



# Measuring age-friendliness based on the walkability indices of older people to urban facilities

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Accepted: 16 June 2022 / Published online: 14 July 2022

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## Abstract

This study aims to measure age-friendliness based on the walkability indices of the older people to urban facilities in the sample area of Istanbul, Turkey and the various districts within. It focuses on three key urban facilities in age-friendly cities: open public spaces, health services and basic needs; Quantitative datasets are also utilised in order to measure the age-friendliness of the urban environment. There are two main quantitative dimensions of the study: to generate accessible areas to facilities and to identify age-friendly values within the identified accessibility areas. To measure age-friendliness, new index sets were created using the Age-Friendly Approach Index and the Weighted Age-Friendly Approach Index. The results underline that the most age-friendly areas of open spaces are in the districts: Fatih, Beyoğlu and Üsküdar; the most age-friendly areas of health services are in Kadıköy, Şişli, Beyoğlu, Fatih, Bayrampaşa, Güngören and Bahçelievler; the most age-friendly areas of basic needs are in Fatih, Kadıköy, Şişli and Gaziosmanpaşa. Overall, Fatih, Kadıköy, Beyoğlu and Şişli districts were found to have the widest age-friendly accessible areas, whilst districts moving towards the periphery of the city decrease in terms of age-friendliness. The least accessible areas are found in Beykoz, Çekmeköy, Büyükçekmece and Silivri. The results allow us to discuss, compare and better understand age-friendliness and local government policies.

**Keywords** Walkability · Age-friendly environment · The older people · Spatial index

## Introduction

The issue of ageing began to gain attention in the 1960s (Aiken 1995) and this topic has become increasingly relevant in recent years since as a result of unprecedented ageing populations in the world. Developed countries, in particular, are faced with growing ageing populations due to a decrease in fertility rates and developments in health services (Beard et al. 2012; Coleman 2006). The World Health Organization (WHO) has definitive criteria relating to the categorisation of individuals in the older sections of society. WHO has provided the following age categorisations: young old (between 65 to 74), old (75 to 84), and the oldest old (85+).

As such, in the current paper, older people are accepted as being age 65 and above and this is expressed through the abbreviation A65A.

As ageing comes with certain losses such as mobility, social network, income, emotional and physical health, a supportive living environment is the indisputable necessity required in order to provide support for active ageing people. A supportive age-friendly environment consists of many indicators such as adequate housing, accessible and affordable health services and transportation (Warth 2016; WHO 2002, 2018). Beyond these, meeting the basic needs of the older people in their daily life routine plays a critical role in ageing in place. Open spaces (parks and squares), basic needs (grocery, leisure facilities, pharmacies and hairdressers) and health services are the fundamental urban facilities to deliver an age-friendly environment (Bayar and Türkoğlu 2021). Furthermore, as mobility decreases while ageing, people become more dependent on these urban facilities within walking distances (Leyden 2003), and as such, an age-friendly environment should provide urban facilities considering accessibility within the walkable area.

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Open public spaces, such as green parks, squares and green areas are places where older people can socialise, do physical activities and feel encouraged to spend time outside of the home (Sugiyama and Thompson 2007; Yung et al. 2016), of particular importance as older people can often feel excluded and isolated from the community due to changes in social network and roles in the society. Therefore, an accessible open public space provides a social environment to meet and talk to people, helping to prevent older people from isolation and loneliness, as well as providing an opportunity to recover from health problems through spending time in an open space, walking and exercising (Gutman 2007).

To continue with urban facilities, delivering basic needs in a closed living environment supports outdoor activities of older people, such as visiting the post office, shopping, banking, picking up prescriptions, as well as engaging in social activities, religious activities, visiting a neighbour or attending a course (Gehl 2011). As we age, health facilities, in particular, become a priority at an accessible distance and an age-friendly environment needs to deliver health facilities, such as hospitals, family health emergency services, walk-in health care and so on (Abbing 2016; Breyer et al. 2010). Walkability to basic needs is essential for the older people to be independent.

On top of all these features of an age-friendly environment, the underlying principle is ‘accessibility’ (Buffel et al. 2014; Buffel and Phillipson 2012, 2016; Neal and DeLaTorre 2009; Warth 2016; WHO 2002, 2018, 2007). Loss of mobility in ageing process results in loss of independence and this causes isolation and loneliness (Porta and Renne 2005; Rantakokko et al. 2013). Thus, being able to access certain needs without depending on others' help is the significant policy for an age-friendly environment to enhance active ageing. The meaning of accessibility differs based on the perspective (Ostroff and Preiser 2001; Stucki et al. 2007; Unit and Information 1994). Regarding measurement points, all essential urban facilities should be accessible by either a certain transport mode or walking. Accessibility involves distance, time, space and financial indicators. In this paper, to measure overarching accessibility, it primarily concerns distance and time, but regardless of older people's capacity (Iwarsson and Ståhl 2003). The distance parameter to urban facilities is determined by considering the walking speed of older people, which also specifies the time parameter (Alves et al. 2021).

Walkability is not only considered as physical activity, but also walkable neighbourhoods encourage people to engage in outdoor social and political activities, to discuss political and community issues and to establish a greater community sense (Jun and Hur 2015). Also, it is evident that there is an encouraging relationship between physical activity and accessibility without a mode of transport to leisure

facilities and the presence of walking areas (Humpel et al. 2002; Porta and Renne 2005).

Creating age-friendly environments in built-up areas is challenging, especially in metropolitan cities (van Hoof et al. 2021). Nonetheless, the population projections underline the fact that 60% of the world population will live in cities by 2030 (United Nations 2020). In this study, Istanbul is selected as the case area and it is the main metropolitan city in Turkey, which is considered a developing country. Istanbul hosts more than 15 million people in total and a growing number of the older residents A65A. Therefore, transforming urban areas into more age-friendly environments is becoming essential.

Research on people A65A in the case of Istanbul is quite limited in terms of spatial studies. Among the research, Şentürk and Ceylan (2015) discussed the sociological dimensions of people A65A through the use of a survey. Another study, Bayar and Türkoglu (2021), revealed the impacts of the existing urban environment on the daily needs of the older people through in-depth interviews and survey methods on specific sampling areas. Also, Özer et al. (2022) conducted a survey with people A65A using the age-friendly cities and communities questionnaire provided by Dikken et al. (2020) based on WHO-Age-friendly Guide (WHO 2007) to understand the validity of measurement tools of age-friendly environments in Istanbul. This study will support local governments while developing the areas for age-friendliness and contribute to future spatial policies. However, addressing the lack of spatial assessments is paramount in this research, the presence of an ageing population and future spatial planning policies will become increasingly important in this context.

The hypothesis of this study is that an urban area is more age-friendly if urban facilities that are crucial for daily life for the older people are within walking distance. Thus, the study measures age-friendliness based on the walkability indices of the older people to urban facilities to reveal age-friendly environments in the city and provide a guideline for policy makers and practitioners. Although creating an age-friendly environment requires several determinants of both environmental and personal, this study focuses on three urban facilities in age-friendly cities: open public spaces, health services and basic needs within walking distance. This study is laid out as follows; The spatial analysis steps start with creating walkability indices to determine accessible areas to these urban facilities in the city. The two indices, the *Age-Friendly Approach Index (AFAIndex)* and the *Weighted Age-Friendly Approach Index (WAFIndex)*, are created based on the literature review of age-friendliness primarily for this study. The dimensions of indices are decided considering age-friendly city models provided by researchers and practitioners (Warth 2016; WHO 2007, 2002). As the hypothesis of the study stands on the importance of



walkability to spatial structure, the social perspective is not used as a dimension of indices. Secondly, these determined accessible areas are also analysed using the *AFAIndex* and the *WAFIndex* to assess whether or not environmental factors have an impact on these walkable areas. Lastly, the results are evaluated regarding both existing and recommended urban policy and planning processes.

## Data and methodology

The section comprises the study area, determining analysis dimensions, data collection and the method used for analyses of the study.

### Study area

Istanbul is a metropolitan area with a size of 5400 km<sup>2</sup>, with districts on both the European and Asian continents (Fig. 1). Istanbul has thirty-nine districts, which are located as urban and rural settlements on the periphery while the districts in the centre are predominantly urban settlements. The districts with rural settlements are Arnavutköy, Başakşehir, Beykoz, Büyükçekmece, Çatalca, Çekmeköy, Eyüp, Pendik, Sancaktepe, Sarıyer, Silivri, Şile and Tuzla. Overall, Istanbul is home to more than one million people aged 65 and above. This population is distributed into districts with a total population ratio of 10% or more are as follows: 19.7% of Adalar, 19.3% of Kadıköy, 18.2% of Şile, 16.2% of Beşiktaş,

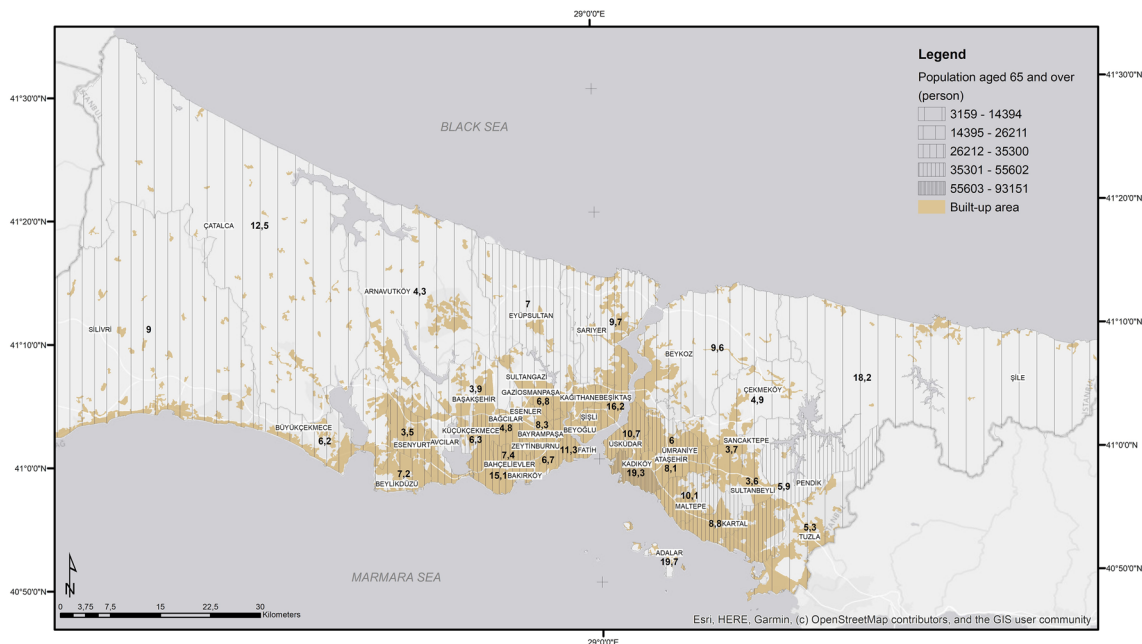
15.1% of Bakırköy, 12.5% of Çatalca, 11.3% of Şişli, 11.3% of Fatih, 10.7% of Üsküdar and 10.1% of Maltepe (Fig. 1) (TUIK 2020).

Different urban forms are seen according to the urban morphologies of Istanbul districts. While the central districts are seen as a more compact form of settlement, it is seen that the settlement areas towards the periphery are rural settlements and leapfrog patterns. In addition, it is seen that the northern peripheral districts and the southern Central districts have a high rate of the population aged 65 and above (Fig. 1).

### Data collection

Since the aim of the study is to measure age-friendliness based on the walkability indices of the older people to urban facilities, the initial step is to create dimensions -urban facilities and spatial data- as seen in Table 1. Accessibility of older people in this study is defined as 'to be able to reach basic activities without depending on a mode of transport. Accessibility is measured on the basis of the distance parameter from urban facilities, which is determined by considering the walking speed of older people.

As mentioned before, the literature review has led us to three fundamental *urban facility dimensions*: open spaces, health facilities and basic needs. The rationale for choosing these particular facilities within these dimensions is as follows:



**Fig. 1** The study area and spatial distribution of the percent of the population age 65 and above [prepared by the authors based on the data taken from TUIK (2020)]



**Table 1** The dataset and definitions used in the study

Dimensions	Facilities	Data definitions*	
Urban facilities	Open spaces	Open public space	The spatial locations of squares and public waterfront areas in the land use map of Istanbul Metropolitan Municipality (IMM 2015)
		Open green space	The spatial locations of parks and recreational areas in land use map of Istanbul Metropolitan Municipality (IMM 2015)
		Religious building	Refers to the central point spatial position representing the buildings of places of religion covering all types of religions. This is point feature data which have longitudes and latitudes (OSM 2021)
	Health facilities	Family Health Centre (FHC)	Defined as Family Health Centres of the Ministry of Health of the Republic of Turkey. This is point feature data which have longitudes and latitudes (OSM 2021)
		Basic needs	Leisure Facility
	Grocery facility		Markets, general stores, greengrocers that have their NACE codes: 47.11.01, 47.11.02, and 47.21.01 (ICOC 2021). The data types are postal addresses of all places in the Istanbul Metropolitan Area
	Hairdresser facility		Hairdressers of all genders that registered to the board that have their NACE codes: 96.02.02 and 96.02.03 (ICOC 2021). The data types are postal addresses of all places in the Istanbul Metropolitan Area
	Pharmacy facility	Pharmacies are registered to the board. This is point feature data which have longitudes and latitudes (OSM 2021)	
Spatial data	Land use	The spatial locations of residential and mixed-use areas (commercial and residential use) in the land use map of Istanbul Metropolitan Municipality (IMM 2015)	
	Physical geography	Slope	Terrain characteristics derived from digital elevation model (DEM) data that is a raster (USGS n.d.). It is used to obtain slope percentages ranging from 0 to 100
	Road Intersection of urban network	Intersection points	Refers to connectivity nodes to roads. The street crossings are obtained from nodes of network analysis (“Methodology” section)

\*All data are collected in the Istanbul Metropolitan Area

## Open spaces

An accessible open space provides a social environment to meet and to talk to people which prevents older people from isolation and loneliness. Additionally, walking and exercising can help to recover from health problems (Gutman 2007). In this study, considering the environment, open spaces are categorised into three groups: (a) open public spaces: squares and waterfront areas, (b) open green spaces: parks and recreational areas and (c) religious buildings. In Turkey, religious buildings’ courtyards, especially mosques, are frequently used as gathering points and places to engage in social activities (Arnberger et al. 2017; Bayar and Türkoğlu 2021; Biando 2005; Wen et al. 2018). The spatial data of open public spaces (a) and open green spaces (b) are obtained as polygon feature data from Land Use Map of Istanbul Metropolitan Municipality (IMM 2015). The spatial locations of religious buildings (c) are retrieved as point feature data, nodes by longitude and latitude, within the Istanbul Metropolitan Area from OpenStreetMap, which is a map created for free use under an open licence (OSM

2021). In the OSM (2021), it is tagged as *amenity=religious buildings* in the spatial data search.

## Health facilities

As the main idea stands on walkability instead of measuring the accessibility to general hospitals, this study decided to focus on family health centres (FHCs) as a walk-in health facility. Because hospitals offer services on a larger scale (citywide or district-wide), whereas family health care centres target smaller areas such as local neighbourhoods (Aktürk et al. 2015; Sparkes et al. 2019). Therefore, it is important for the older people to be able to access walk-in centres, especially for those who are unable to use public transportation either due to health problems or financial restrictions (Padeiro 2018; Somenahalli and Shipton 2013). In this study, the spatial locations of all FHCs are retrieved as point feature data from OpenStreetMap (OSM 2021). Health data are obtained from the OSM (2021) source. Within this health data, the spatial data terms *primary health*



*care* (sağlık ocağı in Turkish) and *family health centres* (aile sağlık merkezi in Turkish) are used.

### Basic needs

Basic needs here refer to facilities that enable the accomplishment of daily routine of older people. The obligatory activities decided to measure are as follows: grocery and leisure facilities, pharmacies and hairdressers (Bayar and Türkoğlu 2021; Gehl 2011; Steels 2015; WHO 2007). The daily routine is encouraged by the presence of facilities, as well as accessibility to those facilities that keep the older people active. Therefore, this study measures the accessibility in walking distance to those basic needs to determine age-friendliness (Hornakova and Hudakova 2011; Metz 2000; Somenahalli and Shipton 2013). The spatial locations of pharmacies are retrieved as point feature data from OpenStreetMap (OSM 2021). In OSM, it is tagged as *amenity=pharmacy* in the spatial data search. All leisure, grocery facilities and hairdressers within the Istanbul Metropolitan Area, which are used for converting spatial locations (see “Methodology” section), are obtained as addresses. The addresses are found via NACE (Nomenclature of Economic Activities) code (Table 1) and the affiliated Istanbul Chamber of Commerce (ICOC) (ICOC 2021). The NACE code can be translated into the International Standard Industrial Classification (ISIC). The ISIC is the international reference classification of all economic activities. Economic activities used in the study, therefore, can be expressed as common references utilised for the data collection and analysis of the same activities in similar studies.

This study is also aware of some advantages and restrictions of physical structure, which are data of the factors used in the study methodology (“Methodology” section). There is a significant amount of evidence that the physical environment contributes to the walkability of people (Leslie et al. 2007). *Physical geography*, *road intersection of urban networks*, the high number of *intersection points* and *land use* (Table 1) are factors affecting the walkability of the age 65 and above (Alves et al. 2020). The for choosing the *spatial data dimensions* is as follows:

### Land use

The mix of *land use* delivers multiple options for the older people to maintain their daily activities in the living environment, so they are more encouraged to walk and cycle regularly (Kahn et al. 2002; Porta and Renne, 2005; Ramirez et al. 2006; Saelens et al. 2003). Residential and commercial areas are fundamental parts of *land use* that allows the older people to be active in outdoor life. Therefore, the mix of *land use* has positive associations with age-friendliness.

### Physical geography

*Physical geography* such as slopes are a real barrier to older people moving around easily. Changes in the body during the ageing process result in a decline in mobility (Rantakokko et al. 2013). The distance to a certain place may be 400 m in walking distance but the presence of a *slope* increases the use of energy and travel time because it decreases the travel speed (Koh and Wong 2013).

### Road Intersection of urban network

The final dimension is the *road intersections of the urban network* which may refer to the connectivity to major roads. However, some researchers underline that the high number of *intersection nodes* which means street crossings may result in confusion, safety risks and longer waiting times in walking distance in especially in crowded metropolitan areas (Ferrer et al. 2015). For this reason, the older people may choose to avoid using certain routes to walk and may also result in feelings of intimidation by the environment.

### Methodology

As mentioned before, this study utilises quantitative datasets to measure the age-friendliness of an urban environment. There are two main quantitative dimensions of the study, which are to generate accessible areas to facilities in the city and to identify age-friendly values within the identified accessibility areas.

### Preparing the basis of analysis of spatial data

Firstly, in order to generate accessible areas, geocoding of addresses, which converts addresses into map locations with the locator, the main tool for geocoding in ArcGIS, was used to spatially locate the addresses of basic need occupations in ICOC (2021) data, which are leisure facilities, grocery facilities and hairdresser facilities. Open public space and open green space used as area data are converted from polygons to point data to cover all these areas. Thus, all urban facilities used in the study are converted to *spatial point data*.

Secondly, the service areas of all urban facilities were created by *Network Analysis* through ArcGIS. They were evaluated to identify accessible areas around the location of the facilities on the road network. Service areas are a region that covers all accessible streets at a distance. Through all these spatial analyses, walkable areas were generated.

### Identifying the impact area of urban facilities

To identify the impact area of urban facilities in certain walkability lengths, the *first step*, the maximum distances



to basic needs, open public spaces and family health services were determined. As the walking speed of older people differs from other groups, people A65A are able to walk 400 m in 10 to 15 min on average, depending on their health condition (Julius et al. 2012; King and King 2010; Sundquist et al. 2011). Regarding the average timing of the round trip, accessing basic needs and going back home should be less than 30 min (Millward et al. 2013); therefore, the maximum distance to basic needs (leisure facilities, grocery, hair-dresser and pharmacy) is accepted as 400 m in this study. Moreover, with a normal walking speed, a person of 65 can walk 500 m in less than 10 min and this is found to be the best daily exercise for the older people (Alves et al. 2020). As such, the accessible distance to open spaces (open public space, open green spaces, religious buildings) is determined as being 500 m. On the other hand, general practitioners are considered accessible within a 20-min walk, and therefore, family health centres are expected to be within 800 m in this study (Todd et al. 2015). Afterwards, walkability indices were created to measure the age-friendliness of an urban environment regarding the walkable areas.

### Measuring walkability indices and defining factors

*Age-Friendly Approach Index (AFAIndex)* and *Weighted Age-Friendly Approach Index (WAFIndex)* are created to measure age-friendly values within the identified accessible areas. The AFAIndex comprises the factors of the mixed-use area with residential use, diversity (Plouffe and Kalache 2010), slope (Alves et al. 2020) residential area and intersection nodes (Ferrer et al. 2015). The definitions and total values of the AFAIndex can be seen in Table 2.

The evaluation of indices is interpreted as follows: the more the percentage values of mixed-use and diversity increase, the more age-friendly areas occur. Because mixed-use diversity has a positive influence on the daily activities of older people (Landorf et al. 2016), it (which is residential and commercial areas existing together) delivers more age-friendliness. On the other hand, while the percentage of the slope, residential area without mixed-used and intersection nodes increase, the less age-friendly road network is found. Residential area here means a housing area without any mixed-use or existing retail shopping facilities around and these types of areas are considered as having a negative impact on age-friendliness (Finlay and Kobayashi 2018). The existence of a slope also significantly affects the accessibility to the urban facilities in terms of both walking speed and spending energy negatively (Kang and Dingwell 2008; Webb et al. 2017). Moreover, a high number of intersection nodes, which are street crossings, create a high number of usage density and unsafety that discourage the older people from walking in certain routes especially in metropolitan areas (Ferrer et al. 2015). Hence, these dimensions are

considered for people A65A as negative spatial variables. The AFAIndex is formulated as follows:

$$AFAIndex_i = \frac{(Mx_i + Dv_i) + 100}{(Sp_i + Rs_i + In_i) + 100}$$

where  $i$  is the facility accessible area;  $j$  is the intersection set of  $i_n$  facilities;  $Mx$  is the mixed-use;  $Dv$  is the diversity;  $Sp$  is the slope;  $Rs$  is the residential area; and  $In$  is the intersection nodes (see Table 2 for descriptions).

The WAFIndex is the sum value of every intersected part of AFA Index areas. The AFAIndex performs a calculation from the service areas of each facility, while the WAFIndex runs a calculation in one layer from the areas where the AFAIndex's service area layers intersect on top of each other. The purpose of the WAFIndex's assessment is that having a few facilities together in walkable areas will give older people an advantage in having an alternative facility selection opportunity. The WAFIndex is formulated as follows:

$$WAFIndex_j = \sum_{i=1}^n AFAIndex$$

The AFAIndex values are minimum 0.25 and maximum 3. The WAFIndex values are minimum 0 and do not have a maximum value because accessible areas can have many intersecting parts. The increase in values refers to the values from non-age-friendly spaces to the age-friendly area. The threshold value of the AFAIndex is 0.75, which means that a value above refers to age-friendly areas when a value below is non-age-friendly areas. The ArcGIS software (Esri) was used to perform all spatial analyses in this study. All spatial analyses were carried out in the GCS\_WGS\_1984 Geographic Coordinate System.

## Results

The study focuses on three urban components in age-friendly cities within walking distance, which are open public spaces, health services and basic needs. The results of the analysis are compared among districts where the population of people A65A is higher than 10%. This section reveals the highest and the lowest values of age-friendly areas at the district level (all result maps are given in Online Appendix A).

### Open spaces

Open spaces are analysed based on three categories: open public spaces, open green spaces and religious buildings. The intersection analysis of three categories in Fig. 2 shows that the most age-friendly areas are overriding in Fatih,



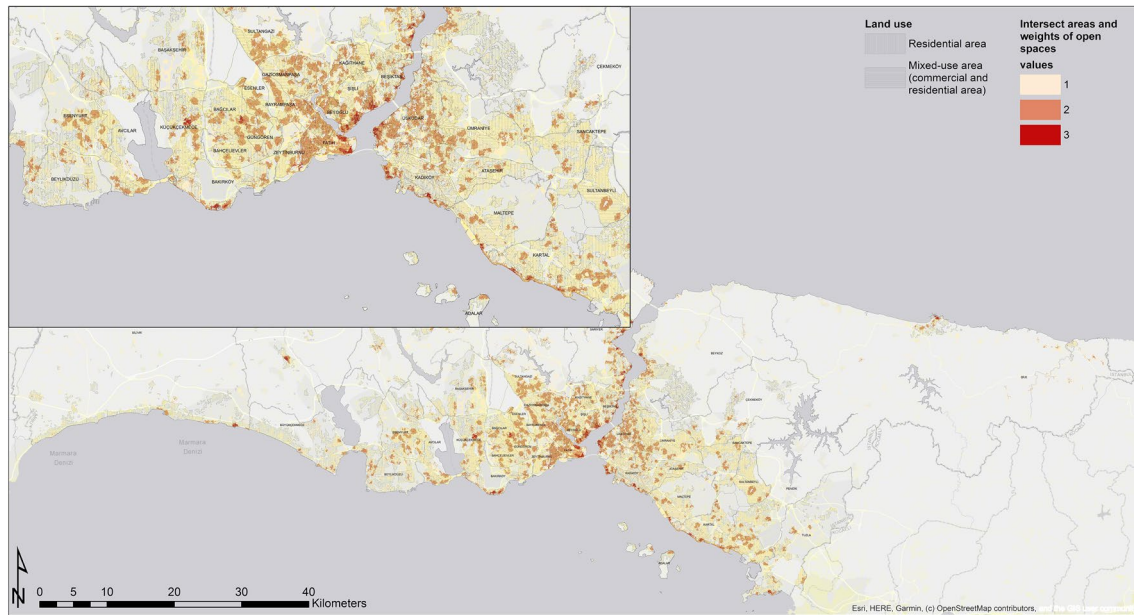
**Table 2** Descriptions, measurement, and rationality of factors using AFAIndex

Factors	Description and measurement	Rationality of developing factors	Total values
Mixed-use	Common use area of residential and commercial areas in the accessible areas based on facilities served by the road network It is explained that as the mixed-use usage rate increases in the accessible area, there are more age-friendly areas	As the value of diversity within accessible areas increases, the need for motorised movements decreases, which greatly increases age-friendly neighbourhood quality of life (Porta and Renne 2005). Mixed-use diversity has a positive influence on the daily activities of the older people (Landorf et al. 2016)	Min.: 0 Max.:200
Diversity	Commercial use area in the accessible areas based on facilities served by the road network It is described that as the commercial use rate increases in the accessible area, there are more age-friendly areas	Porta and Renne's (2005) study emphasises that commercial centres of neighbourhood units are important in ensuring social sustainability	
Slope	Refers to areas of physical geography with a slope of 8% or more, which is inappropriate for age 65 and above As the percentage of surface slope increases, it means moving away from an age-friendly environment	Burton et al. (2011) study notes that older people who live on flat streets are adversely affected by a lack of deceleration for motor vehicles caused by the slope of street topography. Moreover, Slope surfaces are one of the biggest challenges for all age groups, as well as especially the older people, to walk (Alves et al. 2020; Kang and Dingwell 2008; Webb et al. 2017)	Min.: 0 Max.:300
Residential use	Residential area in the accessible areas based on facilities served by the road network In accessible areas, only the increase in residential use indicates that there are less age-friendly areas	Finlay and Kobayashi (2018) found that residential areas without mixed-use are considered a negative impact on age-friendly neighbourhoods	
Intersection nodes	Junction points within the accessible areas based on facilities served by the road network. The rate is the percentage within the sum of the junctions in all accessible areas As the number of intersection nodes increases, the age-friendly environments of the older people are adversely affected	Burton et al. (2011) found that the older people living in high-density areas tend to feel less safe from motorised traffic The high number of <i>intersection nodes</i> , which means street crossings, may be resulted in confusion, safety risks and longer waiting times crowded in walking distance in especially in the metropolitan areas (Ferrer et al. 2015)	

All measurements were made through network analysis on the road network

The measured unit of all factors is the percentage—%





**Fig. 2** Intersecting accessible areas and weight values of open spaces (prepared by the authors)

Beyoğlu and Üsküdar districts, respectively. However, the spatial data analyses of the results of categories underline significant differences between open spaces. The dominant age-friendly areas within walking distance are where religious buildings are located, and Fatih district is found to have the highest value among the other districts in this section (Fig. A.3). Secondly, open green areas within walking distances have the next highest values for age-friendly areas and the coastal areas of the Anatolian side become prominent. Also, Fatih district is the most age-friendly area regarding open green spaces (Fig. A.2). Open public spaces have the lowest values among all categories (Fig. A.1). Still, Fatih district comes out ahead among all districts. The AFAIndex values of open public spaces, open green spaces and religious buildings vary from 0.37 to 1.58, from 0.33 to 1.81 and from 0.33 to 1.79 in Istanbul, respectively. And the WAFIndex values of these facilities vary from 0.18 to 1.98, from 0.15 to 1.62 and from 0.19 to 1.79, respectively.

### Health facilities

The Family Health Centre facilities are evaluated within an 800-m accessible area. The analysis underlines that some areas cannot be accessed by all residential and mixed-used areas (residential + commercial) (seen in Fig. 3). Kadıköy, Fatih, Şişli, Zeytinburnu, Bayrampaşa, Güngören, Bahçelievler, Esenler and Bağcılar are the districts where there is a very wide range of accessible residential e (shown in Fig. A.4). Accordingly, while the AFAIndex values of FHCs vary between 0.34 and 1.89 in Istanbul, the WAFIndex values vary between 0.15 and 1.71. This means that, according to

the AFAIndex threshold value of 0.75, age-friendly areas are seen in certain districts, which are Kadıköy, Şişli, Fatih, Güngören, Bahçelievler and Bayrampaşa. These are also the districts with high ratios of people A65A. However, this assessment was also obtained from all residential and residential + commercial areas, where people A65A can reside, except for age-friendly areas (Fig. A.4).

Among the districts with the highest AFAIndex value, the districts with the most age-friendly areas are Kadıköy, Şişli, Beyoğlu, Fatih, Bayrampaşa, Güngören and Bahçelievler. On the other hand, when the WAFIndex values of these districts are examined, it is seen that the values of Kadıköy and Şişli decrease at a high rate. Additionally, the values also decrease in Şişli, Güngören and Fatih districts. The reason for this reduction in value is that the advantageous and disadvantageous spatial factor variables of the AFAIndex (Table 2) increase or decrease while converting them to the WAFIndex. The reason for the decrease in the indices value of these districts shows that the disadvantageous spatial factors of the AFAIndex are in the same regions as the intersect.

### Basic needs

The measure of age-friendly areas of basic needs reveals that Fatih, Kadıköy, Şişli and Gaziosmanpaşa districts have the highest ratio of the age-friendly areas (Fig. 4). However, the analysis also delivers that the wider range of age-friendly areas among basic needs within walking distance is groceries (Fig. A.6). Fatih, Bahçelievler, Bayrampaşa and Sultanbeyli districts are found to be the most age-friendly districts





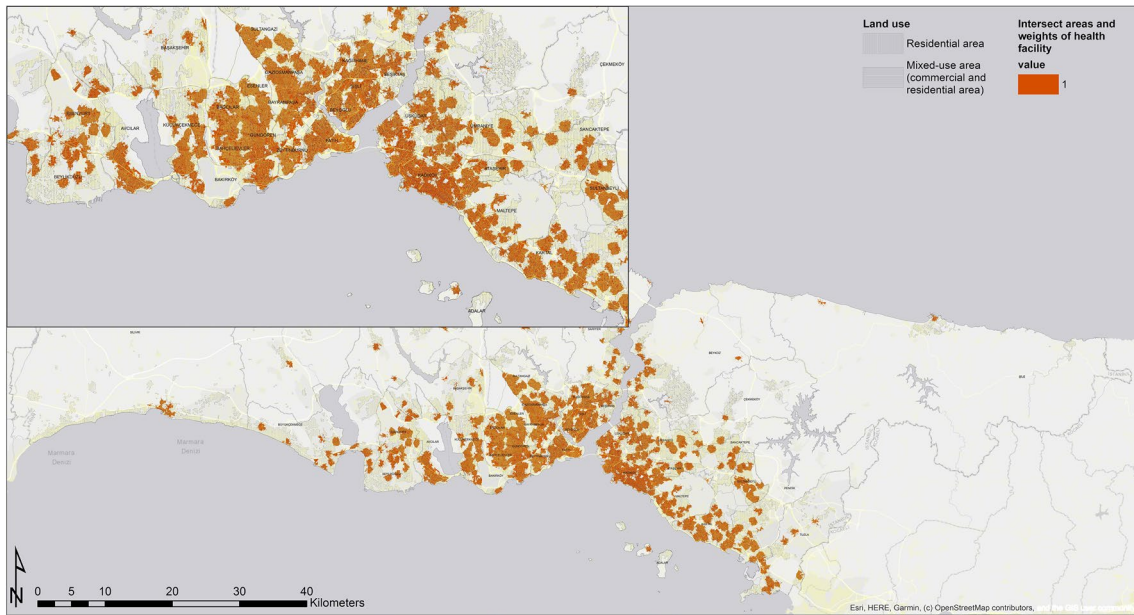


Fig. 3 Intersecting accessible areas and layer of FHCs (prepared by the authors)

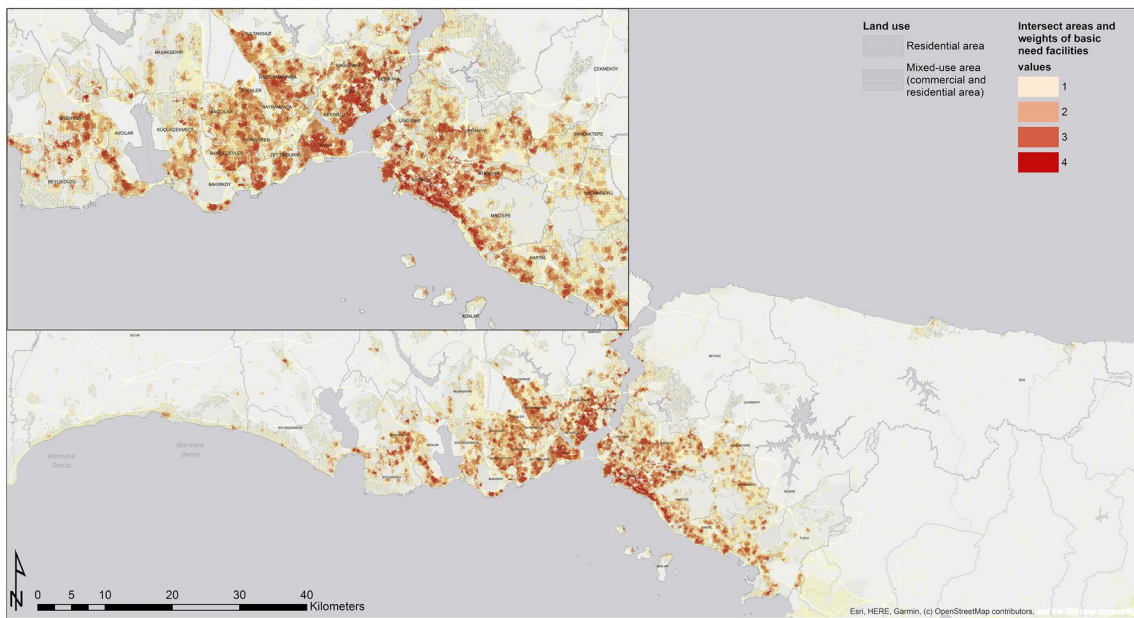


Fig. 4 Intersecting accessible areas and the number of overlay layers of basic need facilities (prepared by the authors)

regarding accessibility to groceries, respectively. The AFAIndex values of groceries diverge from 0.33 to 1.89 but there is a significant decrease in the WFAIndex which varies from 0.10 to 1.02. Pharmacies (Fig. A.8) are the second dominant basic needs that have the higher values in Fatih, Bayrampaşa, Bahçelievler and Kadıköy districts, respectively. The AFAIndex values of pharmacies are between 0.33 and 1.98. There is a slight difference between the WFAIndex which is 0.13–2.04. On the other hand, leisure facilities

in Fatih, Beyoğlu, Şişli and Kadıköy districts have more service areas (Fig. A.5). There is a considerable difference between the AFAIndex and the WFAIndex values of leisure facilities. While the AFAIndex values are in between 0.33 and 1.82, the WFAIndex values vary from 0–13 to 2.49. Finally, hairdressers get higher values in Kadıköy, Şişli and Fatih districts, respectively (Fig. A.7). There are slight changes between the AFAIndex and the WFAIndex values, which are 0.33–1.74 and 0.14–197, respectively.



## Intersecting accessible areas and weight values of eight facilities

Figure 5 presents the overall values of the intersection of all urban facilities that are used to understand the age-friendliness of the city. Regarding the most accessed age-friendly areas, Fatih, Kadıköy, Beyoğlu and Şişli districts have the widest area compared to others. The least accessible areas are found in Beykoz, Çekmeköy, Büyükçekmece and Silivri. The analyses show that in these towards the periphery districts, moving from the central districts, the clustering of potential age-friendly areas decreases. The clustering of urban facilities or decentralisation depends on several factors, such as compact growth of the city, land use decisions or road network patterns. On the other hand, the black areas in Fig. 5 indicate the residential areas that have no access to analysed urban facilities. It can be seen that the major inaccessible areas are in the urban periphery areas, but the central districts also have inaccessible areas in terms of age-friendliness.

In terms of the accessibility to urban facilities from residential areas, Bayrampaşa, Beyoğlu, Esenler, Fatih, Kadıköy, Sultangazi, Şişli and Zeytinburnu districts have the highest ratio of accessible areas to the facilities compared to the other districts. Among the districts where the population ratio of people A65A is more than ten per cent, Adalar, Bakırköy, Beşiktaş, Çatalca, Maltepe, Şile and Üsküdar districts have the most inaccessible areas compared to the others. On the other hand, Esenyurt, Bağcılar, Bahçelievler and Zeytinburnu, where the population of

people A65A is low, have the highest accessibility rate to urban facilities.

Figure 6 is produced to underline the distribution of the ratio of inaccessible areas to each category in the districts. Open spaces are the greatest value compared to others. This means that the districts that have the more inaccessible areas to open spaces and basic needs have a similar value to open spaces. On the other hand, health facilities have the least inaccessible areas among all categories. It is understood that the city has the most accessible areas to health facilities.

The districts, where inaccessibility to urban facilities rate is the higher, are found to be: Adalar, Arnavutköy, Başakşehir, Beykoz, Beylikdüzü, Büyükçekmece, Çatalca, Çekmeköy, Sancaktepe, Silivri and Şile, respectively. The details reveal that open public spaces create the most inaccessible areas among all districts in Fig. 7. The inaccessible areas to open public spaces have the highest value among all facilities and all districts have similar values. Additionally, the ratio of areas which have no access to hairdressers is considerable. The districts which have inaccessible areas to hairdressers are Adalar, Şile, Silivri, Küçükçekmece, Gaziosmanpaşa, Eyüpsultan, Büyükçekmece, Beykoz, Beylikdüzü and Başakşehir. The common thread to all these districts is that many of them are periphery districts. The third urban facility that has the highest inaccessible areas is open green spaces. Adalar, Maltepe, Silivri, Sultanbeyli and Şişli districts have the least accessible areas to open green spaces. Leisure facilities follow open green spaces regarding inaccessibility. Arnavutköy, Başakşehir, Beykoz, Beylikdüzü, Büyükçekmece, Silivri, Sultanbeyli and Şile districts

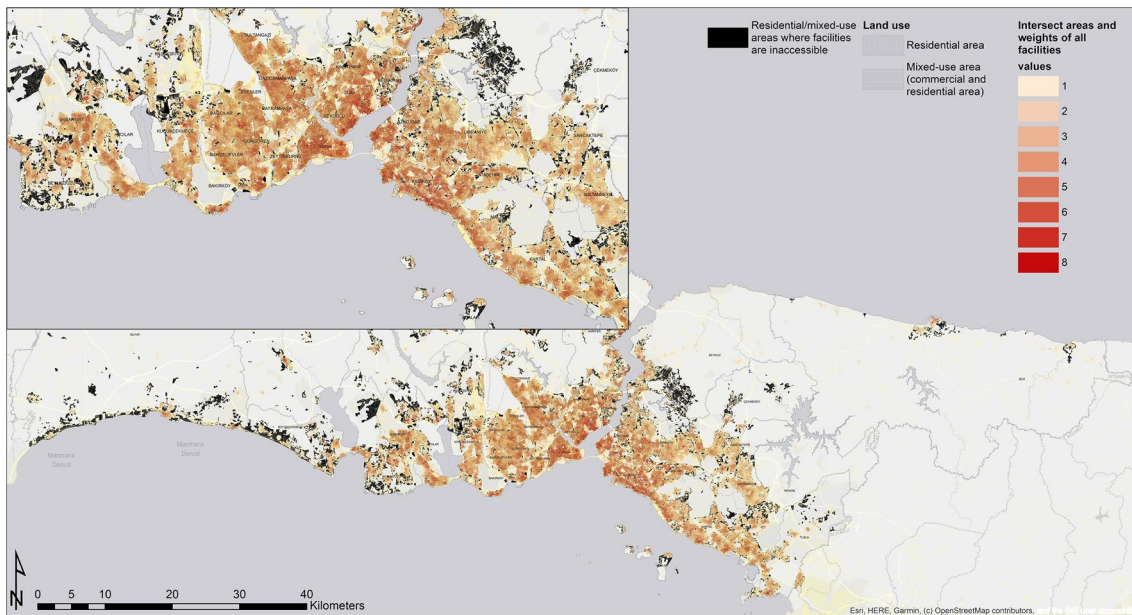
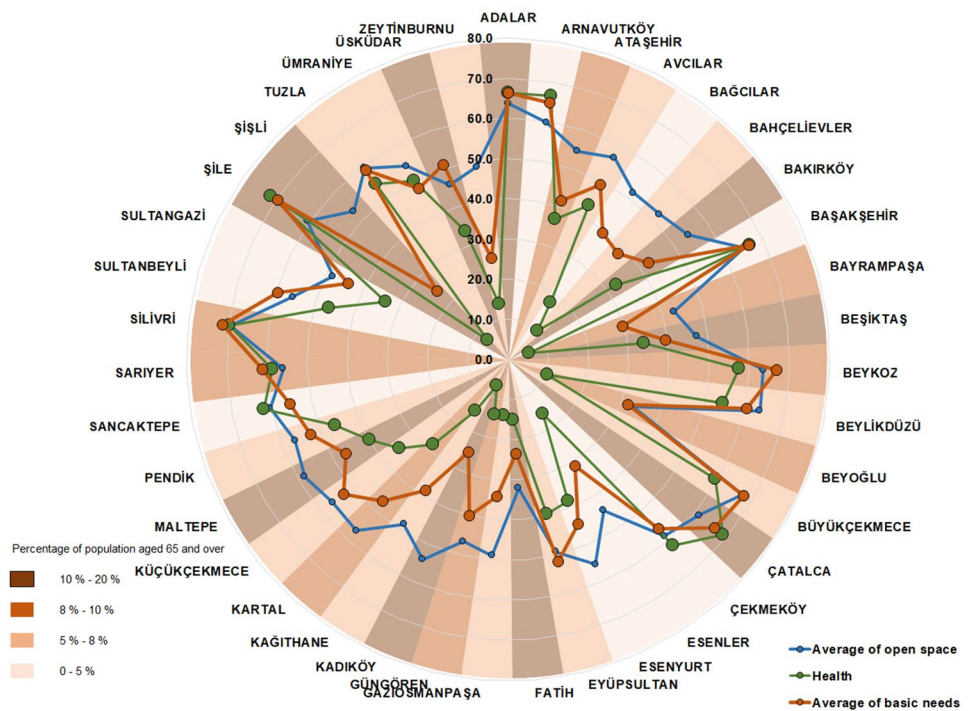


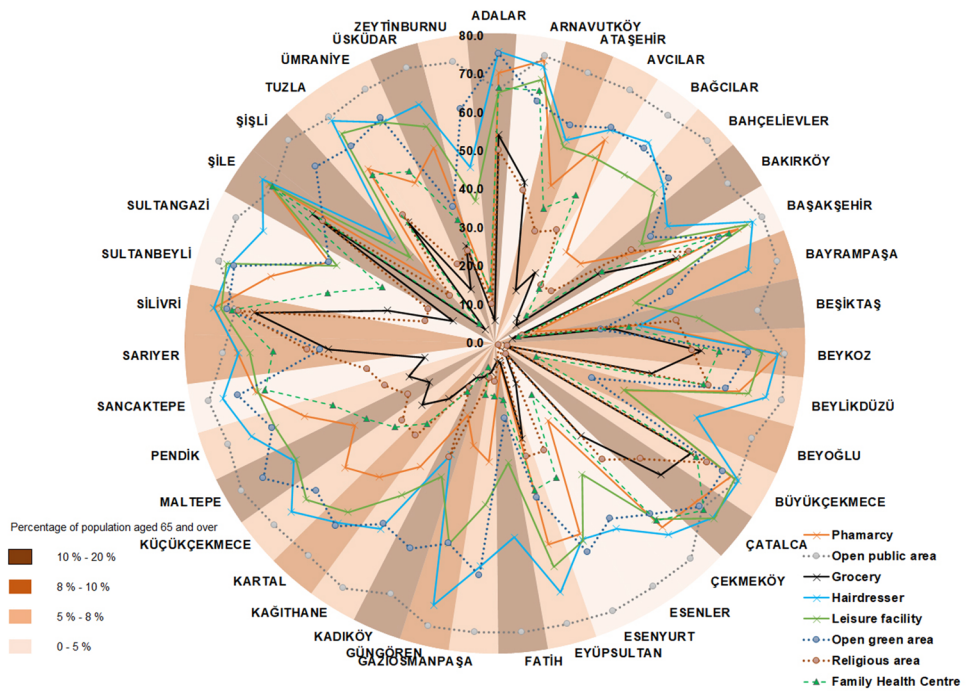
Fig. 5 Intersect areas and the number of overlay layers of all facilities, and residential/mixed-use areas where facilities are inaccessible (prepared by the authors)



**Fig. 6** Average percentages of inaccessibility to facilities in residential area and mixed-use area (prepared by the authors)



**Fig. 7** Inaccessibility land use percent to facilities based on residential area and mixed-use area (prepared by the authors)



have the highest values of inaccessibility to leisure facilities. Pharmacies are the fifth facility on the inaccessibility scale. Silivri, Şile, Adalar, Arnavutköy, Başakşehir, Beykoz and Büyükçekmece are on the top of the list of inaccessible areas to pharmacies.

The least three inaccessible areas to facilities start with religious areas. The highest rate of inaccessible areas to

religious buildings are in Silivri, Şile, Adalar, Başakşehir and Büyükçekmece. The least accessible areas to Groceries are dominant in Silivri, Şile, Adalar, Başakşehir, Beykoz, Büyükçekmece and Çatalca districts. However, Sancaktepe, Silivri, Şile, Adalar, Arnavutköy, Başakşehir, Çatalca and Çekmeköy districts still have higher inaccessible areas to family health centres (Fig. 7).



To sum up, the spatial analysis of the city based on accessibility to urban facilities from residential areas reveals the most and the least accessible areas in all districts. The results underline the residential areas which have no access to these facilities and the need to be improved in order to deliver an age-friendly environment. The results also underline the current spatial situation of the districts where the population of people A65A is the highest. In the discussion section, the spatial analysis and urban policies are evaluated, and recommendations are provided.

## Discussion

This study aimed to measure age-friendliness based on the walkability indices of older people to urban facilities and as a result, this study provides an analytical approach on the importance of walking distance for older people. To achieve this purpose, the study utilised quantitative datasets to measure the age-friendliness of an urban environment (“Methodology” section). Through all these spatial analyses, walkable areas are generated and afterwards the walkability indices (the AFAIndex and the WFAIndex) are created to measure the age-friendliness of an urban environment regarding the walkable areas.

### Spatial approach of age-friendliness

The hypothesis of this study is that an urban area is more age-friendly if urban facilities that are crucial for daily life for older people are within walking distance, because the most common transport mode for the specific age group, like older people, is walking. The results of the ageing process lead to refined preferences of lifestyle; therefore, they depend more on the availability of their necessities within the walking area (Dellamora 2013). They choose walking instead of commuting by a mode of public transport for their daily routines (Bayar and Türkoğlu 2021; Porta and Renne 2005). The significance of the study is that the results allow researchers to discuss and compare spatial age-friendly areas and their relation to existing local government policies.

For walkability, older people’s health and physical situation is significant because ageing primarily causes a decline in health, especially in mobility (Lee and Talen 2014; Sundquist et al. 2011; Woolrych 2017; Zhang et al. 2014) and healthy ageing discusses the necessity of independence in later life (Zaidi et al. 2017). Being independent in later life means to be able to perform daily needs without asking for full support from others (Hunter et al. 2011; Lager 2015; Schehl and Leukel 2020; van Dijk et al. 2015). Therefore, accessing urban facilities without depending on a transport mode is highlighted in this research as the independence of the older people. Moreover, the distances to the facilities,

the urban design and the physical geography are the determinants of walkability and, therefore, they should not interfere with mobility. For this reason, the walkability in the study is a measure of the age-friendliness of the living environment through age-friendly indicators. The factors of interference used in the age-friendly indices are mixed-use, diversity, slope, residential use and intersection nodes, which affects the results either positively or negatively, as has been found in similar studies (Alves et al. 2020; Fan et al. 2018; Zaidi et al. 2017). According to the indices of the study, the main findings indicate that the values of the age-friendly approach can be changed by geography, locations of districts and the role of settlements in the urban system. As previously mentioned, Istanbul has nine districts where people A65A account for more than 10% of the population. The main reason for analysing these nine districts from among thirty-one is that local municipalities in Istanbul and the national government supports age-friendly initiatives where the older population is higher.

The relationship between quality of life and age-friendliness has been discussed by many researchers as well as social exclusion (Cornwell and Waite 2009; Dickens et al. 2011; Garner and Holland 2020; Gibney et al. 2020; Mullen et al. 2022). The most used age-friendly approach is developed by WHO to identify primary indicators for age-friendly cities that cover both the environmental and the personal determinants (WHO 2007). The common criteria mentioned in the age-friendly approaches are related to services, mobility and safety. In the current study, the AFAIndex and the WFAIndex have been developed through the older people-oriented approach with flexibility and simplicity. This research focuses on walkability to services in built environment, which also intersects and supports other age-friendly research in terms of area-related outcomes as well as negative effects of environmental challenges such as slope and intersection nodes (Aguiar and Macário 2017; Alves et al. 2021; Gibney and Ward 2018; Horak et al. 2022). The indices used in this study significantly contributed to the understanding of age-friendliness in spatial planning detail. The AFAIndex is made up of mix-used, diversity, slope, residential use and intersection nodes that directly affects the walkability to basic urban needs of the older people. The intersection of urban facilities creates the higher density of age-friendliness and this is measured by the WFAIndex. The importance of the indices is that it can be adopted and used by metropolitan cities like Istanbul, because the large study area scale restricts the possibility of an assessment at the neighbourhood scale of detail. The AFAIndex can be extended by including the public transportation, the flatness and the safety issues, because it is flexible and simple for use regarding large and the metropolitan cities to reveal the lack of urban needs of people. On the other hand, this study primarily concerns the existing built environment effects on



age-friendliness, therefore, dimensions like the safety, the security is not included into indices. Another perspective of this study is that it focuses on the specific demographic group, but it can be adapted to the other levels of society by changing the walking distance.

Although creating an age-friendly environment comprises both design and policies, this study proves the noteworthy effect of urban planning on age-friendliness. The created indices can be applied to any type of urban environments to measure age-friendliness before developing planning and policy implications. Furthermore, it can be improved by adding different factors to apply the other aspects of the community issues, such as people with disabilities. While the districts are found to be lacking in open spaces, the municipalities have been focusing on delivering institutional-based policies. Therefore, researchers and policy makers can identify the possible areas that need to be improved to support older people and develop urban planning and policies. Furthermore, the data of walkability in Istanbul can be used for public health and encourage the other policy makers to underline the importance of walkability for older people.

### Implications and impacts on urban planning and policies

All urban policies can be accepted as not-spatial based but social services. However, successful age-friendly cities aim to provide adequate and accessible urban environments and social policies that are integrated into the spatial design process (Green 2013; Neal and DeLaTorre 2009; Ruza et al. 2012). Therefore, the age-friendly approach of the study contributes to a spatial approach. Governments, authorities, planning practitioners and academicians have carried out age-friendly city implementations (Buffel and Phillipson 2012; Chan et al. 2016; Colangeli 2010; Greenfield et al. 2015; Green 2013; Menec et al. 2011; Neal et al. 2014; Phillipson 2012; Pittsb 2020; Steels 2015) and they have created policies to deliver age-friendliness.

As a result of Kadıköy, Şişli and Fatih in Istanbul being central districts with a high proportion of commercial areas in the city, the residential areas cluster in certain areas of the city. This, therefore, played a role in the differentiation of the index values. The basic needs and the urban facilities can be within the clustered residential areas and can be located unequally in terms of accessibility. However, these districts are among the central business districts of Istanbul, so there is a considerable amount of urban facilities. So, despite these areas' drawbacks, there are advantages regarding the issue of accessibility.

On the other hand, Adalar, Şile, Çatalca and Maltepe can be considered periphery districts. The spatial layout is more of a sprawl pattern and urban facilities, and basic urban needs are distant from the central districts. This study

found that the central districts are more age-friendly regions compared to the periphery districts. Essentially, the central districts have a more complex road network and dominant central business districts; therefore, the features can be less age-friendly areas in terms of the mobility of people A65A. However, since the districts have more attractive urban facilities, their age-friendly values can be higher than the periphery districts.

Although the polycentric city patterns have become more commonplace in many cities, the city centres are still the most walkable areas because cultural, economic and commercial activities are more concentric. In line with the findings of Fan et al. (2018), the central districts of Istanbul are found to be the highest accessible and walkable places in this study. The results of the indices proved that the most accessible areas are in the central districts and as a result, policy makers should make it their priority to improve walkability in the periphery district to contribute to age-friendliness. In contrast, however, Finlay and Kobayashi (2018) also found that residential location in neighbourhood units is associated with reporting loneliness increasing with settled "outwards" from the city centre.

The evaluation of spatial analysis and urban policies of the local government regarding age-friendliness is among significant topics (Abbing 2016; Moulaert and Garon 2016; United Nations 2017). As many countries are experiencing an increase in their ageing population, there are various age-friendly approaches. For example, the first age-friendly country, Ireland (Age-Friendly Ireland 2019), and the award-winning example Age-Friendly Philadelphia (Glicksman et al. 2014) achieved their goals through a communicative, advocative and catalyst programme where older people have the opportunity to represent themselves in the political sphere during the process of creating age-friendly policies. Since the only spatial explanation is not enough for an age-friendly approach, this study found that some local government policies are not related to the improvement of the spatial environment. The Greater Istanbul Municipalities have been providing urban policies to support the older residents. However, the district municipalities provide only institutional-based approaches rather than improvement of efficiency of the urban environment. On the other hand, the analysis of this research found a lack of open public and open green areas in all districts.

Kadıköy and Beşiktaş in Istanbul are two local municipalities that joined the age-friendly network of WHO in 2016 (WHO 2016) and 2019, respectively (BM 2019). However, when their policies are deeply examined, it is seen that all policies focus on bringing care and needs at home for the older people who live alone or have a disability. Kadıköy municipality focuses on providing social services, such as personal grooming at home and home cleaning services. Additionally, the local government provides basic health



services at homes such as ambulances for patient transfer and nursing (KB n.d.). However, the spatial analysis underlines that Kadıköy lacks accessible open public spaces and open green spaces, despite having the higher values of the age-friendly indices among the others. Also, urban policies of Beşiktaş municipality stand on home care, leisure centres, providing cleaning and catering for those who live alone. According to the findings, the leisure facilities, the religious buildings and the open spaces are the least accessible areas in Beşiktaş. It must be underlined that Beşiktaş district has various cafes, restaurants; however, the accessibility to these facilities is limited from residential areas. Therefore, a combination of open public spaces and leisure facilities is underlined as a need for age-friendliness.

Şişli, Fatih and Üsküdar municipalities also deliver similar policies for the older people such as catering, organising free field trips (this policy is cancelled due to pandemic COVID-19) and healthcare at home. The districts at the periphery Adalar, Şile and Çatalca have the highest value of inaccessible areas to urban facilities. Adalar Municipality (AB 2016) provides free transfer for the older people when they need it; Şile municipality (SB n.d.) and Çatalca Municipality (ISM 2019) also provide home care services similar to others.

Although these policies also support the ageing process, they may require a procedure to benefit from and also depend on the ability to commute to access the social centre. Therefore, spatial planning policies need to focus on the provision of more open public and green spaces within walking distances (Koohsari et al. 2015; Yung et al. 2016). This will especially support older people who abstain from using public transport.

The limitation of this study is that it is difficult to make the accessibility assessment for each individual older person. The assessment was made to cover all residential areas in the city on the assumption that older people can live in each residence. In addition, older people may have many different personal needs (Ceylan et al. 2015) and the focus of urban facilities in this study means they have been recognised as the most basic needs of people A65A. The large study area scale restricts the possibility of an assessment in the neighbourhood scale detail.

## Conclusion

The evidence-based approach of the study examines the age-friendliness of Istanbul based on walkable areas to major urban facilities. This research provides, as its main novelty, the method of spatial measurement of age-friendliness. Moreover, it creates walkability indices for especially the older people considering the living environment facilities.

The spatial analysis conducted here addresses being able to access the basic needs of daily life and indicates it is the main determinant for creating the age-friendly environment for older people. Due to the mobility limitation of ageing, commuting with a vehicle is found to be less desirable meaning walking becomes the first choice in later life. Therefore, this study contributes to the literature by providing the existing walkability situations and the accessible areas in Istanbul in terms of age-friendly perspective through the developed spatial analysis model. This model has the potential to be used and applied to any urban settlement to uncover the walkability for developing urban planning and policies.

The study goes beyond by exposing that the walkability of the older people to certain facilities is affected by the land use and the geographical situation. Although overall values of all urban facilities are higher in the area, some urban facilities are found to be more accessible with walking while others have limited reachable areas in Istanbul. Open public spaces and open green spaces are the most important features of the urban environment, yet most of the districts in the city lack residential areas with access to these facilities. Thus, this study brings forward the idea that the compactness of a city may offer various urban facilities over shorter distances and that the diversity of the urban settlement also supports the experience of the living environment.

Additionally, compared to successful age-friendly city processes, this study found that local governments in Istanbul have been focusing on social policies without any contributions from the older people and other stakeholders who use them, and that their age-friendly approaches are lacking in delivering spatial developments. Therefore, this study suggests that the local government needs to focus on spatial analysis of the districts and should pursue a collaboration with any kind of stakeholders that might support the policies and involve the older people in the process and make room for their representation.

In this study, the necessity of spatial analysis and the gaps in the regulation of urban planning policies for age-friendly approaches are emphasised. Therefore, this study suggests that the analysis of social and spatial behaviour of the older people regarding their physical and mental needs in the minimum terms significantly contributes to the decision-making process of spatial policies delivered by local governments. Therefore, future studies need to focus on the existing spatial situations and combine the social policies with the urban planning process.

**Supplementary Information** The online version contains supplementary material available at <https://doi.org/10.1057/s41289-022-00194-w>.



## Declarations

**Conflict of interest** The authors declared no potential conflict of interest concerning the research, authorship and publication of this article.

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