Fair transport policies for older people: accessibility and affordability of public transport in Santiago, Chile

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Abstract
In this paper, we test how different public transport policy scenarios score in terms of fairness for a specific population group, considering a more complex representation of mobility-related inequalities and the policy implications of transport justice. To do so, we assess potential accessibility to public transport in Santiago de Chile under different policy scenarios, focusing on older people as a group whose demographic and socioeconomic conditions can determine different forms of disadvantage. We compare alternative accessibility policies based on the expansion of the Metro infrastructure network or on reduced public transport fares, considering the interaction between the spatial availability and the affordability of public transport. Results show that subsidized fares for public transport services are more beneficial to expand the accessibility of older people, especially those with lower incomes, while the expansion of the Metro network benefits mainly middle- and high-income older people. The proposed analysis is a first step towards a more detailed, place-based reading of mobility-related inequalities, aimed at assessing alternative policy measures.

Keywords Transport justice · Accessibility · Older people · Affordability · Transport policy · Urban inequality

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**Introduction**

Transport is one more field in which urban inequalities are reproduced, but the definition of alternatives to achieve fair mobility systems is not an easy task. Concepts such as justice, equity, and fairness are more and more associated with theoretical, analytical, and operational proposals that examine how urban mobility currently works and how it could tend towards more socially sustainable outcomes (Beyazit 2011; Lucas 2012; Pereira et al. 2017; Sheller 2018). A key reference in this debate is Martens’ *transport justice*, which he defines as “all members of a society should be guaranteed a sufficient level of accessibility under most, but not all, circumstances” (Martens 2017, p. 128). This reflects a slow but steady paradigm shift in transport planning, emphasizing accessibility rather than on mobility. Accordingly, studies focused on transport fairness use accessibility as their primary evaluative principle, both in Global North and Global South settings (Cui et al. 2020; Nazari Adli et al. 2019; Vecchio, Tiznado-Aitken et al. 2020, Tiznado-Aitken et al. 2020).

Granting a similar or sufficient level of accessibility to all appears to be difficult when translating this concern into policy guidelines for a specific place. First, it is required to determine areas and groups for priority interventions, but socioeconomic inequalities are often overrepresented compared to those deriving from age, gender, and ethnicity. For example, many scholarly accessibility assessments focus on the low-income active population and their access to basic opportunities such as jobs and education (Bocarejo and Oviedo 2012; Grengs 2010; Hernandez 2018; Hu et al. 2017; Pucci et al. 2019). Second, it is necessary to propose suitable forms of action. Still, scholarly works often fall short in providing policy suggestions based on study results and make generic calls for enhanced public transport coverage or better land use-transport coordination (see Vecchio et al. 2020b for a review in the Latin American context). Moreover, ‘neoclassical’ approaches prevail in transport planning, privileging efficiency and utility maximization over equity and social redistribution (Kęblowski and Bassens 2018; Martens 2006).

This paper aims to test how different public transport accessibility policies benefit a specific population group, intending to explore the policy implications of an intersectional perspective on transport justice. To do so, we focus on spatial availability and affordability as the two main dimensions of accessibility. We choose older people as our target population, comparing different policy strategies based on expanding existing infrastructures and introducing subsidies. We hypothesize that an intersectional perspective, examining jointly different dimensions of potential social vulnerability (in our case, age and income), allows us to better account to what extent a certain policy benefits the more in need.

We develop our analysis focusing on the elderly population of Santiago de Chile, a highly segregated 7-million Latin American metropolis. We do so for four reasons. First, older people are often overlooked in the growing debate on mobility justice, even if the ageing population shows manifold elements of social vulnerability—such as limited physical and financial autonomy—which also affect their possibility to move and access urban opportunities (Akhavan and Vecchio 2018; Friman and Olsson 2020; Nordbakke and Schwanen 2014; Ryan 2020). Second, the possibility to access and use public transport is especially relevant for older people considering not only driving cessation, but also that in Global South settings the use of cars is less frequent than in the Global North (Ravensbergen et al. 2022; Villena-Sanchez and Boschmann 2022). More in general, urban ageing in Global South settings shows different sociospatial trends compared to the Global North, also in relation to mobility (Porter et al. 2018; Sánchez-González and Rodríguez Rodríguez 2016; Zunzunegui 2016). Third, Santiago de Chile is a highly unequal city, in which
Transportation has produced uneven mobilities and accessibility patterns (Figueroa Martínez et al. 2018; Iglesias et al. 2019; Jirón and Imilan 2015; Tiznado-Aitken et al. 2021). As a result of social inequalities in Santiago and Chile, there have been massive protests and social unrest in and after October 2019. Not by chance, these protests started due to an increase in public transport fares and ended up becoming a country-wide mobilization against the socioeconomic regime under a market-driven country. Fourth, a focus on older people in Santiago is relevant considering the growth of this demographic group within the city population—by 2050, they will be one third of the Chilean population (INE 1993; United Nations 2017) and the difficult situation they face in a country where pensions are usually meagre, and public welfare services are scarce in terms of quality and availability (Jeong 2013; Rotarou and Sakellariou 2019).

The paper is structured as follows. After discussing the subjects and the objects we deal with when considering fair public transport (Section "Transport, ageing and fairness: defining subjects and objects for fair transport policy measures"), we introduce the case of older people in Santiago (Section "Case study and policy scenarios") and explain the adopted methodology (Section "Data and methods"). Then, results are presented with a focus on the interaction between spatial availability and the affordability of public transport (Section "Results"), discussing their policy implications as well as the possible relevance of a policy focus on older people (Section "Discussion").

**Transport, ageing and fairness: defining subjects and objects for fair transport policy measures**

**Disadvantaged groups: distributing accessibility to whom**

The main dimension of transport justice is the distribution of benefits that are usually identified with accessibility—that is, the possibility to move and, therefore, access key opportunities. Accessibility is recognized as a key concept by approaches interested in theoretical (Di Ciommo and Shiftan 2017; Lucas 2012; Martens 2017; Pereira et al. 2017) and operational fairness (Bocarejo and Oviedo 2012; Hu et al. 2017; Manaugh et al. 2015; Neutens 2015). Most accessibility-based analyses assume a distributive stance, based on political philosophers such as Rawls and Sen, and propose to redistribute accessibility privileging disadvantaged groups (Lucas et al. 2016; Martens et al. 2014; van der Veen et al. 2020; van Wee 2016; van Wee and Geurs 2011).

Redistributive approaches raise the need to define what disadvantaged groups are. Transport-focused approaches tend to consider “interpersonal differences in individuals’ accessibility” (Pereira et al. 2017, p. 186), comparing the accessibility available to population groups defined according to simple (and easily quantifiable) variables. From this perspective, income is the dominant variable. Most socially-oriented evaluations consider how accessibility is differently available to different socioeconomic groups. They emphasize the disadvantages of low-income subjects that often live in marginal areas far from basic opportunities such as work and education, rely on public transport to cover long distances, and experience economic barriers to use it. Other relevant variables receive less attention when considering how accessibility is distributed: this is the case for age (Lättman et al. 2019; Reyes et al. 2014), gender (Erik et al. 2012; Kwan 1999), and ethnicity (Epprecht et al. 2011; Helling and Sawicki 2003), elements that in some cases contribute to defining adaptive thresholds for differentiated accessibility assessments (Rojas et al. 2016).
Current characterizations of disadvantage tend to overlook how different variables intersect or interact at both the collective and individual levels. Therefore, it becomes relevant to carefully consider how transport policy constructs mobile subjects and recognizes disadvantaged groups acknowledging the multiplicity of individual lives (Smeds et al. 2020).

However, age cannot be considered as an element that determines a disadvantage in itself. On the one hand, while ageing is usually associated with a higher incidence of physical and cognitive impairments that result in reduced autonomy, such impairments differently affect individuals (Akhavan and Vecchio 2018). On the other hand, it is necessary to consider how age interacts with other significant features: for example, high-income older people do not face the same restriction as those with lower incomes; gender may determine differences for older people men and women – although often not much significant (Gale et al. 2016; Leinonen et al. 1998; Mendes De Leon et al. 1994; Milanović et al. 2013); or being a migrant may affect the experience of ageing (King et al. 2017). Moreover, depending on the examined setting, the same features can differently affect older people and their mobility: while the absence or the poor frequency of public transport services can determine relevant forms of disadvantage (Ryan and Wretstrand 2019), in other cases the most trip deprived older people are found where more public transport stops are available (Deka 2022); instead, while lower income people generally have worse modal options, financial reasons may only partially affect their possibility to move (Ryan 2020). The affordability of public transport—also for older people—is not a new issue (Brown 2018; Myung-Jin et al. 2018; Rye and Mykura 2009; Wachs and Taylor 1998), but less explored is its relationship with the spatial availability of such services, and how the intersection of demographic and socioeconomic features potentially determines new patterns of injustice in relation to accessibility.

Drawing on this, a twofold take on disadvantage—focusing on a vulnerable demographic group but distinguishing the different socioeconomic conditions of its members—can be a first suitable approach to defining the subjects to which redistribute accessibility.

**Fair transport policy scenarios: distributing accessibility through what**

Alternative scenarios of intervention can be drafted to promote fair transport systems, focusing exclusively on transport and excluding crucial, long-term interventions on land use. Public transport plays a fundamental role, being the mode on which low-income groups often rely for their mobility, particularly in the case of long distances that are difficult to cover by walking or cycling. Especially in Global South cities, international planning guidelines and successful best practices have emphasized the role of public transport to grant accessibility to basic opportunities for low-income populations (OECD-CoR 2015; United Nations Human Settlements Programme 2013; World Bank 2002). This approach has often focused on spatial availability by providing new infrastructure or services to areas that previously were not covered by public transport. These measures are considered as interventions that can benefit different users regardless of their age, gender or income.

Nonetheless, the apparently universal service offered by public transport infrastructure has some limitations when assuming a fairness perspective, as the issue of affordability demonstrates. Transport expenses, as determined by public transport fares, can in fact be a further barrier for the use of public transport. For example, the literature shows that low-income people are often unable to afford the cheapest tickets per trip, i.e., travelcards, paying more for public transport use than affluent individuals (Bondemark et al. 2020). Depending on the context, affordable transport costs are up to 10% or 20% of the total
household expenses (Dewita et al. 2020). As a result, subsidy policies can enhance the affordability of public transport, particularly for disadvantaged groups (Serebrisky et al. 2009). These can address specific population groups defined as disadvantaged, such as youth (Goodman et al. 2014; Jones et al. 2012), older people (Laverty et al. 2018), and low-income people, especially in Global South countries (Cho-yam Lau 2011; Falavigna and Hernandez 2016; Serebrisky et al. 2009; Venter 2011), or provide free public transport for all (Kębłowski 2019). Additionally, cross-subsidies across users exist by implementing different fare schemes, achieving progressive results by implementing distance-based fare schemes (Farber et al. 2014), or adopting flat fare schemes (Tiznado-Aitken et al., 2020a; b). Thus, public transport fares are an essential element to grant fairness in relation to mobility, and its proper assessment should consider the intersectionality of different disadvantage conditions, like age and income.

Spatial availability and affordability are important features that determine the accessibility of public transport and can affect the fairness of transport policy measures. In particular, the interaction of these two dimensions determines to what extent public transport is available for specific groups. Four possible situations emerge, which help assess the differentiated effects of various transport policy measures on disadvantaged groups (Table 1):

- **Accessible public transport.** Disadvantaged users can easily reach public transport and can afford to pay its fares, being thus able to use it in case they are willing to do so;
- **Unaffordable public transport.** Disadvantaged users can easily reach public transport, but its fares are not affordable, resulting in the impossibility to use public transport unless a high price is paid;
- **Missing public transport.** Disadvantaged users could afford to pay the public transport fares, but no services are available (for example, these are not available within walking distance). As a result, the users may need to use other modal alternatives if they are willing to move, with the risk of paying higher prices (for example, using shared taxis or private vehicles);
- **Inaccessible public transport.** Public transport is not available, and its fares are not affordable, so disadvantaged users necessarily need to move with other modes.

### Case study and policy scenarios

#### Public transport and older people in Santiago

Our analysis focuses on Santiago de Chile, a segregated Latin American city where older people are an increasingly relevant demographic group. Moreover, they are characterised...
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by significant socioeconomic inequalities, which determine remarkable differences in their life expectancy even within the same city (Bilal et al. 2019). Considering these issues, Santiago can be thus representative of other Global South cities whose population is or will be rapidly ageing, in which the older age may worsen existing forms of mobility-related social exclusion. In Greater Santiago, composed of 34 municipalities, older people (i.e. people with an age of 65 years or more) are about 11.4% of the population (INE 1993). Demographic projections by the United Nations forecast that by 2050 three out of ten Chileans will be older than 65 years, meaning a significant increase in the next few years (United Nations 2017) and posing Santiago as a rapidly ageing city. Currently, older people are distributed mainly along a peripheral ring, including mostly low-income areas, and almost half of them belong to the lowest socioeconomic groups (Fig. 1 and Table 2).

In this unequal city, we assess alternative policy scenarios focused on how the elderly population can access and use the public transport network of Santiago. Transantiago, the integrated public transport system active since 2007, comprises buses and Metro lines serving the 34 boroughs of the metropolitan area (Muñoz and Gschwender 2008; Tiznado-Aitken et al. 2021). Public transport covers 26% of daily trips in the city, with 52% being bus only, 22% Metro only, and 26% involving bus-Metro combinations (SECTRA 2015). For elderly mobility in Santiago, public transport and its fare system play a central role, as demonstrated by organized elderly groups and normative proposals advocating for reduced public transport fares (like the Marcha de los bastones—“March of the canes”—organized in 2014; Cooperativa.cl 2014).

Fig. 1 Older people in Santiago: population density and socioeconomic conditions (source: own elaboration, based on INE, 2018 and Observatorio de Ciudades UC 2018)
The main policy for improving public transport in Santiago has been and is the construction of new infrastructure, especially Metro lines—often as a promise to voters by candidates in presidential elections. Buses are not receiving high priority in road space allocation and lack specialized infrastructures such as segregated bus lanes and priority signalling (Tiznado-Aitken et al. 2020a, b). In contrast, during 2010–2016, almost 50% of transport investment has been devoted to Metro (Iglesias et al. 2019). Santiago has a network of 140 km, with seven lines, and a new line is being constructed, three existing ones are being extended, and two more lines are being planned. The expansion of the Metro network is intended to cover most areas of the city, including peripheral ones, adding public transport provision to the existing bus coverage (Fig. 2). This may suggest that the expansion of the infrastructure can have a redistributive role by expanding the range of inhabitants that can access it and also reaching some marginal areas of Santiago.

Moreover, transport use has a substantial impact on the finances of Santiago’s families (Iglesias et al. 2019) and even more so in the case of older people, considering that most pensions are below the minimum salary (PNUD 2017, p. 26). On average, transport expenses amount to 12% of older people’s monthly expenditure, which lowers to 7% in the case of vulnerable older people because of a lower number of realized trips (Clapes UC 2019î). In the latter case, i.e., vulnerable older people, the basic public pension they are entitled to amount to 110,201 CLP (approx. 143 USD) in 2019. The impact of transport costs implies that “vulnerable older people are almost unable to allocate their scarce resources to cover transport costs, for the features typical of their condition” (Andrade 2019, p. 3).

A fare subsidy allows older people to pay a discounted fare at any time. Until June 2020, the Beneficio Adulto Mayor (BAM) was valid only for the Metro, with a fare of 230 CLP (0.3 USD). Not covering bus services did raise a significant issue since most older people do not have a Metro station within walkable distance. As a result, older people develop strategies to use public transport paying lower fares, for example, using free local shuttle buses provided by some boroughs to reach the Metro network. Likewise, to save on travel expenses, older people have been willing to undertake longer trips (Vecchio et al. 2020a, Table 2).

| Quintile     | Average income (CLP/USD) | % over total elderly population |
|--------------|---------------------------|--------------------------------|
| 1–2 (basic pension) | $ 110,201 ($ 153 USD) | 19.5 |
| 1–2          | $ 157,641 ($ 219 USD)   | 33.3 |
| 3            | $ 197,344 ($ 274 USD)   | 19.6 |
| 4            | $ 264,570 ($ 367 USD)   | 21.1 |
| 5            | $ 514,182 ($ 714 USD)   | 6.6 |

î This estimation refers to October 2019, the last month before Chile’s protests and before the COVID-19 pandemic, two events that strongly reduced individual mobility.
b). Since July 2020, the BAM was extended to buses, with a fare of 350 CLP (0.45 USD) for using any public transport combination. Until the moment of sending this article, it was therefore impossible to observe a difference in travel behavior given this new fare benefit, considering the mobility restrictions imposed by the COVID-19 pandemic.

Policy scenarios

Considering different public transport services and fare schemes, it is possible to compare transport policy scenarios that in Santiago may benefit older people and their possibility to move. In each scenario, we consider for how many older people public transport is spatially available and affordable. While scenarios such as door-to-door services or on-demand mobility could be relevant for our context, these are currently absent from official strategies devoted not only to urban mobility, but also to addressing the needs of the older population of Santiago. Similarly, due to historical limitations of the Chilean planning system, neither urban development strategies have effectively promoted the creation of metropolitan service centers. Therefore, our scenarios focus on the possibility that older people have to reach a Metro station, using both walking (scenarios 1 and 2) and buses (scenarios 3 and 4). Several reasons that make the Metro a fundamental element for mobility in Santiago: as previously explained, the Metro covers half of the trips by public transport; compared to the buses, it is faster; in a segregated city, where urban opportunities are mostly concentrated in the high-income Eastern part of the city, the inhabitants of peripheral areas need
to cover large distances and the Metro represents the most suitable public transport alternatives to do so; public policies have privileged the city’s Metro network, investing less in the bus system of the city; and for several years, older people could pay a reduced fare only when using the Metro, privileging this system over buses. Therefore, we assess four different scenarios, which are based on official plans and policy; another potentially relevant scenario, based on increased the frequencies of public transport, here is not considered since it is not explicitly discussed in official strategies. For each one, we consider for how many older people public transport is spatially available, and to what extent fares are affordable:

1. **Former scenario—Fare subsidies for Metro.** Older people have discounted fares only for the Metro while paying the full fare if they use bus services. This scenario was in place in Santiago until the end of June 2020;

2. **Infrastructure growth scenario – network extension.** As drafted in the most recent planning documents and government announcements, official plans for Santiago forecast the expansion of the existing Metro network, which includes building three new lines and expanding three existing ones. The new Metro branches may expand elderly accessibility to the Metro, reaching new areas of the city – both central and peripheral. In this scenario, a discounted fare is also available only for Metro;

3. **Current scenario—Fare subsidies for Metro and buses.** An alternative strategy was to expand elderly accessibility through the extension of fare subsidies to include bus services. A new subsidy for all public transport services was introduced by the national government in July 2020 and is the current scenario found in Santiago, in which older people can pay a reduced fare for using both the Metro and the buses;

4. **Comprehensive scenario—network extension and fare subsidies.** A comprehensive scenario would combine interventions on the Metro network and fares, expanding the existing network and providing subsidized fares also for bus services.

**Data and methods**

**Data**

The analysis draws on two types of data: sociodemographic data of Santiago’s population and data on the city’s public transport system. As for the population, census data (INE 1993) were used to map the elderly population as well as to calculate their socioeconomic condition based on the Socio-Material Territorial Index (ISMT in Spanish) (Observatorio de Ciudades UC 2018). The ISMT, following similar indices in Chile, allows dividing the households in Chile into five socioeconomic groups based on educational and housing dimensions. As for affordability, we considered data referred to the average income of older people, differentiated for each socioeconomic groups (SEREMI de Desarrollo Social y Familia Metropolitana 2019). The available data unfortunately do not allow us to examine more in depth the eventual differences between older men and women. On the one hand, census data at the block level do not allow to observe how many older people are men or women (due to privacy issues). On the other hand, the scarce information available about pensions does not allow to examine more in detail possible socioeconomic differences between them.

As for the transport system, the geographic location of bus stops and the General Transit Feed Specification (GTFS) with public transport timetables were based on official
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data made available by DTPM (Santiago’s Directory for Metropolitan Public Transport) (DTPM 2019a). It has to be noted that the GTFS timetable data used in the analysis was valid for August 2019, in order to represent the functioning of Santiago’s public transport before the protests that affected Chile since October 2019 and the COVID-19 pandemic, which caused major disruptions in the functioning of both the Metro network and the bus lines. Moreover, we used smart card validations in the public transport system to obtain the observed travel time distribution by bus for each block analyzed. Finally, metro stations were georeferenced using existing information, while official information available in planning documents and institutional webpages was used to map stations for planned lines or lines under construction (Subsecretaría de Transportes 2013).

Methods

We use a cumulative opportunities approach, deploying a rectangular or isochronic impedance function (Eq. 1) (Wu and Levinson 2020). For the calculations, we assume access to the Metro infrastructure using just walking or walking and buses. We obtained the area covered through isochrones using the OTPR package for R (Young 2020), which deploys the API of OpenTripPlanner (v 1.4.0).

In the first case (Metro access through walking), we assumed existing Metro stations \(i\) as starting points. We assume an average speed of 2.5 km/h for older people \(k\) and a maximum walking time \(t\) equivalent of 10 min to different blocks \(j\) (Eq. 1).

\[
f(t_{ijk}) = \begin{cases} 1 & \text{if} \ t_{ijk} \leq t \\ 0 & \text{otherwise} \end{cases}
\]  

For our calculations, we assume that there is no prohibited traffic direction on the sidewalks. In practice, this means that the calculated accessibility from each Metro station \(i\) to a block \(j\) \((A_i)\) is the same as that calculated from block \(j\) to Metro station \(i\). Thus, we calculated how many older people \(O_s\) have spatial availability to a Metro station considering residents in the blocks \(j\) of the socioeconomic condition \(s\) \((O_{js})\) contained within an isochrone (Eq. 2). A street block was considered to have access to a station or a stop if 70% or more of the block’s area is included in the area delimited by a station or bus stop isochrone (see Fig. 3). We used the city’s division into 42,574 street blocks, i.e. geo-zones, originating from the census.

\[
O_s = \sum_j O_{js} = \frac{A_i}{\sum_j f(t_{ijk})}
\]  

In the second case (Metro access through walking and buses), we performed an additional calculation using the same Equations. In Eq. 1, for each block, we considered the 95th percentile of observed travel times \(t\) by bus based on smart card data (DTPM 2019b) and calculated accordingly an isochrone considering time riding a bus, plus walking time to a bus stop. Using Eq. 2, if the isochrone includes a Metro station, then the older people of socioeconomic group \(s\) \(O_s\) living in the block \(j\) from which the isochrone was generated have spatial availability to a subway station.

Thus, to calculate the impact of network expansion and fare reduction in terms of the percentage of older adults that are able to access public transport, we structured

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the analysis around the following sequential steps. First, using census data, we calculated the number of older people living in each block and the socioeconomic condition of each household as expressed by ISMT (see Fig. 1). Second, considering the spatial availability of public transport, we calculated isochrones from Metro stations and blocks for each scenario, considering access to stations by walking and using buses (see Fig. 4 for a summary of each scenario). We also calculated the access to bus stops for older people for each street block to evaluate impact of reduced bus fares alone, assuming a walking time of 10 min.

To consider the affordability of public transport, we calculated the potential monthly expenditure of older people for transport. To do so, we assumed that older people realize three round-trips per week, considering that a majority of them mentions that they frequently leave home during the week (not on a daily basis, but more than just one day per week; see Ibañez and Tello 2017). According to more recent sources (DTPM 2021), the estimation could be prudential since older people for whom reduced fares are available seem to realise even more trips per month. Then, we calculated the transport expenditure depending on different fares that are currently found in Santiago’s transport system: a full, off-peak fare ($720 CLP, corresponding to $1 USD); a reduced fare for older people, restricted to Metro ($230 CLP, corresponding to $0.32 USD); and a reduced fare for older people that is valid for the whole public transport network ($350 CLP, corresponding to $0.49 USD). Then, we calculated the price of the assumed three weekly round-trips under these three different fares. Finally, we calculated how the deriving transport costs affect the expenditures of older people, considering the different monthly income of diverse socioeconomic groups (SEREMI de Desarrollo Social y Familia Metropolitana 2019). To assess whether public transport is affordable or not, we assumed that the monthly expense for transport cannot be higher than a certain threshold; in particular, we considered two different scenarios, in which public transport expenditures are affordable if they do not overcome 5% or 10% of the whole monthly income.

Fig. 3 Intersection of blocks with the isochrone
Results

Spatial availability of public transport

According to the examined policy scenarios, access to public transport in Santiago shows quite different results regarding the number of older people for whom the city’s Metro and/or bus network are spatially available (Table 3 and Fig. 5). Only 7.6% of older people in Santiago have walking access to an existing Metro station (Fig. 5a), still more than...
the active population living within the same isochrone (4.1%). It must be noticed that the concentration of older people in pericentral areas in Santiago determines the higher level of walking access to Metro, while low-income active population is highly present also in peripheral areas, which compared to pericentral zones have lower levels of walking access to Metro stations. Excluding the immediate surrounding of the stations, the map of areas without access resembles quite closely the distribution of socioeconomic groups in the city: many low-income and middle-income areas with no access can be found across the city. In contrast, smaller high-income areas—also without access—are concentrated in the eastern part of Santiago. Low-income older people, who are the majority in the capital, are also those who have lower levels of walking access to a Metro station: they are 52.7% of the whole elderly population of the city, but only 2.3% of them have access to a station. For a few central boroughs, more than 10% of older people can walk to a Metro station. These results show that urban inequality, here reflected in the unequal possibility of moving by public transport, is a structural condition of Santiago and affects older people.

Considering the walking access to the future Metro network—including three new lines, serving both central and peripheral areas, and three extensions reaching outer zones of the city—the access for older people will not improve considerably (Fig. 5b). Only 10.4% (i.e., +2.9%) of older people in Santiago will have walking access to a Metro station, benefiting especially middle-class groups. Low-income older people will still have scarce access since only 5.9% of this group will have a station within walking distance. Considering the access distribution in the boroughs, no significant variations emerge. As in the former scenario, older people will be able to walk to a Metro station only in a few central boroughs.

Different is the case for accessing Metro stations by bus (Fig. 5c). In Santiago, 97.4% of older people have walking access to a bus stop, showing that public transport services are widely available to different parts of the city. Examining the observed travel times by bus, we focused access for two different times on a working day: in the morning (10 am), more blocks appear to have access, highlighting continuous corridors with access along the main city axes. This includes some areas and corridors that are not close to a Metro station but probably benefit from the existence of direct bus services. In the afternoon (5 pm), areas with access increase dramatically, probably due to increased bus lines and additional services around the main city axes. A vast part of the city has access to a Metro station, including areas relatively close to them and huge zones (in the eastern, north-western, and southern part of the city), which are quite far from a Metro

| Table 3  | Older people for whom public transport is spatially available, per income quintile |
|---------|----------------------------------|
| % of older people for whom public transport is spatially available, per income quintile |
| Total (%) | Q1–Q2 (basic pensión) (%) | Q1–Q2 (%) | Q3 (%) | Q4 (%) | Q5 (%) |
| Walking access to existing Metro stations | 7.6 | 1.3 | 1 | 1.3 | 3.4 | 0.6 |
| Walking access to new Metro stations | 10.5 | 2.1 | 1.6 | 1.7 | 4.0 | 1.0 |
| Bus access to existing Metro stations | 64.1 | 18.3 | 14.0 | 12.7 | 15.2 | 3.9 |
| Bus access to new Metro stations | 71.5 | 20.9 | 15.9 | 13.6 | 16.5 | 4.5 |

Table 3: Older people for whom public transport is spatially available, per income quintile

The concentration of older people in pericentral areas in Santiago determines the higher level of walking access to Metro, while low-income active population is highly present also in peripheral areas, which compared to pericentral zones have lower levels of walking access to Metro stations. Excluding the immediate surrounding of the stations, the map of areas without access resembles quite closely the distribution of socioeconomic groups in the city: many low-income and middle-income areas with no access can be found across the city. In contrast, smaller high-income areas—also without access—are concentrated in the eastern part of Santiago. Low-income older people, who are the majority in the capital, are also those who have lower levels of walking access to a Metro station: they are 52.7% of the whole elderly population of the city, but only 2.3% of them have access to a station. For a few central boroughs, more than 10% of older people can walk to a Metro station. These results show that urban inequality, here reflected in the unequal possibility of moving by public transport, is a structural condition of Santiago and affects older people.

Considering the walking access to the future Metro network—including three new lines, serving both central and peripheral areas, and three extensions reaching outer zones of the city—the access for older people will not improve considerably (Fig. 5b). Only 10.4% (i.e., +2.9%) of older people in Santiago will have walking access to a Metro station, benefiting especially middle-class groups. Low-income older people will still have scarce access since only 5.9% of this group will have a station within walking distance. Considering the access distribution in the boroughs, no significant variations emerge. As in the former scenario, older people will be able to walk to a Metro station only in a few central boroughs.

Different is the case for accessing Metro stations by bus (Fig. 5c). In Santiago, 97.4% of older people have walking access to a bus stop, showing that public transport services are widely available to different parts of the city. Examining the observed travel times by bus, we focused access for two different times on a working day: in the morning (10 am), more blocks appear to have access, highlighting continuous corridors with access along the main city axes. This includes some areas and corridors that are not close to a Metro station but probably benefit from the existence of direct bus services. In the afternoon (5 pm), areas with access increase dramatically, probably due to increased bus lines and additional services around the main city axes. A vast part of the city has access to a Metro station, including areas relatively close to them and huge zones (in the eastern, north-western, and southern part of the city), which are quite far from a Metro...
line. Considering also the access to the planned Metro stations by bus, only a marginal improvement of the walking access is observed (Fig. 5d). As a result, for most older people, public transport is spatially available (Table 3): more than half may access a Metro station by bus, and most of them belong to the lowest income quintiles. However,
the actual possibility of reaching a Metro station by bus depends on the affordability of public transport fares, as discussed in the next section.

**Affordability of public transport**

Public transport fares have quite varied impacts on the transport expenses that older people have to face, depending not only on the examined groups but also on the financial threshold taken into account (Table 4). If we assume that older people should not spend more than 10% of their income for transport reasons, the existence of subsidised fares appears to provide a significant benefit: the full fare determines an unaffordable cost for the two lowest income quintiles, while subsidies considerably diminish the transport costs and each group can afford the fares. Nonetheless, in the case of Santiago, a 10% threshold may be too high: as research on older people’s expenditure mentions, transport costs amounting to 7% of the total monthly expenditures may be too high for low-income older people, who may privilege other expenses over the ones related to mobility (Andrade 2019). This issue justifies using a lower threshold, in which older people should not spend more than 5% on transport. Such stricter threshold highlights significant restrictions related to fares: the full fare would imply that only a few older people in the highest income quintile can afford public transport; the reduced fare for the Metro would still be unaffordable for the receivers of a basic pension; and the reduced fare for all public transport services would still be too high for the two lowest income quintiles. Even adopting a mobile threshold, the lowest quintiles appear to be disadvantaged: with the lower 5% threshold, people relying on the basic pension can afford paying only the reduced Metro fare; assuming a 6% and 7% threshold for quintiles 1–2 and 3 respectively, public transport is affordable only when reduced fares are available; finally, a 8% threshold for quintile 4 shows that public transport expenses would always be affordable for this group.

| Socio-economic group | Average income | % of income spent on transportation expenses for older adults |
|----------------------|---------------|-------------------------------------------------------------|
|                      |               | Full fare, off-peak hours | Reduced fare for older people—only for Metro | Reduced fare for older people—for all public transport |
| Quintile 1–2 (basic pension) | $110,201 ($153 USD) | 15.7% | 5.0% | 7.6% |
| Quintile 1–2 | $157,641 ($219 USD) | 11.0% | 3.5% | 5.3% |
| Quintile 3 | $197,344 ($274 USD) | 8.8% | 2.8% | 4.3% |
| Quintile 4 | $264,570 ($367 USD) | 6.5% | 2.1% | 3.2% |
| Quintile 5 | $514,182 ($714 USD) | 3.4% | 1.1% | 1.6% |
Combining spatial availability and affordability: who can use public transport?

Examining jointly the spatial availability and the affordability of public transport, a more precise picture emerges of how older people can actually access public transport (Table 5; see Table 1 for a description of the four categories). Depending on the scenario analyzed some people may reach a Metro station by walking, while others may use a bus to do so; nonetheless, the affordability of fares determines if a person can actually do so. In general, results show that policies based on the expansion of the Metro network generate incremental results, which are lower in comparison to those generated by subsidised fares. However, the benefits of reducing public transport fares depend considerably on the adopted affordability threshold.

Considering a higher affordability threshold (10%), public transport is accessible—that is, both spatially available and affordable—for 34% of older people in the former scenario. 30% may use it, but the full fare is unaffordable, while another 15.5% may pay for it but has no services that can make them reach a Metro station on time. Finally, for 20.4% public transport is both unavailable and unaffordable. The introduction of subsidised fares improves the affordability for all older people in Santiago so that public transport is accessible for 64.1% of them; instead, the expansion of the Metro network generates marginal benefits, as both scenarios 2 and 4 demonstrate.

Results are more critical when a lower affordability threshold (5%) is considered since the people belonging to the lowest socioeconomic quintiles experience significant affordability issues in most scenarios. This becomes visible considering for how many people public transport is unaffordable—that is, it would be available but its fares do not allow its use: more than half of the older people in Santiago cannot use public transport due to its fares, and even the introduction of subsidies leave approximately one-third of them without the possibility of reaching a Metro station by bus. On the contrary, the people for whom public transport is accessible are less than in the previous scenario: 10.9% in the former scenario, and 38.4% when fares are reduced, and the Metro network is expanded.

Significant is also the case of older people for whom public transport is inaccessible. In their case, fares are unaffordable, and existing public transport services do not allow them to reach Metro stations on time. People in this group are mainly found in between the main road corridors of the city—which are usually served by a Metro line or by high-frequency bus services—and as well at the margins of Santiago (especially in the eastern zone of the city). It has to be noted that in our analysis we do not consider a likely restructuring of the bus services that usually follows the opening of new Metro trunk. Given the usual restructuring procedure, it is possible that new services may serve at least some of the areas that in the comprehensive scenario appear to have no access to the Metro. Our results allow identifying areas that currently have no access, and that could be prioritized when designing new services or modifying existing ones.

More in general, the examined scenarios show clear incremental effects and gradually increase the areas of the city (and their elderly population) with access to the Metro network (Fig. 6). The ideal scenario, providing walking access to the Metro network, is available to a very small number of elderly citizens of Santiago, even when considering the new planned branches of the network. When considering the use of buses to access Metro stations, the situation improves considerably even if a significant share of older people remains without access. Nonetheless, the most beneficial element appears to be the access to a public transport stop, which is available to most older people in Santiago,
| Affordability threshold | Scenario                                                      | % of older people with accessibility to public transport |
|-------------------------|---------------------------------------------------------------|---------------------------------------------------------|
|                         |                                                              | Accessible public transport (%) | Unaffordable public transport (%) | Missing public transport (%) | Inaccessible public transport (%) |
| 10%                     | 1. Former scenario—Fare subsidies for Metro                  | 34.0                          | 30.0                          | 15.5                          | 20.4                          |
|                         | 2. Infrastructure growth scenario—network extension           | 38.4                          | 33.0                          | 12.6                          | 16.0                          |
|                         | 3. Current scenario—Fare subsidies for Metro and buses        | 64.1                          | 0.0                           | 35.9                          | 0.0                           |
|                         | 4. Comprehensive scenario—network extension and fare subsidies| 71.4                          | 0.0                           | 28.5                          | 0.0                           |
| 5%                      | 1. Former scenario—Fare subsidies for Metro                  | 10.9                          | 53.2                          | 2.7                           | 33.2                          |
|                         | 2. Infrastructure growth scenario—network extension           | 14.0                          | 57.4                          | 2.0                           | 26.5                          |
|                         | 3. Current scenario—Fare subsidies for Metro and buses        | 34.0                          | 30.0                          | 15.5                          | 20.4                          |
|                         | 4. Comprehensive scenario—network extension and fare subsidies| 38.4                          | 33.0                          | 12.6                          | 16.0                          |
and the existence of subsidised fares: reduced fares in fact at least permit some older people to use a bus and later transfer to the Metro, enhancing thus elderly accessibility at the urban scale.

The comparison between different scenarios (Fig. 6) also highlights those areas with no access to public transport, even when considering only access to a bus stop. While less than 3% have no walking access to a bust stop, we found five boroughs of Santiago with more than 10,000 older people in areas with no access, involving mainly low-income inhabitants or middle-income groups. These areas are primarily located on the fringe of the city, for example, at the feet of the Andes mountains (east of Santiago), in zones that, in general, do not have high levels of connectivity. Their location and their lack of accessibility suggest tailored forms of intervention that can be based on (i) the improvement and expansion of on-demand mobility services, (ii) the provision of local opportunities, i.e., service centres, which can be reached by walking; and (iii) the provision of basic door-to-door services, especially considering the spatial features of these zones which may impede the movement of older people.

**Discussion**

The analysis shows how the interplay of age and income potentially determine unequal possibilities to move by public transport and therefore access to urban opportunities, a phenomenon that in Global South settings emerges with different intensity and features.
in comparison to the Global North. Our analytical results show the importance of considering both age and income together. On the one hand, older people are usually associated with different mobility impairments, which often reduce their psycho-physical autonomy or even the simple perception of one’s ability to perform certain tasks. On the other hand, retired people usually deal with a scarcity of economic resources and a generally worse socioeconomic status. In particular, the case of Santiago de Chile shows at least three specificities of urban ageing related to Global South settings:

- the presence of older people is higher in pericentral areas, differently from European or North American settings in which higher densities are found in peripheral or suburban locations (Guida and Carpentieri 2021; Li et al. 2021). These areas in general have better access to Metro or bus lines than most peripheral areas. However, the results also show that in Santiago, the highest densities of the elderly population are found in affluent boroughs of the high-rent cone, demonstrating that an exclusive focus on age may paradoxically benefit those older people with better socioeconomic conditions;

- ageing can become a further element of vulnerability and configure a specific need for movement, especially considering that most older people belong to the lowest socioeconomic group. Due to the unequal Chilean pension system low-income people will receive pensions that are considerably lower than their previous wages, so that age—and the consequent retirement—appears to be a factor that deepens existing socioeconomic inequalities due to the absence of devoted welfare policies (Rotarou and Sakellariou 2019). Moreover, ageing can become a further element of vulnerability and configure a specific need for movement, especially considering that most older people belong to the lowest socioeconomic group. For example, some older people may need to keep working (considering the insufficient pensions they receive), or others may need to cover long distances in the city in order to deal with basic needs (considering, for example, health issues and the unequal quality of care in private and public facilities);

- widespread access to public transport is especially important for older people, not because of driving cessation, but rather because older people in Global South settings are generally not as car dependent as their Global North counterparts (Villena-Sanchez and Boschmann 2022). Nonetheless, public transport is crucial for the access it provides to basic opportunities such as healthcare or green areas, becoming a fundamental tool for older people to reach the places they need (Ravensbergen et al. 2022). The scope of this study is intentionally limited to public transport, but should expand to consider also access to relevant urban opportunities.

The case of Santiago allows to observe not only different socio-spatial patterns of urban ageing in comparison to Global North settings, but also to examine the implications that these may have for urban mobility planning and policy. Considering the widespread spatial availability of public transport, the results allow to examine the relevance of intervening on the affordability of such services. In general, economic affordability is a barrier for the use of public transport by older people (Shrestha et al. 2017), but the case of Santiago shows the importance of prioritizing low-income groups when reducing fares. Once more, age is not a factor of vulnerability for itself (at least when considering urban mobility), and its relationship with socioeconomic features is fundamental also when assessing the effects of urban mobility policies. It must be noted that the promotion of public transport is beneficial for older people since it increases their participation in activities (Liu et al. 2021) and may also health benefits, such as obesity reductions (Webb et al. 2012); early assessments of the reduced fare made in Santiago during the pandemic seems to confirm an increased number of trips for older people (DTPM 2021).
The spatial distribution of older people, combined with their income, suggests that different policy options could be more suitable in the examined setting. On the one hand, the widespread presence of low- and middle-income older people may justify the adoption of ‘universal’ measures, such as subsidized fares, which in the case of Santiago prove to generate wide beneficial effects. On the other hand, the emergence of marginal areas with no access to public transport and low socioeconomic conditions may determine the adoption of specific measures for improving the mobility and accessibility of older people living in these zones, allowing tailored actions to benefit groups and areas most in need. Detecting the areas that cannot access public transport in any proposed scenario, allows planning and policy proposals to define priority interventions for these zones, concentrating the public efforts for improving mobility and accessibility (Pucci et al. 2019). Moreover, these priority areas can also be the object of efforts for representing individuals’ mobility experiences and even to develop people-based accessibility indicators, allowing citizens to have a say in the definition of urban mobility policies (Tiznado-Aitken et al. 2020a, b). Finally, considering the benefits of different universal or targeted policy measures, it is also possible to evaluate investment costs and suitability. While assessing the financial feasibility of constructing new infrastructures, maintaining new subway lines, or expanding fare subsidies is out of the scope of the paper, the concern for transport justice should also consider the impact that building and maintaining alternative policy measures may have on the general public.

A focus on redistributive policies aimed at benefiting vulnerable groups should be aware of at least two risks. The first one is the potential paternalism of redistributive policies. The recent debate on mobility justice calls for an approach going beyond simple distributive concerns and advocating for forms of—among others—deliberative justice (considering how decisions are taken) and epistemic justice (referring to how knowledge is produced) (Sheller 2018). This does not neglect the relevance of redistributive policies, which are fundamental to guarantee that their benefits can actually reach marginalized groups, but resounds with the critical voices that consider transport justice theories as ‘paternalistic’ since institutions rather than people are expected to say what fair mobility is (Vanoutrive and Cooper 2019). The second risk is posed by the stereotypes of vulnerability since the very concept of vulnerability can be harmful when discussing public policy for disadvantaged groups. As research in the field of public health demonstrates (Katz et al. 2019), defining a group as vulnerable risks producing vague definitions of the examined group, overlooking the structural determinants of its condition, and in some cases even blaming them for their vulnerability. In the case of older people, this can also lead to considering as obvious the association between ageing and vulnerability (Grundy 2006).

Nonetheless, the analytical approach proposed in this work provides a contribution for policy approaches that are more effective and—at least potentially—less paternalistic. Moreover, in the case of older people, such focus can be relevant for a more nuanced, less stereotyped representation of their mobility needs and practices, as well as for detecting small scale elements that can significantly affect their mobility experiences—from the elements affecting their ability to use public transport (Gajardo et al. 2012), to their overall perceptions when moving in public spaces (Vecchio et al. 2020a). These elements are relevant to draft those contextual analyses required to further define what features define disadvantage, what forms of accessibility are relevant, and what form a redistributive policy may assume.
Conclusions

In this paper, we assessed the fairness implications of alternative policy scenarios for public transport, focusing on older people. Estimating the access to the existing and the future public transport network in Santiago, we evaluated to what extent alternative policy options—based on fare subsidies and/or new infrastructures—allow older people to access public transport. In doing so, we intended to provide a more nuanced representation of a disadvantaged group, considering the twofold impact of socioeconomic and demographic variables and the mobility-related inequalities these generate. We aimed at going beyond a simple representation of existing imbalances and instead consider the interaction between the spatial availability and the affordability of public transport; in doing so, we assessed different possible policy alternatives and provided an operational contribution for the implementation of just transport. Moreover, we intended to focus on a rapidly ageing Global South city, in which the socio-spatial features of the older population and its mobility needs differ considerably from those of ageing Global North settings, and age may deepen existing socioeconomic inequalities.

Our results show that different scenarios generate significantly different results. Compared to the base scenario in which reduced fares are available only for the Metro, the introduction of subsidised fares for the whole public transport network proves to be more beneficial than the expansion of the Metro network. In the base scenario, public transport is available only to 10.9% of the elderly population in Santiago, while with subsidised fares this percentage increases to 34%; instead, a massive expansion of Metro lines makes public transport available only to 14% of Santiago’s older inhabitants. Moreover, the expansion of the Metro network benefits mainly middle- and high-income older people, while the latter has positive effects also for low-income older people—who are the majority in the city. While the expansion of the Metro network benefits the general public, reducing the public transport fares appears to be more beneficial for granting older people access to the public transport network. Considering this, the older people who currently have no access to the public transport network should be the object of priority interventions. At the same time, the interchanges between Metro and bus lines should be enhanced to provide them a seamless travel experience. Finally, the results also allow assessing alternative policies that are currently in place. In Santiago, older people can choose to have a reduced fare (one-third of the regular price) valid only for the Metro or to have a slightly higher fare (half of the regular price) valid for both the Metro and the bus network. The two subsidies demonstrate to benefit a very different amount of elderly citizens potentially.

The proposed analysis is a first step towards a more detailed reading of mobility-related inequalities, hopefully useful for assessing and designing policy measures. Focusing on older people, it was possible to use adaptive travel time thresholds for estimating access to different public transport services and consider together two factors determining potential disadvantage—age and income—that can determine different forms of inequalities. Nonetheless, the aggregate evaluation of access to public transport should be complemented in at least three ways: first, it would be important to assess older people’ access to significant urban opportunities, considering public transport as a means to reach them; second, it seems relevant to consider the mobility practices of older people, in order to consider also their experiences on the move and the possible strategies they may deploy to access opportunities (such as travelling with relatives or trip delegation to neighbours); third, it would be necessary to assess other relevant scenarios not explicitly discussed in official strategies, as increasing the frequencies of
public transport where feasible. These elements can better shape aggregate accessibility evaluations and inform the design of policy interventions, which can prioritize disadvantaged settings and provide measures that can be beneficial for the public. Thus, the assessment of policy scenarios is a significant first step to evaluate alternative courses of action and define how to promote transport justice better, considering the forms of mobility and inequality significant in a specific place and for a specific group.

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Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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