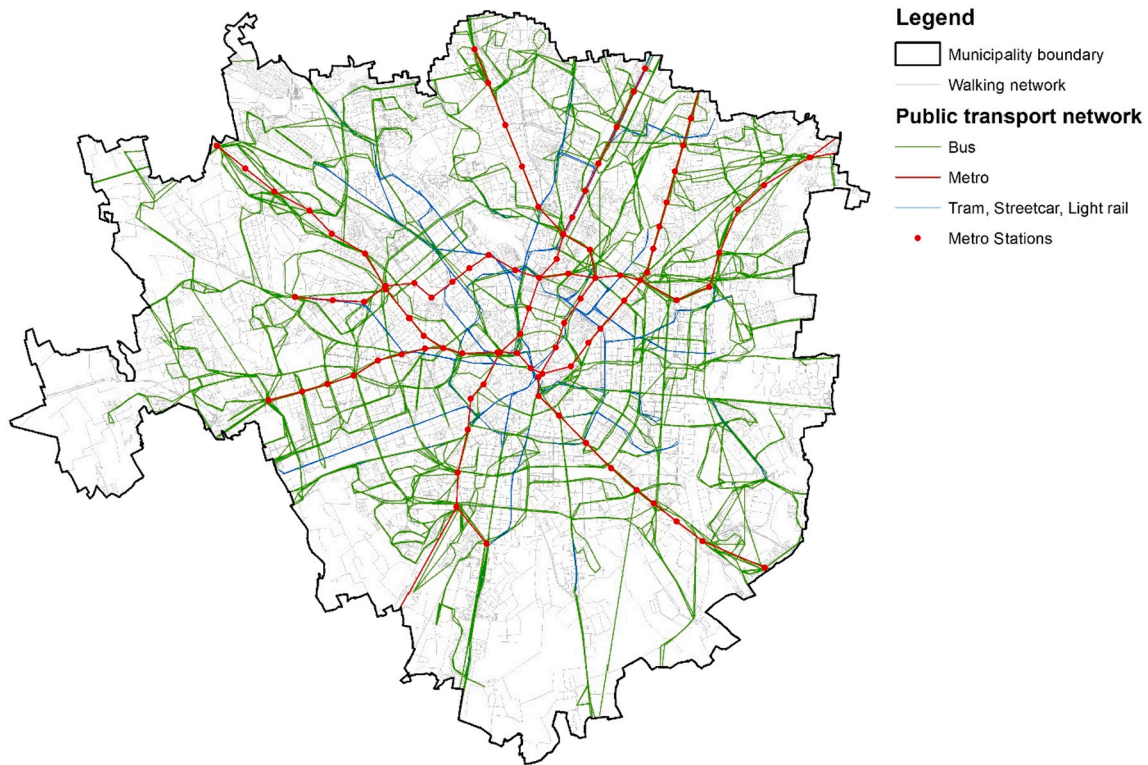
Fig. 4. The multimodal transport network in the city of Milan.
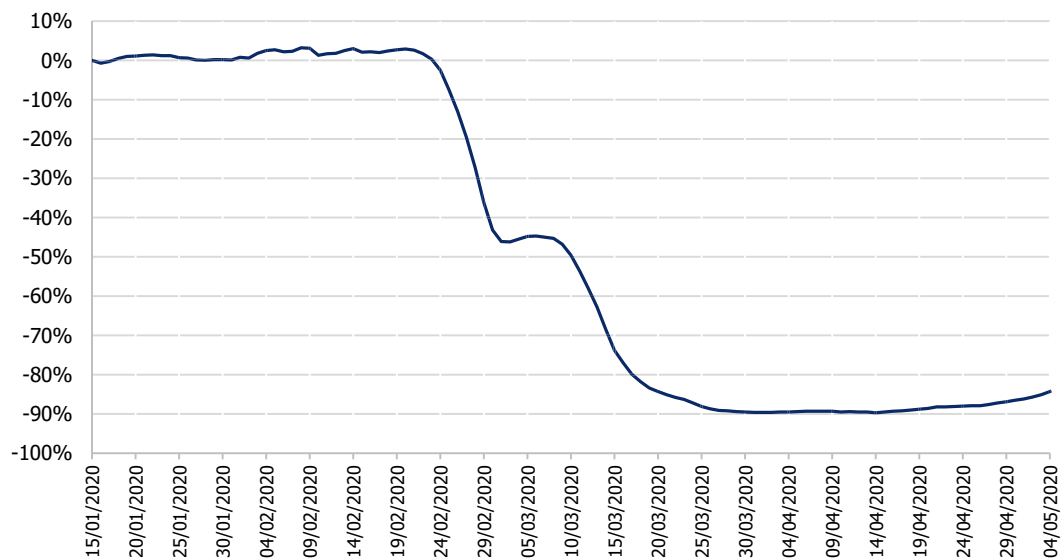

Fig. 5. Decline of Public Transport usage from 15/01/2020 to 04/05/2020 in the city of Milan (Data source: Moovit Italia).

hospitals" for detecting and hospitalising people affected by the coronavirus.

The third map highlights where the Covid-19 restrictions particularly changed the accessibility conditions for the elderly (Fig. 10). It shows that due to the reduction of healthcare provision overall, the whole city suffered a reduction of accessibility. Moreover, neighbourhoods where hospitals were turned into Covid-19 hospital hubs severely decreased their usual standards for the elderly, who are the most vulnerable users and, at the same time, those who most probably have several healthcare needs.

Although the results present some limitations due to the lack of reliable input data reliable input data, their representations show that accessibility-oriented tools for decision-makers could also be very helpful in emergency conditions for guaranteeing high quality-of-life standards, especially for those who are more vulnerable and in need than others. In fact, since the methodology considers both the supply and the demand of primary healthcare services, as well as the transport component, it is possible to identify a range of compatible solutions to manage both the emergency (a health emergency, in this case) and satisfy the essential needs of the more vulnerable users, limiting changes to the accessibility and, hence, the quality-of-life standards.

Table 4
Number of inhabitants per level of accessibility in the base scenario.

Level of accessibility	Percentage of inhabitants			Number of elderly people
	65–69	70–74	≥75	
Level 1 (very good)	9.2%	9.1%	9.3%	28,268
Level 2	12.3%	12.2%	12.8%	38,700
Level 3	12.3%	12.1%	12.1%	37,536
Level 4	11.8%	11.7%	11.8%	36,367
Level 5	10.5%	10.4%	10.8%	32,861
Level 6	10.9%	10.8%	10.6%	33,142
Level 7	10.3%	10.7%	10.4%	32,226
Level 8	8.5%	8.8%	8.5%	26,574
Level 9	7.9%	7.8%	7.7%	24,074
Level 10 (very poor)	6.3%	6.4%	6.0%	19,107
	72,869	78,002	157,984	

Table 5
Number of inhabitants per level of accessibility in the Covid-19 scenario.

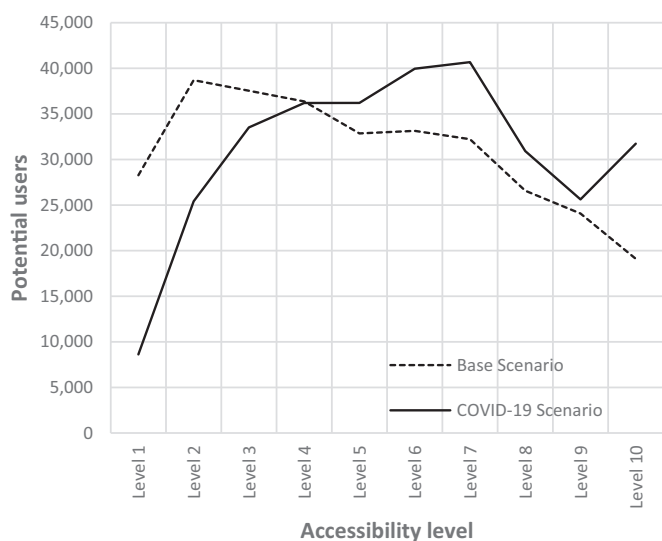| Level of accessibility	Percentage of inhabitants			Number of elderly people
	65–69	70–74	≥ 75	
Level 1 (very good)	3.0%	2.7%	2.9%	8620
Level 2	8.0%	8.1%	8.4%	25,411
Level 3	10.6%	10.7%	11.0%	33,518
Level 4	11.6%	11.6%	11.8%	36,195
Level 5	11.6%	11.6%	11.8%	36,206
Level 6	13.1%	12.8%	12.9%	39,958
Level 7	13.2%	13.3%	13.1%	40,676
Level 8	10.1%	10.4%	9.8%	30,920
Level 9	8.4%	8.2%	8.3%	25,618
Level 10 (very poor)	10.4%	10.6%	10.0%	31,733
	72,869	78,002	157,984	

Fig. 6. The comparison of accessibility levels for the elderly population (over 65 years old) in the two scenarios.

6. Discussion

Accessibility is a complex and multidisciplinary topic and historically, nobody has been responsible for ensuring that people can access key services, employment sites, places of interest, etc.; as a result, services have been developed with inadequate attention to accessibility (Farrington & Farrington, 2005). At the same time, accessibility has often been seen as a problem for transport planners to solve, rather than one that concerns and can be influenced by other organisations, for example, in locating, designing and delivering services that are easily

and conveniently available (Social Exclusion Unit, 2003). Thus, scientific research and planning practices demonstrate that the evaluation of urban accessibility can be a useful instrument in supporting transport and land-use planners in the localisation and integration of different urban services to improve the quality of life in the different inhabitants' various categories. Common practices in urban planning lack some insight on the accessibility issue because of some noticeable critical aspects — namely, from 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 by both decision-makers and technicians. Furthermore, structures, offices or technicians that work to define common strategies for transport and land-use planning are missing for territorial planning authorities. This gap in planning practices is one of the main causes of accessibility issues for urban services, especially for the most vulnerable groups of citizens.

During the following years, the continuous growth of the proportion of elderly people in developed countries will increase the demand for services, suitable for satisfying the needs of this group of interest. Hence, urban services need to be properly designed: structures' locations, the types of services, the transport system supply and the urban morphology are some of the main features influencing users' accessibility to urban services.

The Covid-19 emergency has increased the need to manage the movements of people and organise access to essential public services to reduce congestion, especially in urban areas and during peak hours. The authorities need to reorganise essential urban services, including public transports, to ensure safe access to all users. In particular, access within safe conditions to primary health buildings is very important to avoid the possibility of people renouncing normal routine examinations, and thus worsening the health situation.

This is most important for elderly people, who were already hit hard by the virus and obligated to change their habits through the limitation of movements and contacts. In many cases, these people could give up normal health checks for the fear of contracting the virus.

This study proposes a GIS-based procedure to evaluate the level of urban accessibility to the primary healthcare provision system for the elderly, in order to allow policymakers to define urban areas with critical accessibility issues and quantify the elderly people served. The procedure's application in the city of Milan was useful for the former's validation and has lead to some interesting and meaningful results. Also, the outcomes of a comparison between the two scenarios (base and Covid-19) could be useful to support the policymakers in planning the services by considering the spatial separation between users and primary health buildings and understanding the secondary impacts related to the health emergency of the Covid-19 pandemic and the reduction of accessibility. The results highlight that for the base scenario, some districts need to improve for their own elderly inhabitants the accessibility to primary health services, most of which are located in peripheral areas. The results for the Covid-19 scenario show that a high reduction of accessibility is localised near the primary health centres closed in the peripheral areas, and in the central areas the reduction of accessibility is even more widespread. As shown, the application also allows technicians to provide policymakers with some meaningful and interesting suggestions related to the characteristics and locations of health services, the mobility supply system and the urban morphology (Tira et al., 2018; Battarra, Gargiulo, Pappalardo, Boiano, & Oliva, 2016). 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 components of land use and transport systems defining urban accessibility.

For local planning practices, the urban structure and organization of the Health Local Agency limit the range of actions to improve accessibility to healthcare services from the elderly perspective. Furthermore, the spread of the new coronavirus has reshaped the design of healthcare provision with specialized structures, limiting the number of available services dedicated to the elderly. The following measures represent

Table 6
Percentage variation of inhabitants per level of accessibility between base scenario and Covid-19 scenario.

| Accessibility levels distribution pre Covid-19		Accessibility levels distribution Covid-19									
		Level1	Level2	Level3	Level4	Level5	Level6	Level7	Level8	Level9	Level10
	Level1	30.5%	36.5%	14.2%	5.3%	3.6%	3.1%	2.1%	1.0%	0.1%	3.8%
	Level2		39.0%	38.4%	8.3%	5.4%	3.4%	3.8%	0.8%	0.2%	0.8%
	Level3			39.0%	41.6%	8.0%	5.8%	3.0%	1.9%	0.2%	0.6%
	Level4				43.6%	39.1%	8.2%	6.4%	1.6%	0.1%	0.9%
	Level5					48.5%	36.6%	8.1%	3.5%	1.5%	1.9%
	Level6						61.9%	29.4%	2.8%	4.2%	1.8%
	Level7							70.6%	19.0%	5.5%	4.9%
	Level8								78.6%	12.2%	9.2%
	Level9									77.1%	22.9%
	Level10										100.0%
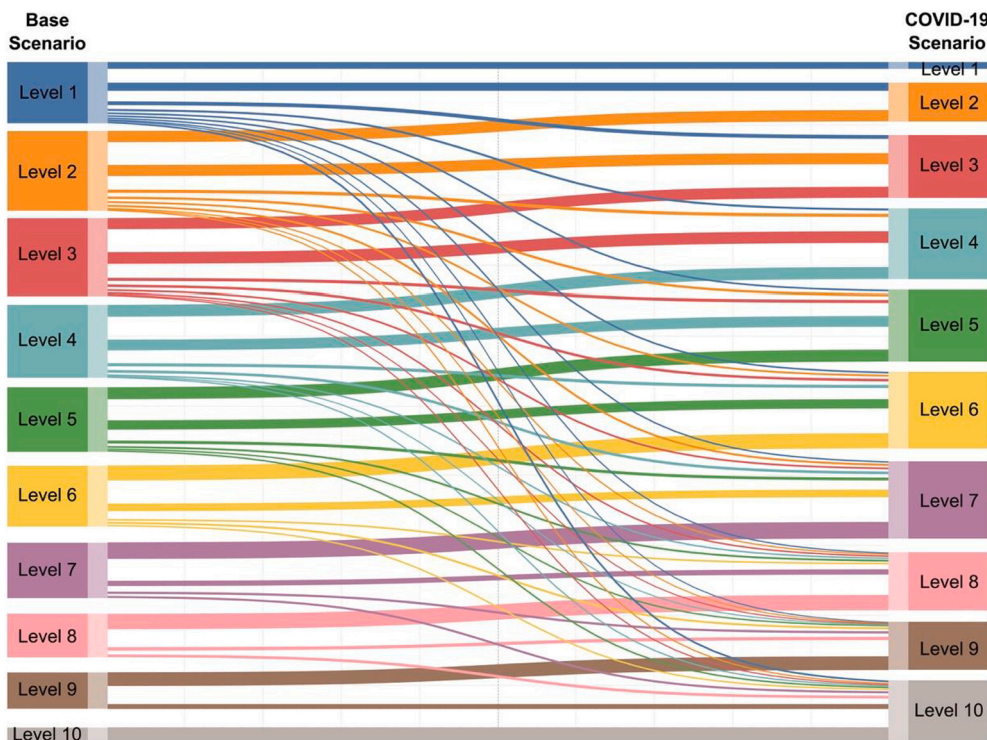
Fig. 7. Sankey diagram of variation of inhabitants per level of accessibility between base scenario (on the left) and Covid-19 scenario (on the right).

feasible ways of enhancing the supply of essential services in dense-populated urban areas: as for the urban component, policymakers can design public transport routes and/or schedules according to the demands of healthcare services; from the perspective of local health agencies, the outputs of the model could be used to better allocate resources (such as number of physicians, number of beds or work schedules) within the existing structures.

In terms of international practices, the planning of healthcare services in urban areas — in particular for the elderly who are the most vulnerable users — should follow two basic guidelines. The first is equity-oriented, since the allocation of resources within cities should take into account the varied socio-economic backgrounds of different groups. As noted in previous paragraphs, studies have shown that due to the lack of mobility capital, elderly people suffer from poor accessibility to essential services. The trip mode has significant influence when assessing accessibility as the availability of multiple choices is crucial to satisfying personal and social needs. The Covid-19 virus raised new unforeseen questions related to perceived safety; public transport companies are working on this issue, limiting the capacity of each vehicle while increasing the number of bus or railway routes, assuring intense and capillary cleaning, etc. The second guideline is related to the

equilibrium of supply and demand. Bearing in mind that, in big cities, the high density of structures cannot allow the reallocation of healthcare or transport structures, the balance of supply and demand can be achieved by improving the level of services designed for the elderly and their peculiar needs. For example, local health agencies can develop and implement strategic plans to promote healthy ageing in urban areas, with the partnership of local authorities and stakeholders, to provide specialized services to the elderly. On the other hand, policymakers can improve road and public transport networks in such a way that the urban fabric could be accessible not only for an average adult but also for the weakest users, promoting special equity and social justice. These are just a few examples of how healthy ageing policies could be implemented in ordinary urban planning tools, especially in light of the new and unprecedented challenges posed by the novel coronavirus.

This paper also has some limitations. Due to the lack of available data, the distance-decay functions do not take into account elderly people's behaviours for the application context; these were deduced from literature. Secondly, we integrated two transport modes, pedestrian and public, but further modes could be considered, such as private modes as well as the availability of sustainable mobility facilities.
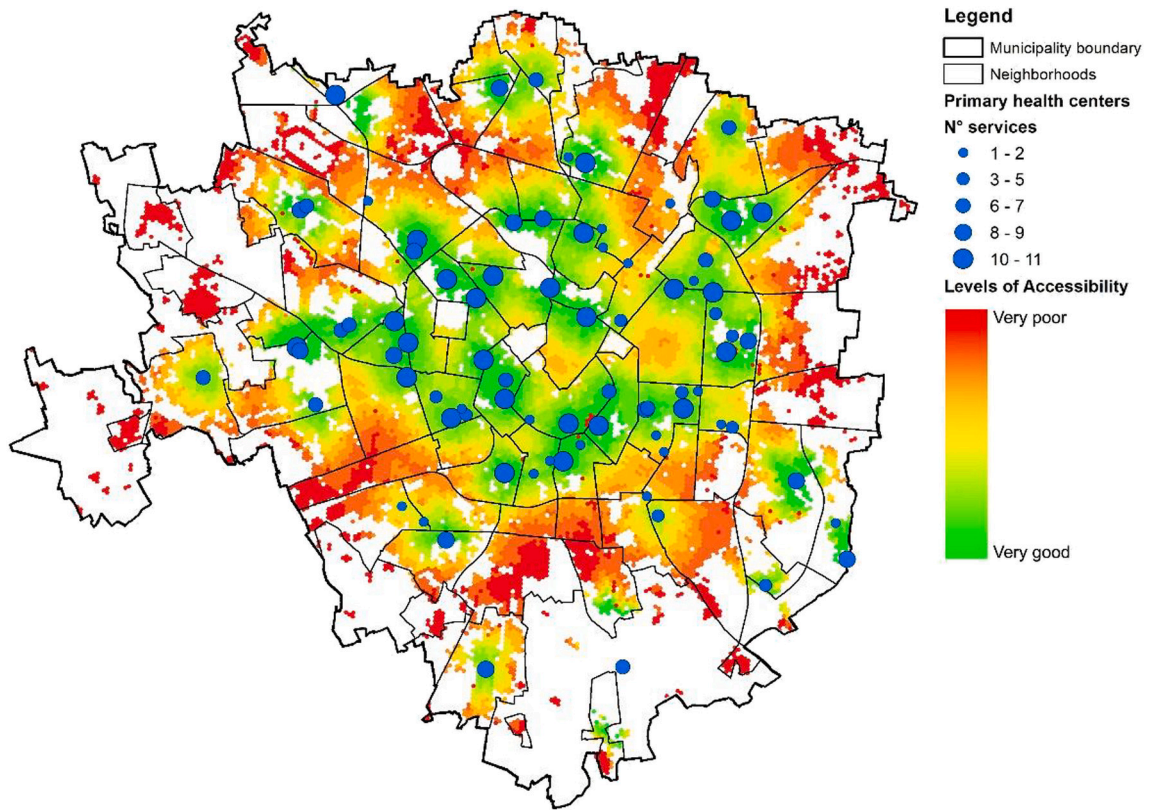
Fig. 8. Spatial accessibility of the inhabitants above 65 to the whole primary health supply of the city of Milan before Covid-19 outbreak.
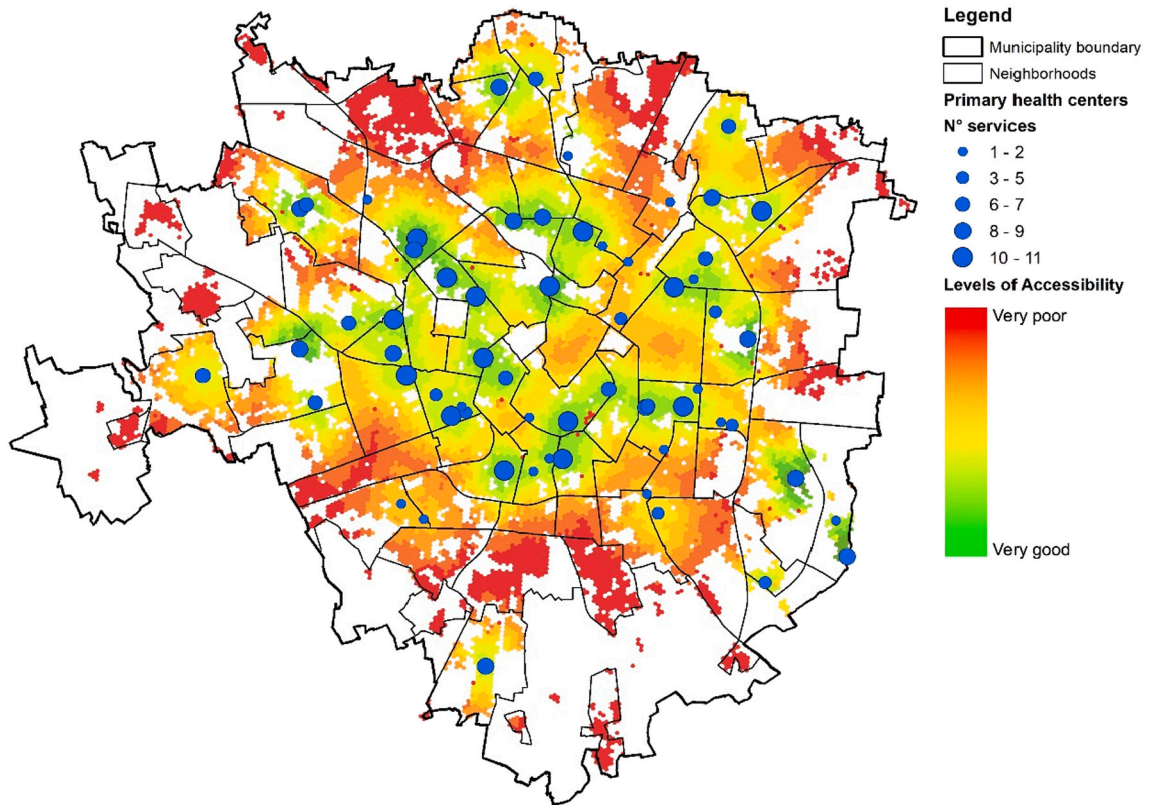

Fig. 9. Spatial accessibility of inhabitants above 65 to the whole primary health supply of the city of Milan in the Covid-19 scenario.

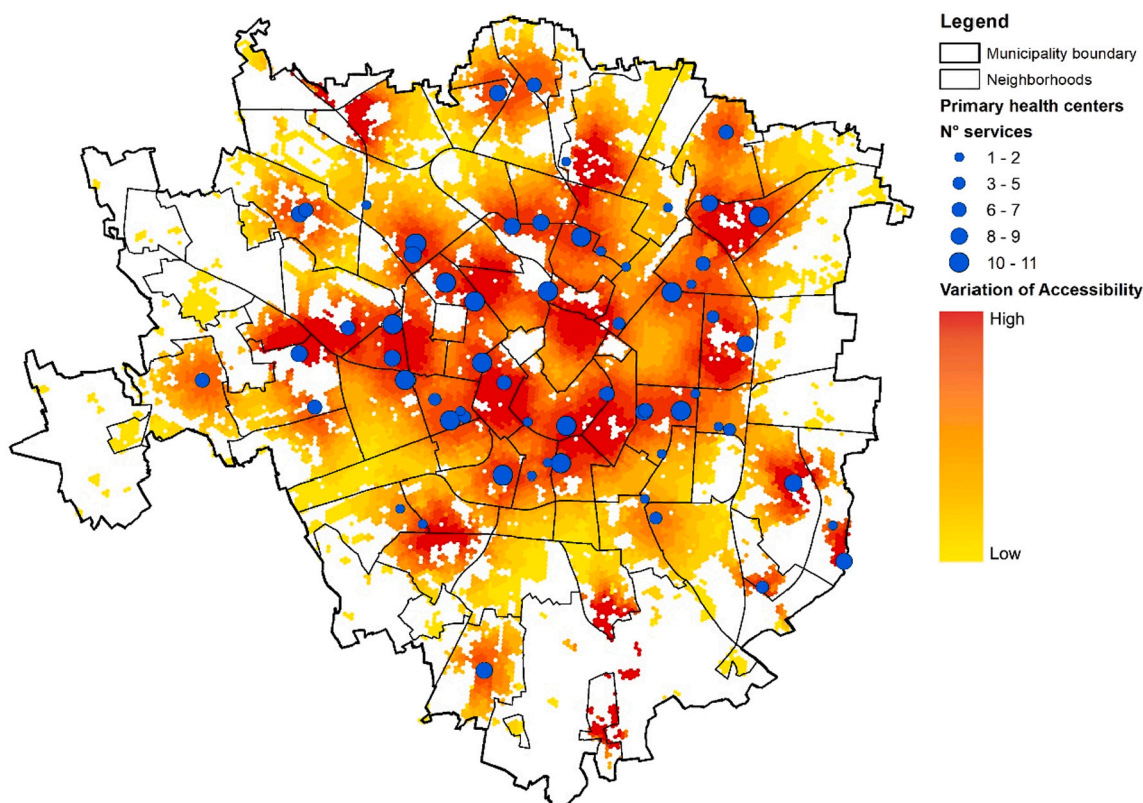**Fig. 10.** Spatial accessibility variation of inhabitants above 65 to the whole primary health supply between base scenario and Covid-19 scenario.

7. Conclusions

It is clear how necessary the development of integrated policies and tools is, through the combination of all aspects — which are easy to understand for the different public and private actors involved — influencing urban accessibility. The outcomes of this tool and its application to the city of Milan could be useful in supporting policy-makers and technicians in the development of future sectorial plans (such as the City Master Plan, Sustainable Urban Mobility Plan, Health Plan, etc.), as well as in the implementation of specific planning instruments, such as the Territorial Time Plan and Master Plan for Ageing.

The study could be further developed by exploring, for example, the relative benefits of a) validating the procedure within other urban contexts; b) considering the urban and environmental aspects that influence the walkability of the elderly in different times of the day, in different seasons and in different social distancing scenarios; c) evaluating the optimal location of new transport and health facilities to improve the urban accessibility level of under-served areas; and d) developing a web GIS tool in order to simplify the application of the procedure and the interpretability of its results.

CRediT authorship contribution statement

Carpentieri G. and Guida C. conceived the presented idea and developed the theory and performed the computations. For what concerns the manuscript, Guida C. wrote paragraphs 2 and 4; Carpentieri G. wrote paragraphs 1, 3 and 5. The authors discussed the results and contributed to the final manuscript (6 and 7 paragraphs).

Declaration of interests

The authors declare that they haveno known competingfinancialinterestsor personal relationships that could have appeared to influence the work reported in this paper.

References

Aceves-González, C., Cook, S., & May, A. (2015). Bus use in a developing world city: Implications for the health and well-being of older passengers. *Journal of Transport & Health, 2*(2), 308–316. https://doi.org/10.1016/j.jth.2015.04.001.

Ahn, J. S., Kim, L. B., & Park, M. R. (2014). An analysis of variation of spatial accessibility pattern based on 2SFCA: A case study of welfare facilities for the aged in Gumi city. *Journal of the Korean Association of Geographic Information Studies, 17*(4), 112–128. https://doi.org/10.1016/j.trpro.2016.11.080.

Allam, Z., & Jones, D. S. (2020). On the Coronavirus (Covid-19) outbreak and the smart city network: Universal data sharing standards coupled with artificial intelligence (AI) to benefit urban health monitoring and management. In *In Healthcare, 8 (1), 46*. Institute: Multidisciplinary Digital Publishing. https://doi.org/10.3390/healthcare8010046.

Alshalalfah, B. W., & Shalaby, A. S. (2007). Relationship of walk access distance to transit with service, travel, and personal characteristics. *Journal of Urban Planning and Development, 133*(2), 114–118. https://doi.org/10.1061/(ASCE)0733-9488(2007)133:2(114).

Bakimchandra, O., Oinam, J., & Kajal, R. K. (2020). A geospatial approach to assess health coverage and scaling-up of healthcare facilities. *Current Science, 118*(5). https://doi.org/10.18520/cs/v118/i5/728-736.

Bauer, J., & Groneberg, D. A. (2016). Measuring spatial accessibility of health care providers—Introduction of a variable distance-decay function within the floating catchment area (FCA) method. *PLoS One, 11*(7), Article e0159148.

Bauer, J., Müller, R., Brüggmann, D., & Groneberg, D. A. (2018). Spatial accessibility of primary care in England: A cross-sectional study using a floating catchment area method. *Health Services Research, 53*(3), 1957–1978.

Buehler, R., & Nobis, C. (2010). Travel behavior in aging societies: Comparison of Germany and the United States. *Transportation Research Record: Journal of the Transportation Research Board, 2182*(1), 62–70. https://doi.org/10.3141/2182-09.

Cabrera-Barona, P., Blaschke, T., & Gaona, G. (2018). Deprivation, healthcare accessibility and satisfaction: Geographical context and scale implications. *Applied Spatial Analysis and Policy, 11*(2), 313–332. https://doi.org/10.1007/s12061-017-9221-y.

Campbell, K. B., Rising, J. A., Klopp, J. M., & Mbilo, J. M. (2019). Accessibility across transport modes and residential developments in Nairobi. *Journal of Transport Geography, 74*, 77–90. https://doi.org/10.1016/j.jtrangeo.2018.08.002.

Carpentieri, G., & Favo, F. (2017). The end-use electric energy consumption in urban areas: A GIS-based methodology. An application in the city of Naples. *Tema. Journal of Land Use, Mobility and Environment, 10*(2), 139–156. https://doi.org/10.6092/1970-9870/5173.

Carpentieri, G., Guida, C., & Masoumi, H. (2019). Measuring multimodal accessibility at urban services for elderly. An application at primary health services in the city of Naples. In C. Gargiulo, & C. Zoppi (Eds.), *Planning, Nature and Ecosystem Services, 810–825.* Naples (Italy): FedOAPress. https://doi.org/10.6093/978-88-6887-054-6.

Carpentieri, G., Guida, C., & Masoumi, H. E. (2020). Multimodal accessibility to primary health services for the elderly: A case study of Naples, Italy. *Sustainability, 12*(3), 781. https://doi.org/10.3390/su12030781.

Clarfield, A. M. (2018). Healthy life expectancy is expanding. *Journal of the American Geriatrics Society, 66*, 202.

Coppola, P., Angiello, G., Carpentieri, G., & Papa, E. (2014). Urban form and sustainability: The case study of Rome. *Procedia: Social & Behavioral Sciences, 160*, 557–566. https://doi.org/10.1016/j.sbspro.2014.12.169.

Currie, G., & Delbosc, A. (2010). Exploring public transport usage trends in an ageing population. *Transportation, 37*(1), 151–164. https://doi.org/10.1007/s11116-009-9224-x.

Cutler, D. M. (2001). The reduction in disability among the elderly. *Proceedings of the National Academy of Sciences, 98*(12), 6546–6547. https://doi.org/10.1073/pnas.131201698.

de Sousa Faria, M. C. C. (2020). Health promotion and wellness in aging. In *In handbook of research on health systems and organizations for an aging society, 12–28.* IGI: Global. https://doi.org/10.4018/978-1-5225-9818-3.ch002.

Ding, Y., Zhou, J., & Li, Y. (2015). Transit accessibility measures incorporating the temporal dimension. *Cities, 46*, 55–66. https://doi.org/10.1016/j.cities.2015.05.002.

Domencich, T., & McFadden, T. (1975). *Urban travel demand: A behavioural analysis.* Amsterdam: North Holland.

Dony, C. C., Delmelle, E. M., & Delmelle, E. C. (2015). Re-conceptualizing accessibility to parks in multi-modal cities: A variable-width floating catchment area (VFCA) method. *Landscape and Urban Planning, 143*, 90–99. https://doi.org/10.1016/j.landurbplan.2015.06.011.

Du, M., Cheng, L., Li, X., & Yang, J. (2020). Factors affecting the travel mode choice of the urban elderly in healthcare activity: Comparison between core area and suburban area. *Sustainable Cities and Society, 52*, 101868. https://doi.org/10.1016/j.scs.2019.101868.

Farrington, J., & Farrington, C. (2005). Rural accessibility, social inclusion and social justice: Towards conceptualisation. *Journal of Transport Geography, 13*(1), 1–12. https://doi.org/10.1016/j.jtrangeo.2004.10.002.

Fredriksen-Goldsen, K. I., Kim, H. J., Emlet, C. A., Muraco, A., Erosheva, E. A., Hoy-Ellis, C. P., … Petry, H. (2011). *The aging and health report.* Seattle, WA: Institute for Multigenerational Health.

Gaglione, F., Gargiulo, C., & Zucaro, F. (2019). Elders' quality of life. A method to optimize pedestrian accessibility to urban services. *TeMA - Journal of Land Use, Mobility and Environment, 12*(3), 295–312. https://doi.org/10.6092/1970-9870/6272.

Gargiulo, C., Gaglione, F., Guida, C., Papa, R., Zucaro, F., & Carpentieri, G. (2020). *The role of the urban settlement system in the spread of the Covid-19 pandemic* (pp. 189–212). Mobility and Environment: The Italian case. TeMA. Journal of Land Use. https://doi.org/10.6092/1970-9870/6864.

Geurs, K. T., & Van Wee, B. (2004). Accessibility evaluation of land-use and transport strategies: Review and research directions. *Journal of Transport Geography, 12*(2), 127–140. https://doi.org/10.1016/j.jtrangeo.2003.10.005.

Gu, F., Hayashi, Y., Shi, F., Zhang, H., & Kato, H. (2016). Measuring and mapping the spatial distribution of the quality of life in a city: A case study of Nanjing. *International Journal of Urban Sciences, 20*(1), 107–128. https://doi.org/10.1080/12265934.2015.1127179.

Guida, C., & Caglioni, M. (2020). Urban accessibility: The paradox, the paradigms and the measures. A scientific review. *TeMA - Journal of Land Use, Mobility and Environment, 13*(2), 149–168. https://doi.org/10.6092/1970-9870/6743.

Holmdahl, I., & Buckee, C. (2020). Wrong but useful—What covid-19 epidemiologic models can and cannot tell us. *New England Journal of Medicine, 383*, 303–305. https://doi.org/10.1056/NEJMp2016822.

Hu, R. S., Dong, X. C., & Hu, H. (2012). A two-step floating catchment area (2SFCA) method for measuring spatial accessibility to primary healthcare service in China: A case study of Donghai County in Jiangsu Province. *Progr. Geogr, 31*, 1600–1607. https://doi.org/10.11820/dlkxjz.2012.12.005.

Julien, D., Richard, L., Gauvin, L., Fournier, M., Kestens, Y., Shatenstein, B., … Payette, H. (2015). Transit use and walking as potential mediators of the association between accessibility to services and amenities and social participation among urban-dwelling older adults: Insights from the VoisiNuAge study. *Journal of Transport & Health, 2*(1), 35–43. https://doi.org/10.1016/j.jth.2014.09.007.

Kanuganti, S., Sarkar, A. K., & Singh, A. P. (2016). Quantifying accessibility to health care using two-step floating catchment area method (2SFCA): A case study in Rajasthan. *Transportation Research Procedia, 17*, 391–399.

Khalil, H. A. E. (2012). Enhancing quality of life through strategic urban planning. *Sustainable Cities and Society, 5*, 77–86. https://doi.org/10.1016/j.scs.2012.06.002.

Kibambe Lubamba, J. P., Radoux, J., & Defourny, P. (2013). Multimodal accessibility modeling from coarse transportation networks in Africa. *International Journal of Geographical Information Science, 27*(5), 1005–1022. https://doi.org/10.1080/13658816.2012.735673.

Kim, Y., Byon, Y. J., & Yeo, H. (2018). Enhancing healthcare accessibility measurements using GIS: A case study in Seoul, Korea. *PLoS One, 13*(2). https://doi.org/10.1371/journal.pone.0194849.

Koh, P. P., Leow, B. W., & Wong, Y. D. (2015). Mobility of the elderly in densely populated neighbourhoods in Singapore. *Sustainable Cities and Society, 14*, 126–132. https://doi.org/10.1016/j.scs.2014.08.012.

Kompil, M., Jacobs-Crisioni, C., Dijkstra, L., & Lavalle, C. (2019). Mapping accessibility to generic services in Europe: A market-potential based approach. *Sustainable Cities and Society, 47*, 101372. https://doi.org/10.1016/j.scs.2018.11.047.

Kwan, M. P. (1998). Space-time and integral measures of individual accessibility: A comparative analysis using a point-based framework. In *Geographical Analysis, 30 (3)*. Ohio State University: Press.

Langford, M., Fry, R., & Higgs, G. (2012). Measuring transit system accessibility using a modified two-step floating catchment technique. *International Journal of Geographical Information Science, 26*(2), 193–214. https://doi.org/10.1016/j.jtrangeo.2012.06.014.

Lee, J., & Lee, C. H. (2019). Analysis of elderly traffic accidents using public data. *Journal of Industrial Convergence, 17*(4), 53–58. https://doi.org/10.22678/JIC.2019.17.4.053.

Levinson, D. M., Marshall, W., & Axhausen, K. W. (2017). *Elements of access: Transport planning for engineers—Transport engineering for planners.* Network Design Lab.

Linchuan, Y., & Xu, C. (2020). Determinants of elderly mobility in Hong Kong: Implications for elderly-friendly transport. *China City Planning Review, 29*(1).

Liu, L. (2020). Emerging study on the transmission of the Novel Coronavirus (Covid-19) from urban perspective: Evidence from China. *Cities.*. https://doi.org/10.1016/j.cities.2020.102759.

Luo, W., & Wang, F. (2003). Spatial accessibility to primary care and physician shortage area designation: A case study in Illinois with GIS approaches. In *Geographic Information Systems and Health Applications, 261–279.* IGI: Global.

Ma, X., Ren, F., Du, Q., Liu, P., Li, L., Xi, Y., & Jia, P. (2019). Incorporating multiple travel modes into a floating catchment area framework to analyse patterns of accessibility to hierarchical healthcare facilities. *Journal of Transport & Health, 15*, 100675. https://doi.org/10.1016/j.jth.2019.100675.

MacLeod, K. E., Satariano, W. A., & Ragland, D. R. (2014). The impact of health problems on driving status among older adults. *Journal of Transport & Health, 1*(2), 86–94. https://doi.org/10.1016/j.jth.2014.03.001.

Makarewicz, C., & Németh, J. (2018). Are multimodal travelers more satisfied with their lives? A study of accessibility and wellbeing in the Denver, Colorado metropolitan area. *Cities, 74*, 179–187. https://doi.org/10.1016/j.cities.2017.12.001.

Manfredini, F., & Di Rosa, C. (2018). *Measuring spatial accessibility for elderly* (pp. 85–94). Mobility and Environment: An Application to Subway Stations in Milan. TeMA - Journal of Land Use. https://doi.org/10.6092/1970-9870/5800.

Manning, K. J., Barco, P. P., & Schultheis, M. T. (2019). Driving evaluation in older adults. In *Handbook on the neuropsychology of aging and dementia* (pp. 231–251). Cham: Springer. https://doi.org/10.1007/978-3-319-93497-6_15.

Mariottti, I., Brouwer, A. E., & Gelormini, M. (2018). *Is Milan a city for the elderly?* (pp. 95–104) Mobility and Environment: Mobility for aging in place. Tema. Journal of Land Use. https://doi.org/10.6092/1970-9870/5764.

Masoumi, H., & Shaygan, M. (2016). A longitudinal analysis of densities within the pedestrian sheds around metro stations. The case of Tehran. Tema. Journal of Land Use, Mobility and Environment, 0, 5–20. doi:https://doi.org/10.6092/1970-9870/3908.

McKibbin, W. J., & Fernando, R. (2020). The global macroeconomic impacts of Covid-19: Seven scenarios. In *CAMA Working Paper No. 19/2020.* https://doi.org/10.2139/ssrn.3547729.

Moroke, T., Schoeman, C., & Schoeman, I. (2019). Developing a neighbourhood sustainability assessment model: An approach to sustainable urban development. *Sustainable Cities and Society.*. https://doi.org/10.1016/j.scs.2019.101433.

Musselwhite, C., Holland, C., & Walker, I. (2015). *The role of transport and mobility in the health of older people.* https://doi.org/10.1016/j.jth.2015.02.001.

O'Neill, D. (2016). Towards an understanding of the full spectrum of travel-related injuries among older people. *Journal of Transport & Health, 3*(1), 21–25. https://doi.org/10.1016/j.jth.2015.11.001.

Pan, X. I., Chahal, J. K., & Ward, R. M. (2018). Quality of urban life among older adults in the world major metropolises: A cross-cultural comparative study. *Ageing & Society, 38*(1), 108–128. https://doi.org/10.1017/S0144686X16000957.

Papa, E., Carpentieri, G., & Angiello, G. (2018). A TOD classification of metro stations: An application in Naples. In *Smart planning: Sustainability and mobility in the age of change* (pp. 285–300). Cham: Springer. https://doi.org/10.1007/978-3-319-77682-8_17.

Papa, E., Carpentieri, G., & Guida, C. (2018). *Measuring walking accessibility to public transport for the elderly: The case of Naples* (pp. 105–116). Mobility and Environment: Tema. Journal of Land Use. https://doi.org/10.6092/1970-9870/5766.

Papa, E., Coppola, P., Angiello, G., & Carpentieri, G. (2017). The learning process of accessibility instrument developers: Testing the tools in planning practice. *Transportation Research Part A: Policy and Practice, 104*, 108–120. https://doi.org/10.1016/j.tra.2017.03.010.

Papa, R., Angiello, G., & Carpentieri, G. (2017), *3. Il Governo del Sistema Integrato Città-Trasporti-Energia.* Naples: FedOA-Federico II University Press.. http://www.fedoabooks.unina.it/index.php/fedoapress/catalog/book/53

Radke, J., & Mu, L. (2000). Spatial decompositions, modeling and mapping service regions to predict access to social programs. *Geographic Information Sciences, 6*(2), 105–112. https://doi.org/10.1080/10824000009480538.

Rossetti, S., Tiboni, M., Vetturi, D., Zazzi, M., & Caselli, B. (2020). Measuring pedestrian accessibility to public transport in urban areas: A GIS-based discretisation approach. In *European Transport \ Trasporti Europei, 76, Paper n° 2* (ISSN 1825-3997).

Sahitya, K. S., & Prasad, C. S. R. K. (2020). Evaluation of opportunity based urban road network accessibility using GIS. In *Spatial information research* (pp. 1–7). https://doi.org/10.1007/s41324-019-00309-6.

Scheurer, J., & Curtis, C. (2007). Accessibility measures: Overview and practical applications. In *Urbanet, working paper no 4*.

Shah, J. S., & Adhvaryu, B. (2016). Public transport accessibility levels for Ahmedabad, India. *Journal of Public Transportation, 19*(3), 2. https://doi.org/10.5038/2375-0901.19.3.2.

Shergold, I., Lyons, G., & Hubers, C. (2015). Future mobility in an ageing society–Where are we heading? *Journal of Transport & Health, 2*(1), 86–94. https://doi.org/10.1016/j.jth.2014.10.005.

Smith, J. P., Strauss, J., & Zhao, Y. (2014). Healthy aging in China. *The journal of the economics of ageing, 4*, 37–43. https://doi.org/10.1016/j.jeoa.2014.08.006.

Tao, Z., & Cheng, Y. (2019). Modelling the spatial accessibility of the elderly to healthcare services in Beijing, China. *Environment and Planning B: Urban Analytics and City Science, 46*(6), 1132–1147. https://doi.org/10.1177/2399808318755145.

Tao, Z., Yao, Z., Kong, H., Duan, F., & Li, G. (2018). Spatial accessibility to healthcare services in Shenzhen, China: Improving the multi-modal two-step floating catchment area method by estimating travel time via online map APIs. *BMC Health Services Research, 18*(1), 345. https://doi.org/10.1186/s12913-018-3132-8.

Tira, M., Tiboni, M., Rossetti, S., & De Robertis, M. (2018). "Smart" planning to enhance nonmotorised and safe mobility in today's cities. In *Smart planning: sustainability and mobility in the age of change* (pp. 201–213). Cham: Springer. https://doi.org/10.1007/978-3-319-77682-8_12.

Unit, S. E. (2003). Making the connections: Final report on transport and social exclusion. Retrieved from http://www.cabinetoffice.gov.uk/media/cabinetoffice/social_exclusion_task_force/assets/publications_1997_to_2006/making_transport_2003.pdf.

United Nations. (2019). World population prospects 2019: Highlights. Retrieved from https://population.un.org/wpp/Publications/Files/WPP2019_Highlights.pdf.

Voss, C., Sims-Gould, J., Ashe, M. C., McKay, H. A., Pugh, C., & Winters, M. (2016). Public transit use and physical activity in community-dwelling older adults: Combining GPS and accelerometry to assess transportation-related physical activity. *Journal of Transport & Health, 3*(2), 191–199. https://doi.org/10.1016/j.jth.2016.02.011.

Wang, F. (2015). *Quantitative methods and socio-economic applications in GIS* (2nd ed.). Boca Raton, FL: CRC Press.

Wang, J., & Cao, X. (2017). Exploring built environment correlates of walking distance of transit egress in the Twin Cities. *Journal of Transport Geography, 64*, 132–138. https://doi.org/10.1016/j.jtrangeo.2017.08.013.

Wang, J., Du, F., Huang, J., & Liu, Y. (2020). *Access to hospitals: Potential vs. observed. Cities, 100*, 102671. https://doi.org/10.1016/j.cities.2020.102671.

World Health Organization. (2017). Global strategy and action plan on ageing and health. World Health Organization, Geneva. ISBN 978-92-4-151350-0. Retrived from https://www.who.int/ageing/WHO-GSAP-2017.pdf?ua=1.

World Health Organization. (2018). Ageing and health. World Health Organization, Geneva. Retrived from https://www.who.int/news-room/fact-sheets/detail/ageing-and-health#:~:text=Common%20conditions%20in%20older%20age,conditions%20at%20the%20same%20time.

World Health Organization. (2020). Decade of healthy ageing 2020–2030. Retrieved from https://www.who.int/docs/default-source/decade-of-healthy-ageing/full-decade-proposal/decade-proposal-fulldraft-en.pdf?sfvrsn=8ad33385d_6.

Xu, W., & Yang, L. (2019). Evaluating the urban land use plan with transit accessibility. *Sustainable Cities and Society, 45*, 474–485. https://doi.org/10.1016/j.scs.2018.11.042.

Zecca, C., Gaglione, F., Laing, R., & Gargiulo, C. (2020). Pedestrian routes and accessibility to urban services: An urban rhythmic analysis on people's behaviour before and during the Covid-19. *TeMA - Journal of Land Use, Mobility and Environment, 13*(2), 241–256. https://doi.org/10.6092/1970-9870/7051.

Zhu, X., Tong, Z., Liu, X., Li, X., Lin, P., & Wang, T. (2018). An improved two-step floating catchment area method for evaluating spatial accessibility to urban emergency shelters. *Sustainability, 10*(7), 2180. https://doi.org/10.3390/su10072180.

Papa, E., Carpentieri, G., & Angiello, G. (2018). A TOD classification of metro stations: An application in Naples. In *Smart Planning: Sustainability and Mobility in the Age of Change* (pp. 285–300). Cham: Springer.

Battarra, R., Gargiulo, C., Pappalardo, G., Boiano, D. A., & Oliva, J. S. (2016). Planning in the era of information and communication technologies. Discussing the "label: Smart" in South-European cities with environmental and socio-economic challenges. *Cities, 59*, 1–7.

O'Hern, S., Oxley, J., & Logan, D. (2015). Older adults at increased risk as pedestrians in Victoria, Australia: an examination of crash characteristics and injury outcomes. *Traffic injury prevention, 16*(Sup2), S161–S167. https://doi.org/10.1080/15389588.2015.1061662.

Jin, X., Liu, H., Luan, Q., & Huang, W. (2007). Technique and methods for spatialization of socioeconomic data. *Geoinformatics 2007: Geospatial Information Science, 6753*. https://doi.org/10.1117/12.761884.

Taleai, M., Sliuzas, R., & Flacke, J. (2014). An integrated framework to evaluate the equity of urban public facilities using spatial multi-criteria analysis. *Cities, 40* (56–69). https://doi.org/10.1016/j.cities.2014.04.006.

De Falco, S. (2018). *Geografich determinism VS urban resilence: an italian scenario analysis. Tema. Journal of Land Use, Mobility and Environment, 11*(1), 65–88. https://doi.org/10.6092/1970-9870/5370.

Arup. (2015). *Shaping Ageing Cities. 10 European case studies.* Help Age International, Intel, Systematica.

Musselwhite, C. B., & Shergold, I. (2013). Examining the process of driving cessation in later life. *European Journal of Ageing, 10*(2), 89–100. https://doi.org/10.1007/s10433-012-0252-6.

Luo, W., & Qi, Y. (2009). An enhanced two-step floating catchment area (E2SFCA) method for measuring spatial accessibility to primary care physicians. *Health & place, 15*(4), 1100–1107. https://doi.org/10.1016/j.healthplace.2009.06.002.

Kiran, K. C., Corcoran, J., & Chhetri, P. (2020). Measuring the spatial accessibility to fire stations using enhanced floating catchment method. *Socio-Economic Planning Sciences, 69*, 100673. https://doi.org/10.1016/j.seps.2018.11.010.

Kuai, X., & Zhao, Q. (2017). Examining healthy food accessibility and disparity in Baton Rouge, Louisiana. *Annals of GIS, 23*(2), 103–116. https://doi.org/10.1080/19475683.2017.1304446.

Xing, L., Liu, Y., Wang, B., Wang, Y., & Liu, H. (2020). An environmental justice study on spatial access to parks for youth by using an improved 2SFCA method in Wuhan, China. *Cities, 96*, 102405. https://doi.org/10.1016/j.cities.2019.102405.

Guo, S., Song, C., Pei, T., Liu, Y., Ma, T., Du, Y., & Wang, Y. (2019). Accessibility to urban parks for elderly residents: Perspectives from mobile phone data. *Landscape and urban planning, 191*, 103642. https://doi.org/10.1016/j.landurbplan.2019.103642.

Qiu, J., Bai, Y., Hu, Y., Wang, T., Zhang, P., & Xu, C.. Urban Green Space Accessibility Evaluation Using Age-Based 2-Step Floating Catchment Area Method. https://doi.org/10.3390/su12010052.

Bryant, J., Jr., & Delamater, P. L. (2019). Examination of spatial accessibility at micro- and macro-levels using the enhanced two-step floating catchment area (E2SFCA) method. *Annals of GIS, 25*(3), 219–229. https://doi.org/10.1080/19475683.2019.1641553.

Wang, F. (2018). Inverted two-step floating catchment area method for measuring facility crowdedness. *The Professional Geographer, 70*(2), 251–260. https://doi.org/10.1080/00330124.2017.1365308..

Fransen, K., Neutens, T., Farber, S., De Maeyer, P., Deruyter, G., & Witlox, F. (2015). Identifying public transport gaps using time-dependent accessibility levels. *Journal of Transport Geography, 48*, 176-187. https://doi.org/10.1016/j.jtrangeo.2015.09.008.

Cesaro, A., & Pirozzi, F. (2020). About the effects of Covid-19 on solid waste management. *TeMA - Journal of Land Use, Mobility and Environment*, 59–66. https://doi.org/10.6092/1970-9870/6904.

World Health Organization (2008). Our cities, our health, our future: acting on social determinants for health equity in urban settings. Report to the WHO Commission on Social Determinants of Health from the Knowledge Network on Urban Settings. Retrieved at: https://www.who.int/social_determinants/resources/knus_final_report_052008.pdf.

Websites

http://www.pcn.minambiente.it/.

https://www.istat.it/.

http://www.comune.napoli.it/opendata.

https://www.atm.it/it/ViaggiaConNoi/InfoTraffico/Pag. https://www.atm.it/it/AtmNews/AtmInforma/Documents/20200714_ATM_digital_leaflet.pdfineInservizioimezzidellareteAtm.aspx.

https://www.ats-milano.it/portale.

Carmen Guida is a Ph.D Student in Civil Systems Engineering Hydraulic and Transportation Systems Engineering at Department of Civil, Architectural and Environmental Engineering at University of Naples Federico II.

Gerardo Carpentieri is an Engineer, Ph.D. in Civil Systems Engineering at University of Naples Federico II and Research Fellow of Land Use Planning at the Department of Civil, Architectural and Environmental Engineering at University of Naples Federico II.