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Urban accessibility in a 15-minute city: a measure in the city of Naples, Italy

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Abstract

Cities accessible in 15 minutes represent a new possibility for reorganizing the urban system (times, spaces and activities) to try to respond to many current challenges, including ageing populations, energy saving and, more recently, Covid-19. A renewed concept of urban accessibility, together with the redefinition of public spaces and "soft" ways of moving (pedestrian and cycle) to reach neighbourhood services, represent a starting point not only from which to face new challenges but also to rediscover the sense of community, especially at the neighbourhood scale. The 15-minute city draws its origins from the concept of the "neighbourhood unit", developed in 1923 in a competition for the city of Chicago, to define compact residential neighbourhoods where the proximity between services and homes contributed to set out the identity character of that part of the city and to create "the sense of belonging" of a community to a place. The events of the last year strongly re-propose experimentation with this approach, also following the proposal by the mayor of Paris, Anne Hidalgo, aimed at giving a new face to Paris starting from the creation of extensive pedestrian green areas on the large boulevards that are now crossed by the cars and, therefore, to allow the inhabitants to reach, by walking, essential urban services within the 15-minute threshold. Other cities, such as New York and Milan, have also begun to work to make their neighbourhoods, especially peripheral ones, accessible in 15 minutes on foot or by bicycle, without neglecting the goal of transforming these neighbourhoods into attractive places for social gathering for local communities. In this perspective, the research work aims at identifying the urban characteristics that define a 15-minute city, starting from the cities that are launching this experimentation. Among the urban characteristics, the geomorphological, physical (concerning both the spaces and the paths, such as the geometry of the pedestrian and cycle networks), functional (distribution and location of services), socio-economic (of the population) and settlement ones are taken into consideration. According to the weights of the variables identified as significant, the work defines different areas accessible in 15 minutes based on users' willingness to walk and the geomorphological, physical, settlement and functional characteristics identified in each urban area. The work is carried out in selected districts of the city of Naples which, due to their demographic, morphological and settlement characteristics, make them a significant area of experimentation.

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1. The rise of the 15-minute city: roots and features from the urban planning perspective

The ongoing pandemic crisis has become the catalyst for re-organizing cities, giving an unlikely "boost" to the development of strategies and actions to deal with climate adaptation, age-friendliness, social cohesion and public health. The awareness that another health crisis might strike has been orienting urban transformation choices to enhance soft mobility as well as the provision of public spaces and proximity-based services, especially at the neighbourhood scale (Lai et al., 2020). Curbing traffic, providing safe and pleasant spaces for walking and cycling, as well as implementing quality affordable public transport, represent the main front lines of city defence against the Covid-19 pandemic and are essential to mitigating harm from future epidemics. In particular, the most widespread measures are aimed at making the main urban streets car-free, increasing the supply of open built spaces and pedestrian routes for city inhabitants, and providing temporary infrastructure or temporary use of unexploited spaces to reduce queues and crowds for essential services, such as procuring local food. Therefore, the Covid-19 emergency, with its progressive limitations and lockdowns, has forced changes in the use of urban spaces and routes, to reach and use services as close as possible to home, to rediscover the livability of the neighbourhood by requiring travelling short distances to only the immediate area around the homes, and contributed to raising the "walking appeal", which for some years has been studied within the scientific community and political and institutional domains (Doubleday et al., 2021). The numerous benefits of walking have been widely noted in several scientific fields: from transport (in terms of decreasing pollutant emissions and vehicular congestion) to health (in terms of lowering cardio-vascular, mental and obesity risk diseases) and to sociology (in terms of reducing exclusion forms). Furthermore, many scholars have deeply studied the role of the built environment as a determinant of walking for improving global health and quality of life (Forsyth et al., 2009). This led to investigating which physical (related to morphology and pedestrian network) and functional (related to the supply of activities) characteristics of urban areas define and influence the walkability of a neighbourhood (or part of it), that is "the extent to which the built environment supports its residents to walk for leisure, exercise, or recreation" (Liao et al., 2020)

To date, the scientific community has principally addressed the nexus between walking and the urban built environment through two different approaches. The first approach is oriented to improve the practicability, safety and attractiveness of the pedestrian network by focusing on the neighbourhood scale. Cervero and Kockelman (1997) led the way to this kind of study by identifying the main urban features to take into account: they identified the primary "3Ds" (density, diversity and design) that have since been extended to the "7Ds" related also to demographic characteristics and demand management (Singh, 2016). Most scholars concur that connectivity, convenience and pleasantness are included in the physical characteristics influencing walking activities (e.g. Motamed and Bitaraf, 2016). More generally, street furniture and layout, presence of amenities, pedestrian crossings and proximity to green areas are positively correlated to walking behaviour (Barnett et al., 2017; Jansen et al., 2018). Loh et al. (2019) and Gaglione et al. (2019 and 2020) also demonstrated that to increase the walkability of the urban built environment a systemic approach should be used in order to consider it as a feature of urban accessibility based on the integration among the localization and distribution of services and open spaces, the characteristics of the network and the "needs" linked to the behaviour of segments of the population. The second approach seeks to define mode-choice modelling and travel route decision-making of pedestrians, to optimize the use of both local public transport and walking networks. Built environment interventions oriented to increase access, attractiveness, safety, and comfort could result in behavioural changes leading to increased walking and, in addition, could stimulate different perceptions and attitudes as well as increase the desire and motivation to walk (Krizek et al., 2009; Rossetti et al., 2014). Hoogendoorn and Bovy (2005) modelled different walking scenarios according to trip purpose, availability of travel modes, and economic constraints to predict travel patterns based on behaviours. Other scholars such as Loebach and Gilliland (2016) used GPS devices to track the actual routes travelled by specific population segments to investigate the frequency of use of some routes and the distances travelled daily. It is worth noting that both these two lines of research are strictly related to the urban accessibility studies aimed at measuring levels of pedestrian accessibility to urban and proximity services in order to improve their reachability and use.

If this brief scientific framework reveals the relevance of the primary form of mobility for regenerating and reconfiguring urban areas as well as improving the quality of life of their inhabitants (especially the vulnerable

population segments such as the elderly and children), it also allows realisation of the spread of 15-minute city model. The more time people spend walking, the more they are willing to fulfil their daily needs and activities within a short distance or bike ride from home by considering this soft mobility form as a way of reconnecting them to neighbourhoods and whole city life. The 15-minute city is not a new idea: before the second postwar period, the central part of urban areas was still characterized by high densities (100-200 inhabitants/ha), by a functional mix and by an organic form in which all destinations could be reached on foot. This form of organization was repeated in the small urban centres (characterized by medium density) which developed in correspondence with the stations of new transport infrastructure. The subsequent and more recent diffusion of the principles of New Urbanism ('60s) and transit oriented development (TOD) has once more focused on the walking distance to move through the city, even by referring to 5-minute walking. Furthermore, as early as the last century cities like Copenhagen, Amsterdam, and London reconfigured main streets for pedestrians.

The main difference between these previous approaches and the 15-minute city model is that the latter aims for everyone to have access to all essential services within this maximum distance on foot or by bike, both those who live in the central areas and those who live in the suburbs. The access to a wide range of services and amenities essential for quality of life should be guaranteed without spatial and social inequalities as a core spatial planning principle, in line with recent theories of urban accessibility and Universal design. From this perspective, the level of the neighbourhood is renewed, as it becomes the elementary unit from which to start to create many connected walkable communities. This work proposes a GIS-based methodology to identify which parts of an urban area can be defined as a 15-minute city, according to geomorphological, physical (related to the spaces and the paths, functional (distribution and location of services), socio-economic (population) and settlement characteristics.

2. Methodology

In accordance with the previous section, the research work focuses on understanding how the idea of the 15-minute city, based on the three pillars of inclusion, safety and health, can be adapted to current organizational forms of the city. However, if on the one hand the 15-minute city takes up well-established principles of urban planning, on the other, the relationships among all the urban elements are so complex as to indicate that this model could be a utopian vision. With this in mind, this research proposes a method to measure whether a neighbourhood is accessible in 15 minutes based on access to services, the walking needs of pedestrians and the conformation of the urban fabric. The work described in these pages aims to define the areas accessible in 15 minutes through a method in a GIS environment divided into four phases. To this end, the significant characteristics of the urban system have been selected, adopting a systemic approach, including (i) the characteristics of the population (ii) the characteristics of urban fabrics, in particular their shape, (iii) the physical characteristics relating to safety, amenities and pleasantness of the pedestrian network. Therefore, 17 variables have been identified as reported in Table 1. The socio-economic variables were parameterized using the Istat database regarding the minimum territorial unit, that is, the census parcel and the same for the characteristics related to the urban context. The geolocation of local urban services took place with the help of the Google “My Maps” platform. In the second phase, the relationships among the different groups of characteristics were identified through a correlation analysis. The intensity of these links was measured using the Pearson coefficient and the coefficients close to unity were eliminated by not providing additional information to the set of meaningful data. Phase three was aimed at relating the demand (users) to the supply (local urban services) by considering the pedestrian mode. As regards the demand, a spatial proximity analysis was developed. The algorithm underlying the proximity analysis allows defining a matrix of Euclidean distances from the centroids of the census sections to the related closer local urban services. The distance matrices relating to each urban service have the limit of not considering the actual orographic characteristics of the territory and real walkable pedestrian paths. To overcome this limit and to integrate supply and demand, the service areas were measured through further spatial analysis. For the definition of the service area, the preparatory step involved the study of how users can move along the pedestrian network. In particular, the study of the pedestrian network constituted the most onerous phase of the research work because, for each pedestrian path, 13 characteristics were classified, detected through direct surveys in the study area. Some of these variables have been parameterized to a qualitative scale (0-1) and others to a quantitative scale as shown in Table 1. For the quantitative variables, both the favourable and difficult conditions to be walked by a user are identified based on the indications provided by regulatory or planning documents. For each network link, the weighted

average of the associated characteristics defined concerning the user's availability/ability to walk expressed in terms of time, as can also be seen in the previous works by the authors (Cottrill et. al, 2020). On the basis of the travel times defined on each link of the pedestrian network and the distribution and location of all the local services examined, urban areas accessible in 15 minutes have been defined, i.e., those areas that present a functional mix of activities concerning the willingness of users to walk within them.

The comparison of the two spatial methods allows us to obtain a double indication: on the one hand, it identifies the actual Euclidean distances that users can travel to reach the services and, on the other, the users served within the neighbourhood, highlighting the gap between existing demand and supply. Finally, in phase four, the population density was compared with the 15-minute accessible areas. For each section of the census, both the total population served and not served was calculated in three population groups: 20-39, 40-59; and > 60.

ID	Variable	Unit of measure	Source
Socio-economic characteristics			
1	Population density	Ab	Istat
Characteristics of the urban fabric			
2	Height of buildings	M	Geoportale Nazionale
3	Density of the built	mc/mq	Istat
4	Compactness of the urban fabric	S/V	GIS
Characteristics of the pedestrian network			
5	Network connectivity	n of intersections / link length	GIS
6	Slope of the network link	M	GIS
7	Sidewalk width	M	Google maps
8	State of the pavement	yes/no	Google maps
9	Presence of cycle paths	Km	Google my maps
10	Presence of traffic lights	yes/no	Google maps
11	Crossroad	yes/no	Google maps
12	Pedestrian crossings	yes/no	Google maps
13	Speed of vehicular traffic	km/h	GIS
14	Volume of vehicular traffic	M	GIS
15	Presence of benches	si/no	Google maps
16	Presence of shaded paths	n°	Google maps
17	Noise pollution	dBA	PZA

Table 1. Set of variables related to the main urban characteristics.

3. Results and conclusions

Detecting which parts of an urban settlement fulfil the 15-city minute requirements, namely density, proximity, and diversity of services, by applying the proposed methodology entails a test area that holds relevant differences of pedestrian accessibility, distribution and kind of activities and their typology and built environment both to guarantee the reliability of the procedure and to take into consideration some of the main kinds of urban fabrics widespread in densely built European cities. Therefore, the experimentation area of this work consists of the V (Vomero and Arenella neighbourhoods) and VIII (Chiaiano, Piscinola and Scampia) Municipalities of Naples, which represent two examples of central and peripheral districts, respectively.

From the 17 variables collected for the whole study area, 5 have been excluded because they are strongly correlated with others and, therefore, do not add significant increases in information to the data system. Indeed, the correlation

matrix has some correlation coefficient values close to unity for crosswalk, speed of vehicular traffic, volume of vehicular traffic, noise pollution and compactness ratio. The crosswalk variable is highly correlated to sidewalk width and state of the pavement (both positively) and with slope (negatively), suggesting that the physical characteristics that contribute to determining the usability of a pedestrian arc and its safety depend on each other and that an orography not favourable to the walkability of an area (high slope) can strongly penalize even good quality conditions of the route that would otherwise be used. The speed and volume of vehicular traffic and noise pollution variables have been eliminated due to their mutual correlation, according to the fact that they refer to the safety and urban quality context that a pedestrian can perceive by walking. It is worth noting that these three variables are correlated negatively to the presence of benches, confirming the relevance of the physical and geometric characteristics of the built environment in terms of the quality of the urban space and its potential attractiveness and usability. The compactness ratio variable is negatively correlated to slope, connectivity and noise pollution and these links underline, also in this case, the attention that should be placed in designing and organizing urban spaces and canals through which to move easily and safely, even in densely built and steeply sloping fabrics.The 13 remaining variables allowed development of the spatial analysis aimed at identifying the urban portions accessible in 15 minutes. Figs. 1 and 2 show whether there is a balance between demand (users) and supply (local services) through the interweaving of two spatial analyses in the GIS environment, considering the pedestrian mode of users in the V and VIII Municipalities, respectively. The first proximity analysis highlights which users are able to reach local services in terms of Euclidean distances. The second service area analysis shows, based on the distribution and localization of the necessary local services, the actual areas that can be reached, taking into account the characteristics of the individual pedestrian paths and their temporal availability to follow them. The comparison of these two analyses highlights the areas and users actually served in 15 minutes. In particular, the area fitting a 15-minute city model covered the majority of the territory of this Municipality, resulting from characterization also including demand-supply equilibrium; namely, the satisfaction of users' needs in relation to the location of local services (Fig. 1). This confirms the benefits resulting from thoughtful planning of a compact urban fabric characterized by a good distribution and mix of local services and an extended pedestriannetwork that facilitates reaching necessary services, especially in the more consolidated areas such as Vanvitelli Square.

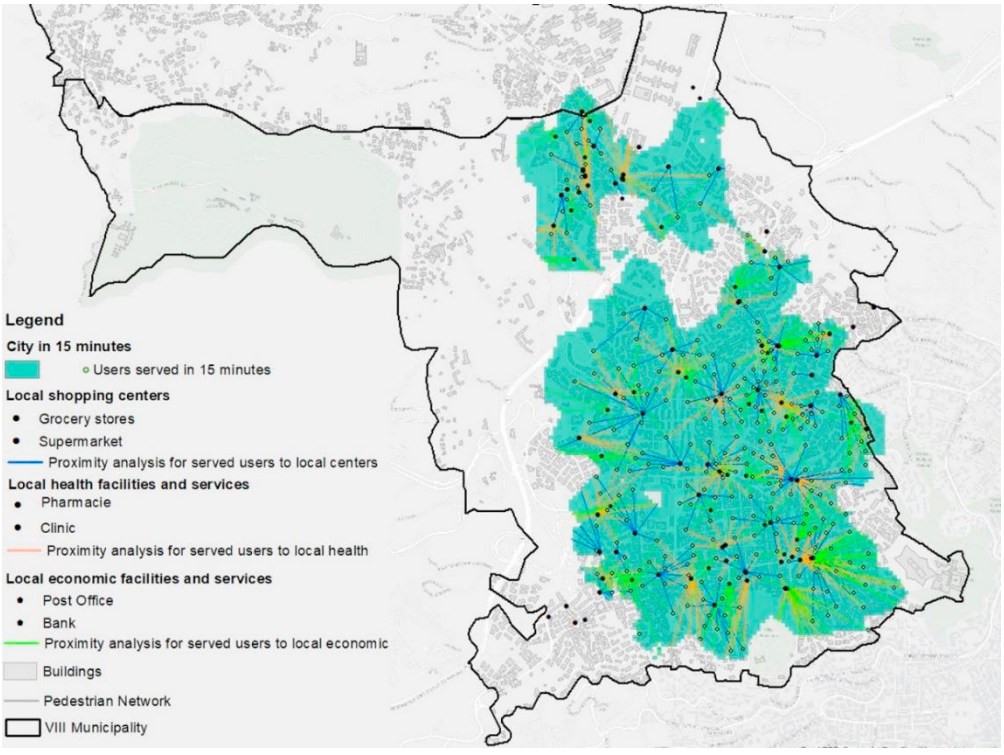
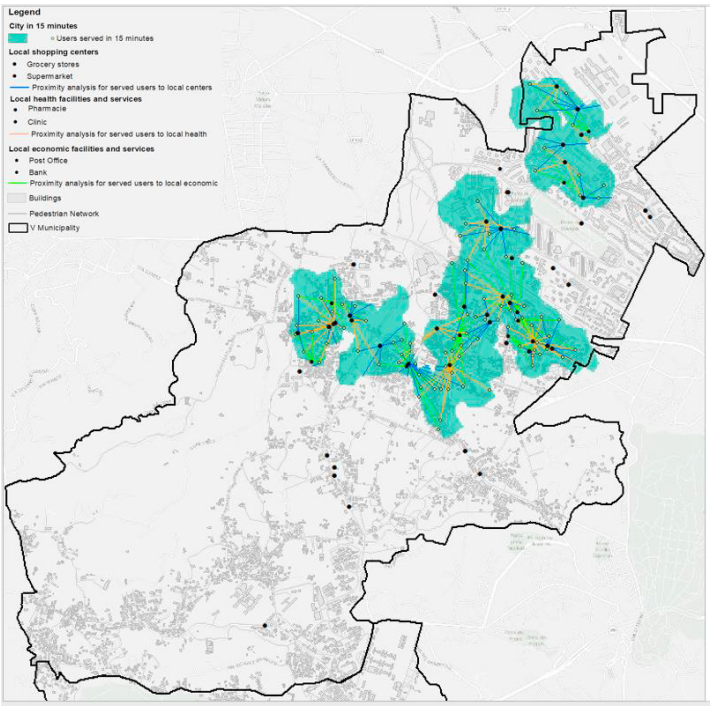


Fig. 1. 15-minute city area within V Municipality.

Nevertheless, the inhabitants living in the south-east area near the boundary of the V Municipality, in the Camaldoli area (North-east zone) and the area near Pietro Castellino street (the area between the two 15-minutes zones) cannot reach local health, shopping and commercial services by walking, as these services are located at distances not compatible with their willingness to walk (distances longer than 800 m). From an overview of Fig. 2, it immediately emerges that areas served in 15 minutes constitute only a small portion of the VIII Municipality. In particular, in the south-west there is a high lack of a good functional mix and only in continuity with the V Municipality is the presence of services related to health, in detail, in the area adjacent to the Cotugno hospital center and in the south-east of the Municipality, while presenting a pedestrian network that is not adequate to be walked. The areas adjacent to the Chiaiano and Piscinola-Scampia underground line is characterised by the presence of a high functional mix of local services due to the planning logic that the station areas are strategic places in which to locate the insertion of new activities. Although the areas have a mix of activities, the users served in the area near the Chiaiano station have a network of pedestrian paths that are safer and more usable than those in the area adjacent to the Piscinola-Scampia station. Finally, in the areas bordering the "vele" buildings and the Scampia, park, which have been the subject of a planning activity linked to economic and social housing, there is the inclusion of different activities at the service of these residences and with adequate pedestrian accessibility.



Accessibility to local services			
V Municipality	Maximum proximity distance (m)		
Time	Local shopping centers	Local health facilities	Local economic facilities
> 15 min	899	870	
< 15 min within service area	476	530	
	Δ= 420	Δ= 340	

Accessibility to local services			
VIII Municipality	Maximum proximity distance (m)		
Time	Local shopping centers	Local health facilities	Local economic facilities
> 15 min	900	880	
< 15 min within service area	472	492	
	Δ= 428	Δ= 388	

Fig. 2. 15-minute city area within VIII Municipality and proximity distances within and out of the 15-minutes area.

In line with current research that defines 15-minutes as the maximum time that people are willing to walk (and the equivalent in terms of distances, such as 800 m) to be able to meet daily needs locally (Badland et. Al, 2014), this research work has questioned the actual proximity distances that can be walked by taking into account the morphological, settlement and functional characteristics, starting from an even greater distance than users are willing to walk, 900 m. Fom this perspective, it emerges that users are able to reach the three types of services considered within 15-minute intervals for the V Municipality with maximum distances ranging from 476 to 530 m, highlighting a delta of difference between 340-420 m between the maximum possible and effective distance (table within Fig. 2). Furthermore, users will reach their destination within 500 m and will have to take the same distance to return, exceeding the limit at which they are willing to walk. Similarly, in the VIII Municipalities the maximum distances that can be walked in 15 minutes to reach the three types of services oscillate between 472 and 554 m, outlining a

delta between 336 and 428 m (table within Fig. 2). Finally, Fig. 3 aims to define the relationship that exists between the population density of the two Muncipalities with the areas that respond, in part, to those characteristics of 15-minute accessible neighborhoods. In detail, it can be seen for the V Municipality that the areas with high population density are served by a good functional mix of services, in the most consolidated part of the Vomero district such as the area of Piazza Vanvitelli and Piazza Medaglie D'oro and in the recently formed area such as the one adjacent to the Hospital Pole. For the VIII Municipality, the areas accessible in 15 minutes are also areas with a high population density, although the areas adjacent to them with a high population density lack the necessary services. This is further confirmed by the calculation of the total served population as can be seen from diagrams of Fig. 4: the entire Municipality of Naples is served for more than half, equal to 68% while 32% is not served. In contrast, in the VIII Municipality the total population served in 15 minutes is 34% while the non-served 66%. The overall calculation of the population is a sign of the large gap between urban areas that emerges from the point of view of the land use intensity of the VIII Municipality, which is connoted as place of marginalization. In addition, the calculation of the population served for three population groups (20-35; 40-55;> 60) shows that for the V Municipality the vulnerable groups of the population over 60, who are those willing to move less, are more served by the different types of local services compared to other population groups due also to a greater concentration of these services in areas where the urban fabric is consolidated in line with the real estate values of the area compared to the area of the Rione Alto. This is in contrast with VIII Municipalities, where the vulnerable groups of the population are marginalized and in the absence of essential care and services are having to move using other modes to reach services in the adjacent Municipalities. The younger segments of the population are better served, also confirming the characteristics of the neighborhood based on an economic and popular building which reflects the social profile of the area, which manifests itself with problems related to poverty, low schooling, and early parenting.

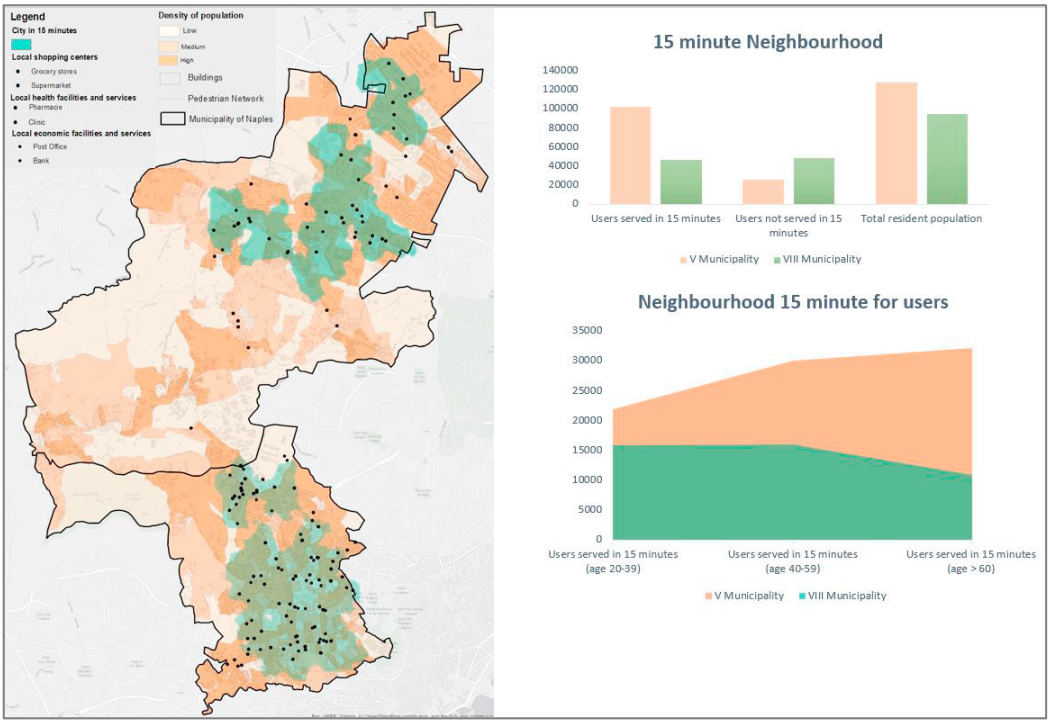


Fig. 3. Distribution of population density within V and VIII Municipalities and related served and unserved population rates

The results highlight how the pandemic has raised new research questions in the scientific field, stimulating the study of how people's lives are affected when they are forced to limit movement and have to rely on their immediate community for both daily needs and entertainment, such as green spaces. In particular, the proposed methodology aims to define a Spatial Analysis procedure, through the use of cutting-edge research software such as ArcGIS Pro, in order to examine the advantages and shortcomings of the neighborhoods located both in the center of the city and peripheral areas, keeping together the urban characteristics of the neighborhoods and the use of more sustainable modes of travel for the city, such as the pedestrian one. The operational results highlight not only the relationships among groups of population, the supply of local services and the network of pedestrian paths, but, at the same time, identify and direct public administrations for the implementation of interventions aimed at developing safer neighborhoods that are accessible and well connected for pedestrians and cyclists, to offer high quality public spaces and open spaces and to provide services and destinations that support local life. A note is that, as the analysis was undertaken based on administrative districts, the findings may be subject to the modifiable areal unit problem (MAUP) at the district boundaries. This is acknowledged as an area to explore in future research.

References

Badland H, Whitzman C, Lowe M, Davern M, Aye L, Butterworth I, Hes, D and Giles-Corti B (2014). Urban liveability: Emerging lessons from Australia for exploring the potential for indicators to measure the social determinants of health, Social Science and Medicine, 111: 64–73. https://doi.org/10.1016/j.socscimed.2014.04.003

Barnett, D.W.; Barnett, A.; Nathan, A.; van Cauwenberg, J.; Cerin, E.(2017). Built environmental correlates of older adults' total physical activity and walking: A systematic review and meta-analysis. Internation Journal of Behavioural Nutrition and Physical Activity, 14, 23. doi: https://doi.org/10.1186/s12966-017-0558-z

Cervero, R.; Kockelman, K. (1997). Travel demand and the 3Ds: Density, diversity, and design. Transportation Research. Part D Transport and Environment, 2, 199–219.

DoubledayA., Choe, Y., Busch Isaksen, T., Miles, S., & Errett, N. A. (2021). How did outdoor biking and walking change during COVID-19?: A case study of three US cities. PLoS one, 16(1), e0245514. doi: https://doi.org/10.1371/journal.pone.0245514

Forsyth, A., Oakes, J. M., Lee, B., & Schmitz, K. H. (2009). The built environment, walking, and physical activity: Is the environment more important to some people than others?. Transportation research part D: transport and environment, 14(1), 42-49.

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. doi: http://dx.doi.org/10.6092/1970-9870/6272

Gaglione, F., Cottrill, C., & Gargiulo, C. (2021). Urban services, pedestrian networks and behaviors to measure elderly accessibility.Transportation Research Part D: Transport and Environment, 90, 102687. doi: https://doi.org/10.1016/j.trd.2020.102687

Gargiulo, C., Zucaro F. & Gaglione, F. (2019), Improving accessibility to urban services for over 65: a GIS-supported method, in C. Gargiulo & C. Zoppi (Eds.), Planning, nature and ecosystem services (pp. 839-850). Naples: FedOAPress. doi: https://doi.org/10.6093/978-88-6887-054-6

Jansen, E., Pijpers, R. & de Kam, G. (2018). Expanding Capabilities in Integrated Service Areas (ISAs) As Communities of Care: A Study of Dutch Older Adults' Narratives on the Life They Have Reason to Value, Journal of Human Development and Capabilities, 19 (2), 232-248, doi: https://doi.org/10.1080/19452829.2017.1411895

Hoogendoorn-Lanser, S., van Nes, R., Bovy, P. (2005). Path size modeling in multimodal route choice analysis. Transportation Research Record: Journal of the Transportation Research Board, 1921,27-34. https://doi.org/10.1177%2F0361198105192100104

Krizek, K.J., Handy, S.L., Forsyth, A. (2009). Explaining changes in walking and bicycling behavior: challenges for transportation research. Environment and Planning B: Planning and Design, 36, 725–740. doi: https://doi.org/10.1068%2Fb34023

Lai, S., Leone, F., & Zoppi, C. (2020). Covid-19 and spatial planning. TeMA - Journal of Land Use, Mobility and Environment, 231-246. https://doi.org/10.6092/1970-9870/6846

Loebach, J.E., Gilliland, J.A., 2016. Free range kids? Using GPS-derived activity spaces to examine children's neighborhood activity and mobility. Environ. Behav. 48 (3), 421–453.

Loh, V. H., Rachele, J. N., Brown, W. J., Ghani, F., Washington, S., & Turrell, G. (2019). The potential for walkability to narrow neighbourhood socioeconomic inequalities in physical function: A case study of middle-aged to older adults in Brisbane, Australia. Health & place, 56, 99-105. doi: https://doi.org/ 10.1016/j.healthplace.2019.01.020

Motamed, B., & Bitaraf, A. (2016). An empirical assessment of the walking environment in a megacity: case study of Valiasr Street, Tehran. Archnet-IJAR: International journal of architectural research, 10(3), 76-99.

Rainham, D., McDowell, I., Krewski, D., Sawada, M., (2010). Conceptualizing the healthscape: contributions of time geography, location technologies and spatial ecology to place and health research. Soc. Sci. Med. 70 (5), 668–676.

Rossetti S., Tiboni M., Tira M. (2014), Road Safety in Italy: an Assessment of the Current Situation and the Priorities of Intervention, Periodica Polytechnica Transportation Engineering, vol. 42 (2), pp. 159-165, doi:: 10.3311/PPtr.7490.

Singh, R. (2016). Factors affecting walkability of neighborhoods. Procedia-Social and Behavioral Sciences, 216, 643-654. doi: https://doi.org/10.1016/j.sbspro.2015.12.048