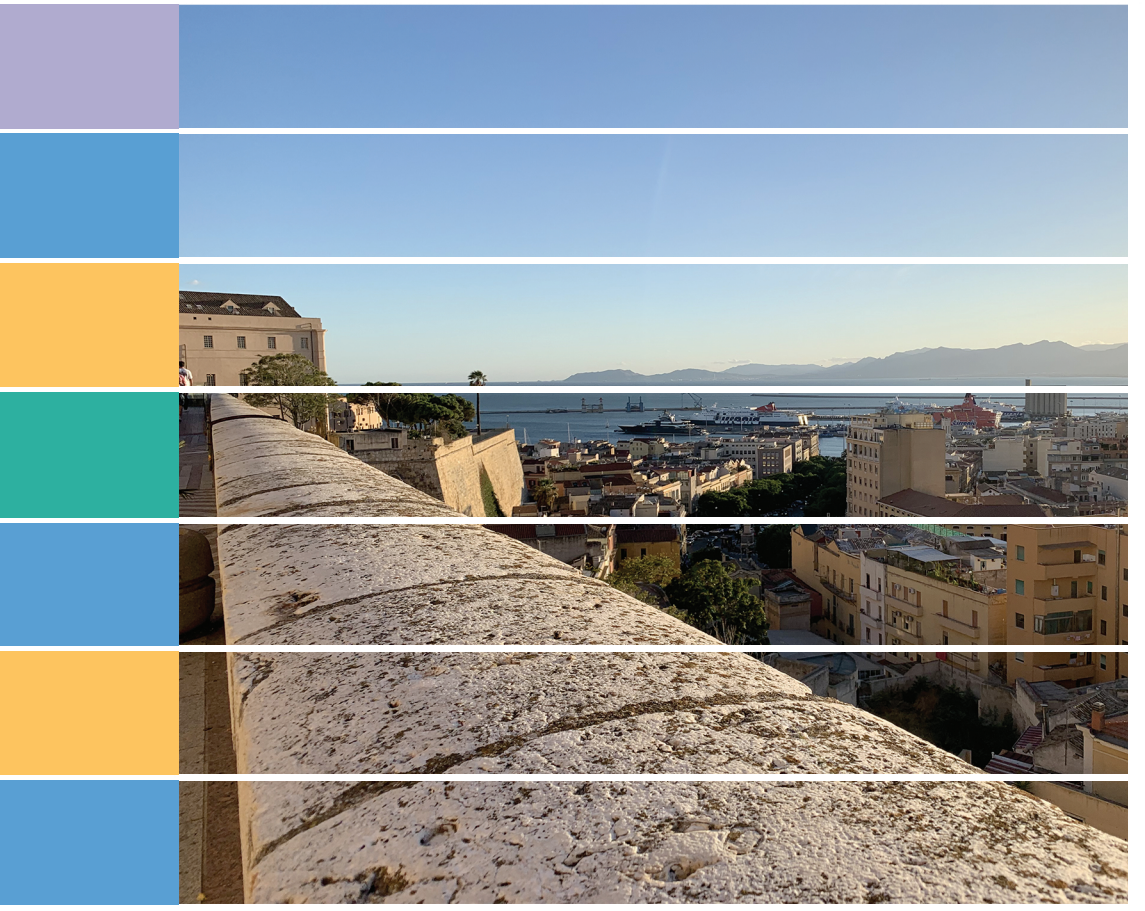
Carmela Gargiulo Corrado Zoppi
Editors

Planning, Nature and Ecosystem Services



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Smart City, Urban Planning for a Sustainable Future

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Carmela Gargiulo Corrado Zoppi

Editors

Planning, Nature and Ecosystem Services

INPUT aCAdemy 2019

Conference proceedings

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This book collects the papers presented at INPUT aCAdemy 2019, a special edition of the INPUT Conference hosted by the Department of Civil and Environmental Engineering, and Architecture (DICAAR) of the University of Cagliari.

INPUT aCAdemy Conference will focus on contemporary planning issues with particular attention to ecosystem services, green and blue infrastructure and governance and management of Natura 2000 sites and coastal marine areas.

INPUT aCAdemy 2019 is organized within the GIREPAM Project (Integrated Management of Ecological Networks through Parks and Marine Areas), co-funded by the European Regional Development Fund (ERDF) in relation to the 2014-2020 Interreg Italy – France (Maritime) Programme.

INPUT aCAdemy 2019 is supported by Società Italiana degli Urbanisti (SIU, the Italian Society of Spatial Planners), Istituto Nazionale di Urbanistica (INU, the Italian National Institute of Urban Planning), UrbIng Ricerca Scientifica (the Association of Spatial Planning Scholars of the Italian Schools of Engineering) and Ordine degli Ingegneri di Cagliari (OIC, Professional Association of Engineers of Cagliari).

This book is the most recent scientific contribution of the "Smart City, Urban Planning for a Sustainable Future" Book Series, dedicated to the collection of research e-books, published by FedOAPress - Federico II Open Access University Press. The volume contains the scientific contributions presented at the INPUT aCAdemy 2019 Conference. In detail, this publication, including 92 papers grouped in 11 sessions, for a total of 1056 pages, has been edited by some members of the Editorial Staff of "TeMA Journal", here listed in alphabetical order:

- Rosaria Battarra;
- Gerardo Carpentieri;
- Federica Gaglione;
- Carmen Guida;
- Rosa Morosini;
- Floriana Zucaro.

The most heartfelt thanks go to these young and more experienced colleagues for the hard work done in these months. A final word of thanks goes to Professor Roberto Delle Donne, Director of the CAB - Center for Libraries "Roberto Pettorino" of the University of Naples Federico II, for his active availability and the constant support also shown in this last publication.

Rocco Papa
Editor of the Smart City, Urban Planning for a Sustainable Future" Book Series
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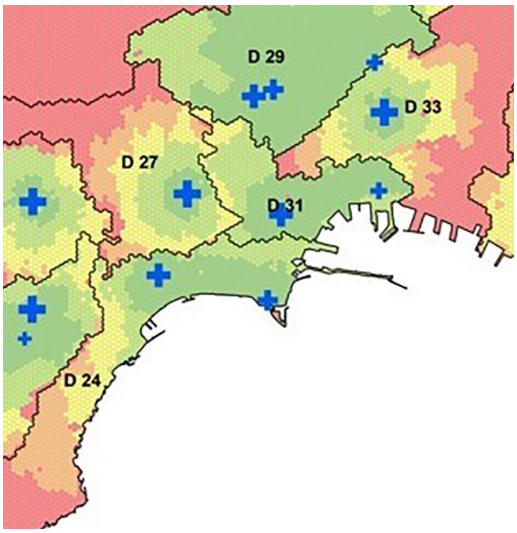

MEASURING MULTIMODAL ACCESSIBILITY TO URBAN SERVICES FOR THE ELDERLY

AN APPLICATION AT PRIMARY HEALTH SERVICES IN THE CITY OF NAPLES

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ABSTRACT

In Europe, the share of people aged 65 years and over is expected to increase exponentially, and for the first time in human history, in 2050, the number of older people will be greater than the number of children under 15 years old. At the same time, aging is associated to an increased vulnerability and dependence on medical care services. An ageing population poses various challenges to a society and improvements in the medical and transportation systems are needed to maintain and to improve the quality of life of the elderly population. From the perspective of social equity, everyone should have the opportunity to access such services equally, but because of economic and geographical issues, it is a challenge to achieve such level of equity. The aim of this study is to fill the gap between scientific and real practices through an accessibility measure able to evaluate urban accessibility to primary healthcare services and to support decision-makers to better allocate resources, in local welfare policies restructuring. The accessibility measure was designed considering both the land-use and the transportation components, taking into account the local healthcare supply system and a multimodal transportation network. The methodology was applied for the city of Naples, considering Local Health Agency (ASL) healthcare services to elderly population. The supply consists of 17 buildings used by nearly 200,000 of old people. The outputs show that entire neighbourhoods' elderly population suffer from a very poor accessibility to primary health services, especially in the city suburbs, and that the methodology could be effective in urban palling strategies to achieve a high quality of life for elderly people.

KEYWORDS
Accessibility; Elderly; GIS

1 INTRODUCTION

Demographic ageing is an increasing phenomenon in urban areas and its economic and social consequences are comparable to the industrial revolution (ARUP, 2015). In Europe, the share of people aged 65 years 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 15 years old (Eurostat, 2018). Moreover, in the European context, the demographic shift would be dramatic for Germany, Portugal, Spain and Italy, where the most aged major cities are located. The Italian Institute of Statistics (ISTAT) forecasts a significant reduction of the total population, from over 60 million people in 2018 to 46 million in 2065, and at the same time a noteworthy increase in the over-65 population (from 22.7% in 2019 to 30.5% in 2065). This means that Italy would be an even older nation.

Considering their significant increase in number and their health condition, the elderly represent an essential group of interest: due to improvements in nutrition, sanitation and medical care older people are healthier than previous generation but, at the same time, aging is also associated to an increased vulnerability and dependence on medical care services. From the perspective of social equity, everyone should have the opportunity to access such services equally, but because of economic and geographical issues, it is a challenge to achieve such level of equity (Kim et al., 2018). Local authorities should prioritise the implementation of policies to promote higher life-quality standards for this increasing portion of population and the accessibility approach can be useful to achieve this aim. It 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 & van Wee, 2004; Papa et al., 2017). Since studies showed that mobility and accessibility trends of the elderly are a critical trial to transport 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's mobility needs, is both urgent and necessary (O'Neill, 2016). On the other hand, the activity system needs to be shaped and organized in order to gain a uniform level of access within the same city. It is crucial to provide decision support tools to local administrator to evaluate and assess the accessibility level to medical care services in urban areas (Papa et al., 2018b).

The aim of this paper is to measure the number of elderly people that suffer from a poor accessibility to public primary health care services according to the active accessibility paradigm. The procedure was applied for the public primary health services in the city of

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Naples, Italy, and it can be taken for other similar cities in case of urban size and socio-demographics.

The project is targeted to develop strategies and decision-making tools for improving the location of services for the elderly and their accessibility using public transport. The structure of the paper is organised into four different parts. Following this introduction, in section 2, a GIS-based methodology is proposed in order to compute the urban accessibility in urban areas; in section 3, we discuss the application to the city of Naples; in section 4, we analyse the results and discuss further research developments.

2 BACKGROUND

Due to the increasing political and scientific interest on the topic, several methods and approaches were produced for determining healthcare accessibility and, based on the application context, these measures vary a lot 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), defining catchment areas by drawing one or more travel time contours around a node and measuring the number of opportunities within each contour. This measure is easy to compute and understand but suffers of a poor theoretical basis, since different distances within the same area have no weight to evaluate accessibility. Moreover, in a metropolis where many alternatives exist the distance to the nearest primary care service does not match people demand. In order to define catchment areas by measuring travel impediment on a continuous scale, gravity measures were introduced: even though they 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). 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. Although the strong theoretical basis (McFadden, 1975), it could be difficult to compute and interpret these measures.

In order to contribute to these debates, this paper proposes a GIS-based procedure to evaluate public primary health care accessibility, considering a multimodal transport network (walking streets, bus lines, metro lines and urban rail lines) and through the lent of social equity. The aim is to quantify elderly people that suffer from a poor accessibility to public primary health care services according to the active accessibility paradigm. The procedure was applied for the public primary health services in the city of Naples, Italy.

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3 METHODOLOGY

In this study, we develop a GIS-based procedure to evaluate the level of accessibility to elderly urban services considering the demographic characteristics of potential users, the multimodal transport service (characteristics of walking street, frequency of service and localization of urban transport stops) and characteristics of health services.

The proposed GIS-based procedure is organised in the following three steps: data collection, GIS spatial analysis and representation of results. Methodologically, our approach integrates the use of open data (spatial and alphanumerical) and organizational capability, analysis and representation of Geographic Information Systems (GIS) software. According to GIS Model Builder tool of ArcGIS Pro 2.2 software, we defined a geoprocessing workflow to execute operations that organize and analyze the alphanumeric and spatial data (Fig. 1).

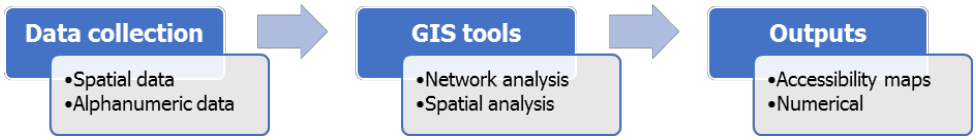

Fig. 1 The phases of GIS-based procedure to evaluate the multimodal accessibility of elderly at urban services

In the procedure first step, 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 introduced a regular spatial grid to divide the area of analysis into small spatial units. The use of grid frames is very important for experimental and observational science, as well as providing the most common framework for spatially explicit models. The hexagonal cell, which is the minimum spatial unit in which the study area is divided, has mainly hexagonal and square shapes, which side may have dimensions previously selected by the user based on the area to be analysed (Papa et al., 2018a). 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 (Kibambe Lubamba et al., 2013). For this GIS-based procedure, we used as a spatial unit a regular hexagonal cell with a side length of 50m that provides greater aesthetic attraction but above all a greater accuracy in the calculation and visualization of numerical data. According to the previous studies, to assignee the census tracks socio-economic data to hexagonal cells, it used a proportional function that considered the buildings footprint located in each cell (Papa et al., 2018b; Carpentieri & Favo, 2017).

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In the second step, geoprocessing, joint data and network analysis operations elaborate the data to evaluate the travel time and accessibility level to health 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. We considered the network as the combination of both walkable streets and local public transport lines (bus and metro) to better simulate elderly mobility habits. The ArcGIS Pro 2.2 Network Analysis tool was used to compute the OD travel matrix. We run four different analysis during morning peak-hour (9:00), for an average adult, for a 65-69-aged person, for a 70-74-aged person and for an over-75-aged person, considering four different walking speeds for each age category (Papa et al., 2018b). In the third step, maps and tables were produced to quantify, numerically and spatially, the results of the GIS-based procedure and support the planning process of decision-policy makers. The results of this procedure can be easily used also by elderly, in order to choose a more comfortable dwelling neighbourhood.

Tab. 1 provides the list of alphanumeric and spatial data (vector and raster) requests for the application of the GIS-based procedure.

DATA	CATEGORY OF DATA	TYPE OF GEOMETRY	SOURCE
Population	Alphanumeric	-	Statistics Institute
Transport schedules	Alphanumeric	-	Transport companies
Primary health services	Vector / Alphanumeric	Point	Local Health Agency
Walking street network	Vector	Polyline	Open Street Map
Transport network	Vector	Polyline	Transport companies
Census tracts	Vector	Polygon	Statistics Institute
Buildings	Vector	Polygon	Geoportal
Digital Terrain Model	Raster	-	Geoportal

Tab. 1 Data selected for the implementation the GIS-based procedure

The accessibility level was measured for each hexagonal cell, using the following formulas:

$$Acc_{j|d,i} = \frac{\sum_{k=1}^{n} S_{k|d}}{P_j * t_{travel\ j,i}} \quad (1)$$

$$Acc_{j|d} = \sum_{i=1}^{m} Acc_{j|d,i} \quad (2)$$

Equation 1 is used to compute the accessibility of each cell j to the nearest health service i, within the same district d. It is the ratio between the sum of primary health services (surgeries) offered in i, Sk, and the dwelling population in each cell j multiplied with the total travel time, in minutes, to reach the primary health building i from the barycentre of each

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hexagonal cell j. Equation 2 represents the second step of the accessibility measurement: for every hexagonal cell, we summed the accessibility of each health building within the same administrative health district. According to the literature (Bauer & Groneberg, 2016; Kim et al., 2018), we identified five different accessibility classes for this case study considering the minimum number of primary health services useful to elderly (S_k) and travel time thresholds (15, 30, 45 and 60 minutes).

According to the literature review (Bauer & Groneberg, 2016; Kim et al., 2018), we identified five different accessibility classes for this case study considering a minimum number of primary health services useful to elderly (eleven services) and travel time thresholds (15, 30, 45 and 60 minutes). These levels of accessibility have also been applied in this study.

LEVEL OF ACCESSIBILITY -	TRAVEL TIME [min]	A_J -
VERY GOOD	<15	>0.73
GOOD	15-30	0.73 – 0.37
LOW	30-45	0.37 – 0.24
POOR	45-60	0.24 – 0.18
VERY POOR	>60	< 0.18

Tab. 2 Accessibility thresholds

The proposed GIS-based procedure is applied to the city of Naples to evaluate the urban accessibility at public primary health services for the elderly people. We selected this case study because it represents one of the most interesting examples of a complex southern European city with high population density, non-uniform urban structure and the absence of a specific plan to satisfy the elderly people's needs.

The city of Naples has 970,185 inhabitants (ISTAT, 2017) within 117.27 km² and is the fifth Italian city in terms of population density. In the last decade, the city was affected by a gradual increase in the elderly population: from 2008 to 2018, the elderly population of the city increased of 20,052 inhabitants (ISTAT, 2018). The Naples Local Health Agency (ASL) is responsible for the primary healthcare supply in the city boundary and it has a very complex structure due to the numerous demand (nearly one million units) and the socio-economic and health heterogeneity within the competence area. The Naples ASL has eighteen hospital institutions spread all over the city but, in order to better program and allocate resources, to monitor and manage medical care and treatments, health districts would have a significant and strategic role.

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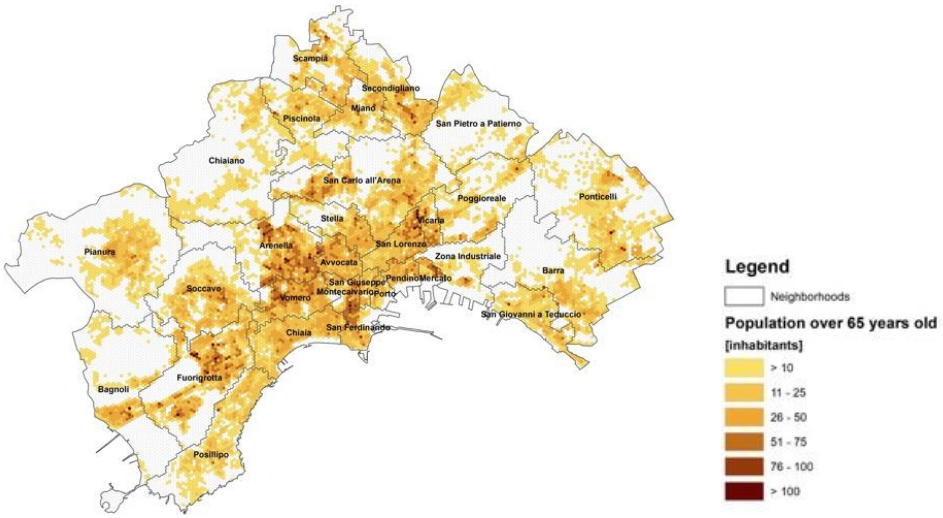

Fig. 2 The distribution of over 65-years-old population

The Italian law (D.Lgs. 229/1999 Art. 3) regulates health districts functions and identify them as territorial joints of ASL, the closest health supply for citizens. A programmatic document of health services supply at local level organizes the Districts activities and the ones belonging to upper health public levels and equivalent private services. Hence, Health Districts have a strategic role in the present welfare system whose aim is to integrate this form of assistance to more institutionalized solutions, such as physicians and voluntary organizations.

Fig. 3 The location of primary health buildings for each district

They represent a significant tool in order to limit social exclusion in urban areas.

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For the first application of this methodology, we selected local health primary services supplied by Naples ASL.

Fig. 4 The multimodal transport network

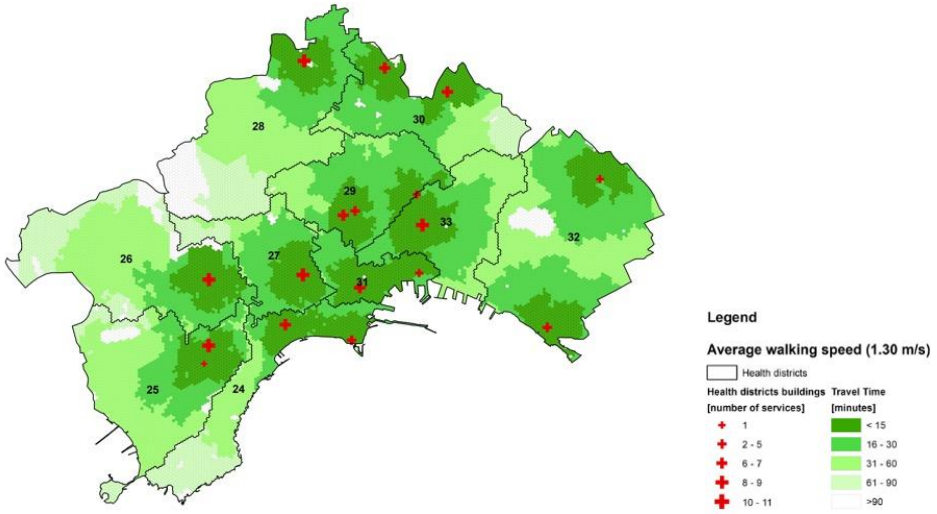

Fig. 5 The travel time to primary health centers

In particular, the municipality of Naples is divided in ten health districts, whose administrative boundaries overlap one or more neighbourhoods' borders, as reported in Tab. 2. Their structures are spread in the whole city territory and they offer the following primary services

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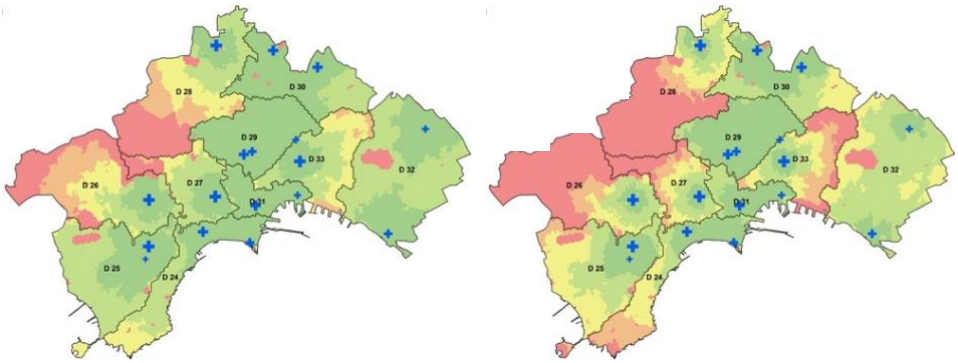
to elderly people: Cardiology, Geriatrics, Dermatology, Urology, Neurology, Pulmonology, Orthopaedics, Dentistry, Otolaryngology, Ophthalmology and Diabetology. They are managed by Campania Region and Naples ASL. A preliminary reading of the data reported in the Tab. 2 would suggest some interesting issues related to the spatial distribution of elderly and health services within the city of Naples. For instance, District 29 is the richest in health resources (building and surgeries) and its elderly inhabitants in between 65-69 years-old are the most numerous.

Moreover, District 27 (Arenella and Vomero) has the highest total and over-75-elderly (the oldest old) population, but just one health building. This initial analysis is not sufficient to investigate on social equity and it was used just as an input for the following evaluations.

According to the literature review (Bauer & Groneberg, 2016; Kim et al., 2018), we identified five different accessibility classes for this case study considering a minimum number of primary health services useful to elderly (eleven services) and travel time thresholds (15, 30, 45 and 60 minutes). In Tab. 4, 5 and 6 below, the number of elderly (65-69, 70-74 and over 75) in Naples Districts have been reported.

LEVEL OF ACCESSIBILITY	TRAVEL TIME	A_J
-	[min]	-
VERY GOOD	<15	>0.73
GOOD	15-30	0.73 – 0.37
LOW	30-45	0.37 – 0.24
POOR	45-60	0.24 – 0.18
VERY POOR	>60	< 0.18

Tab. 3 Accessibility thresholds



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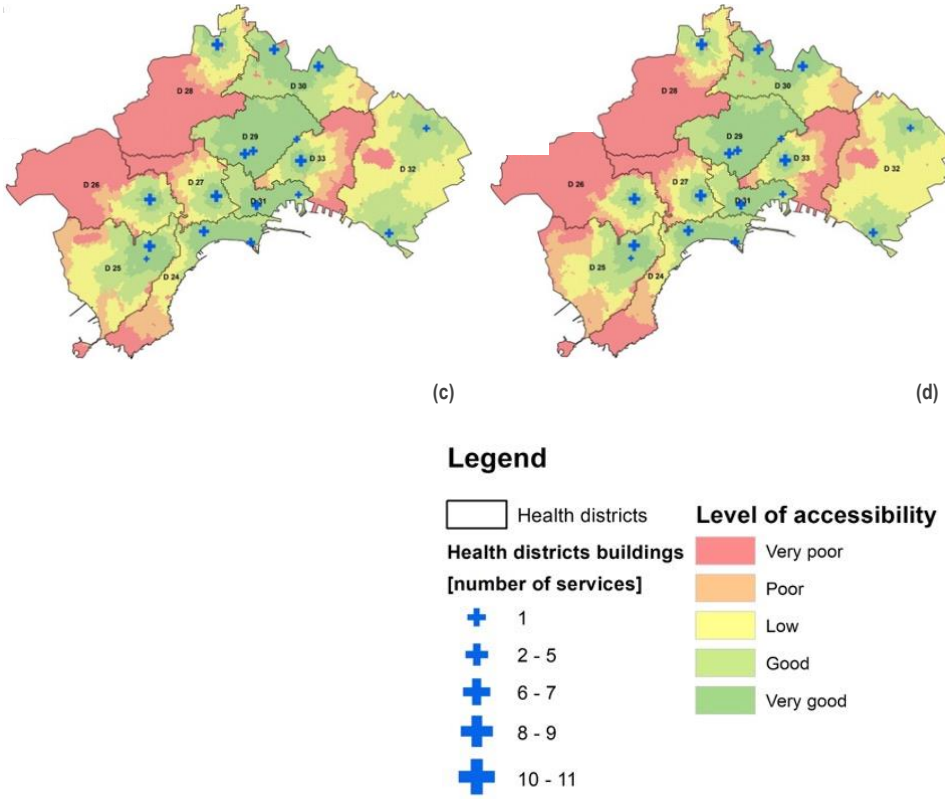

Fig. 6 Level of accessibility for an average person (a) and for the three elderly classes (b, c and d)

4 FINDINGS

For what concerns the first age range (65-69), Districts 26 (Pianura and Soccavo) and 28 (Chiaiano, Piscinola, Marianella and Scampia) need an in-depth evaluation. In District 26 about 2,000 elderly people suffer from a very poor accessibility to primary health services and this percentage increases to nearly 60% if we also consider a low, poor and a very poor level of accessibility; this means that more than half of this District dwellers access to primary health services in more than 30 minutes.

Accessibility level for District 28 is even worst since just the 8% of elderly access to primary health services within 15 minutes, while over 70% have a low, poor and very poor level of accessibility.

Indeed, 98.9% of District 29 (Colli Aminei, San Carlo all'Arena and Stella) dwellers access to primary health services within 15 minutes. This highlights the deep social and spatial inequity even for bordering neighbourhoods.

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DISTRICT	VERY GOOD	GOOD	LOW	POOR	VERY POOR
24	3,441	759	902	268	0
25	3,559	2,130	874	49	0
26	1,149	1,178	685	526	2,235
27	1,578	3,300	2,134	1,174	118
28	338	962	1,446	556	997
29	5,948	61	0	0	0
30	2,994	787	176	1	0
31	3,830	1,792	0	0	0
32	1,065	3,716	730	0	0
33	1,745	1,761	969	611	293
TOTAL	25,645	16,446	7,916	3,184	3,643

Tab. 4 65-69 aged population per district per level of accessibility

For the second age range (70-74), in District 26 and 28 more elderly people suffer from a very low accessibility level: respectively, 39.5% and 28.4% 70-74-aged people access to primary health services in more than 60 minutes. For District 27 (Arenella and Vomero), about 2.500 (more than 40%) people have a low level of accessibility, due to an access travel-time above 30 minutes. District 33 (Vicaria, San Lorenzo, Poggioreale) is not the worst in this context but it could be further investigated since nearly 40% of its 70-74-aged dwellers suffer from a low level of accessibility.

DISTRICT	VERY GOOD	GOOD	LOW	POOR	VERY POOR
24	2,286	723	692	438	23
25	2,365	1,580	882	52	0
26	641	754	622	221	1,425
27	1,205	2,571	1,667	1,024	107
28	176	574	1,049	390	778
29	4,363	143	0	0	0
30	2,009	764	69	22	0
31	2,439	1,461	42	0	0
32	758	1,924	1,100	7	0
33	986	1,273	604	436	357
TOTAL	17,228	11,767	6,726	2,589	2,690

Tab. 5 70-74 aged population per district per level of accessibility

Previous considerations are confirmed even for this last age range (over 75): districts 26 and 28 still have the highest rate of dwellers with the poorest accessibility level (respectively 37%

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and 32%). Due to the slowest walking speed considered for this elderly age rage (0.6 m/s), in every District the number of people with a low, poor and very poor levels of accessibility clearly increase.

DISTRICT	VERY GOOD	GOOD	LOW	POOR	VERY POOR
24	4,061	2,135	1,418	975	556
25	4,309	3,471	2,251	397	24
26	845	1,320	1,613	493	2,460
27	2,298	5,613	4,095	2,527	848
28	141	817	1,486	1,283	1,745
29	7,678	1,414	0	0	0
30	2,298	2,875	54	157	0
31	4,485	2,565	1,134	0	0
32	1,301	2,890	3,064	43	1
33	1,512	2,726	1,235	890	1,424
TOTAL	28,928	25,827	16,349	6,765	7,058

Tab. 6 Over 75 aged population per district per level of accessibility

5 CONCLUSION AND FUTURE DEVELOPMENTS

The growth of the elderly population in the last decades has generated a serious accessibility exclusion phenomenon. Some aspects influence the accessibility for the elderly population. The study of scientific literature on the relationship between service area extension, transport service frequency and age of users revealed the importance of considering these aspects in the evaluation of accessibility to urban services. This paper presented a quantitative method to assess accessibility to primary health services, considering a multimodal transport network and the local health system supply to elderly. In order to validate the methodology, it was applied to the city of Naples. The outputs show that entire neighbourhoods' elderly population suffers from a very poor accessibility to primary health services, especially in the city suburbs (Pianura, Soccavo, Chiaiano). In order to provide a higher accessibility level, more accurate and holistic land use planning policies are needed, also considering elderly needs and preferences. Based on the results, the methodology and the operational procedure proposed can be used as a decision support tool, in order to design new infrastructures or to optimize existing resources, in a G2B (Government to Business) point of view. In order to gain this aim, it would be useful to consider the whole primary health supply system, also considering its administrative rules and, since the main objective of our research is elderly population, a distance-decay function could be introduced to better compute their mobility availability.

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Such decision support systems are efficient tools for policy makers and urban planners, however, their contribution to knowledge production concerning the interactions of urban planning with several other social issues are usually neglected. The future work can be clarifying the knowledge-based contributions of this tool to the European and Italian knowledge of interactions of land use and urban mobility of the elderly.

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AUTHOR CONTRIBUTIONS

Paragraph 1 and 3, Gerardo Carpentieri.; Paragraph 2 and 4 Carmen Guida; Paragraph 5 Houshmand Masoumi.

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