15 years ESJ
Special edition

Mobility on Demand and Transport Services for the Elderly: Challenges and Policy Solutions

Elisabetta Venezia
University of Bari Aldo Moro, Italy

Doi:10.19044/esj.2025.v21n42p1

Submitted: 19 February 2025
Accepted: 10 June 2025
Published: 17 October 2025

Cite As:
Venezia, E. (2025). *Mobility on Demand and Transport Services for the Elderly: Challenges and Policy Solutions.* European Scientific Journal, ESJ, 21 (42), 1. https://doi.org/10.19044/esj.2025.v21n42p1

Abstract

The utilization of public transportation by the elderly is examined in this study according to their varied socioeconomic backgrounds. It explores how newly implemented Mobility on Demand (MOD) public transport scenarios can either mitigate or exacerbate mobility inequalities, and why residents in some locations experience greater or more limited accessibility to public transportation. The focus is on geographic accessibility rather than specific individual demographic characteristics in assessing whom MOD public transportation can effectively serve, based on data collected through interviews. The findings suggest that an MOD system that uses MaaS (Mobility as a Service) and a stop-based mode (where passengers must wait at bus stops) has a higher chance of closing mobility gaps for low-income passengers. Improving spatial justice, particularly for the elderly from socioeconomically challenged backgrounds, is the goal of this article.

Keywords: Mobility on Demand, The elderly, MaaS, Transport Justice

Introduction

A utilitarian reasoning that prioritizes cost-benefit analysis over justice considerations has historically dominated transportation decisions (Venezia, 2019; Nazari Adli et al., 2019). To emphasize a more equitable distribution of the advantages and disadvantages of transportation in society, transport justice defines a normative state in which no individual or group is disadvantaged by a lack of access to the opportunities they need to lead a meaningful and dignified life (Karner et al., 2020; Pereira et al., 2017).

Transport justice has been widely applied in the field of transport planning. Karel Martens (2017) made a significant contribution when he created a framework for transport planning that considers justice principles. He did this after realizing that planners and policymakers have paid more attention to the performance of the transport system and ways to improve it than to the people who use it. Martens (2017) argues that applying a justice lens to transportation is crucial because this component has received less attention and because theories of justice are often aspatial and tend to disregard mobility.

Martens defines three principles of justice - equality, fairness, and accessibility - as the foundation for transportation policy, offering a theoretical, philosophical, and moral critique of current paradigms and practices (Vanoutrive & Cooper, 2019). This allows for an analysis of the current state of the transportation system and the identification of interventions that bring it closer to the fair ideal.

Being equal, particularly in terms of status, rights, or opportunities, is linked to the first justice concept, equality (Victoria Law Foundation, 2019; Venezia, 2019). Persistent disparities between people in terms of accessibility, potential mobility, and travel speed in the transportation environment subtly violate the equality principle (Martens, 2017). Fairness, the second principle of justice, is described as just and impartial behavior or treatment that is free from discrimination or favoritism (Victoria Law Foundation, 2019). According to Martens (2017), fairness or equity in transportation planning refers to the equitable distribution of costs and benefits. When there are significant disparities in access to opportunities, there is injustice. Lastly, accessibility - the third principle of justice - ensures that people utilize the institutions, processes, and resources found in the transportation system (Victoria Law Foundation, 2019). Concerns over how transportation networks contribute to the marginalization of vulnerable demographic groups in society at large have led to the development of accessibility planning. Accessibility highlights how spatial constrains affect mobility, shaping the connection between transportation systems and land use (Martens, 2017).

Mobility justice and the concept of the right to the city, which emphasizes the right to physically access, occupy, and use urban space, are frequently associated with transport justice (Verlinghieri & Schwanen, 2020). According to Nazari Adli et al. (2019), transport justice outcomes must inevitably incorporate both distributive or sufficientarian and egalitarian justice principles. Although the current applications of transport justice have been rather restricted, they have been crucial in decreasing the mobility equity gap globally, with the exception of critiques of public transportation investment and provision (Nazari Adli & Donovan, 2018; Enright, 2019).

Guzman et al. (2021), for instance, investigated the connections between mode share, the allocation of street space, and the cost of building spaces using justice principles. The authors discovered disparities in the way space is prioritized, as cars are given priority over walker.

Literature Framework

The optimal objective of public transportation, as seen through the lens of transport justice, is to allow the poor to depend on it in order to attain the same level of destination-based accessibility as the wealthy, car-owning residents of upscale communities. Poor areas are more likely to use public transportation and therefore need to receive resources or services to do so; otherwise, this results in an uneven allocation of transportation that is considered inequitable under Rawls' difference principle (Rawls, 1999). Any inequality that is allowed in society should only be permitted if it benefits the least fortunate members of society, according to the difference principle. According to Rawls, people would select a social justice system based on the difference principle if they were unable to determine their status in advance. A case application of this principle is the consideration of the elderly, as a vulnerable segment of the population.

In the context of public transportation, accessibility refers to how simple it is for people to use transportation services, especially in terms of regularity, affordability, convenience, and distance. Financial accessibility (the affordability of fares), temporal accessibility (the frequency and dependability of services), functional accessibility (the ease of use, including services for elderly or disabled people), and geographic accessibility (the actual proximity of transit stations to residential and employment areas) are the four main components of accessibility (Maharani, 2025).

Although residents' socioeconomic characteristics are disregarded, urban central areas generally receive more services than suburban communities in the actual distribution of public transportation, as a deliberate strategy to maximize the benefits of limited public transportation resources, particularly for the elderly as a vulnerable segment of the population (Pereira et al., 2017).

Due to its flexibility and on-demand features, MOD (Mobility On Demand) has been suggested as a way to address the issue of the unequal distribution of public transportation, benefiting specific demographic groups. MOD reduces the disparity in mobility that residents in underprivileged communities face. The justification for this choice is that MOD may reduce spatial inequality among suburbanites without private vehicles by improving the long-distance mobility capabilities of zero-car households (Brown, 2019).

Since route-fixed public transportation cannot adequately support the fragmented activity chains of the elderly and women - who have less access to private vehicles than men in their households - MOD can offer an alternative (Qiao et al., 2023). A mitigated mobility gap is also present among residents of areas with poor public transportation (Feigon & Murphy, 2016), particularly in suburban and rural areas where public transportation is not available during off-peak hours (Qiao & Yeh, 2021).

Empirical Analysis

To estimate the relationship between the socio-economic class of the elderly and MOD (Mobility on Demand) accessibility, a regression technique based on the model proposed by Qiao and Yeh (2023a) was applied. This study investigates two key dimensions - equity and accessibility - in the context of the elderly, using the Italian city of Bari as a case study.

Located on the Adriatic Sea in the Puglia region of southeast Italy, Bari is a culturally diverse port city that historically serves as a gateway between East and West. It is both the regional capital and the capital of the province of the same name. Morphologically, Bari has developed along the EuroMed coast, with its port playing a vital role in the local economy. The city's historic center, characterized by charming squares and winding alleyways, is a major attraction for both tourists and elderly residents from various cultural backgrounds. In terms of smart mobility, Bari has implemented a range of initiatives aimed at enhancing sustainable and intelligent transport. These include the development of bike-sharing programs, the expansion of public transportation network, and the promotion of electric vehicles. Efforts have also been made to encourage bicycle and car-sharing services and to restrict vehicle access to the historic center to reduce congestion. All local and urban transportation services are managed by the municipality-owned company AMTAB, which aligns its initiatives with the United Nations' Agenda 2030 goals. These programs aim to promote alternative and sustainable modes of transportation.

This study analyzes how different MOD scenerios reflect both equity and inequality. The dependent variable is MOD accessibility, while the independent variable is the socio-economic status of the elderly. Given that an individual's mobility in a monocentric city like Bari is significantly influenced by their distance from the city center (Venezia, 2019; Venezia, 2011; Huang et al., 2021; Kong et al., 2020; Qiao & Yeh, 2021), distance was included in the model as a moderating variable. The model adapted from Qiao and Yeh (2023), focuses specifically on elderly individuals and is presented as follows:

$$\text{MODAccessibility} = \alpha + \beta \times \text{SocioeconomicStatus} + \gamma \times \text{SocioeconomicStatus} \times \text{DistanceToCentre} + \varepsilon \tag{1}$$

Where SocioeconomicStatus represents the traveler's class, MODAccessibility is the independent variable, and DistanceToCentre is the moderating variable.

A positive β coefficient indicates that MOD accessibility increases with higher socio-economic class. A positive γ coefficient suggests that the marginal effect of socio-economic status increases with distance, meaning that elderly individuals with lower socio-economic status residing farther from the city center experience the greatest accessibility. Socio-economic status is proxied using the average price of residential units, consistent with prior research that links housing prices with travel affordability (Litman, 2013; 2017a, b). Typically, individuals in more expensive neighborhoods rely on private vehicles and taxis, while those in less costly areas depend on buses and metros (Venezia, 2023; Qiao & Yeh, 2023). Thus, residential property prices serve as a valid indicator of socio-economic class (Xu et al., 2022).

MOD accessibility is accessed using two indicators: travel distance and travel time. Travel distance measures the average journey length for residents of each neighborhood (Venezia, 2023). Travel time represents the average time cost for elderly residents. Time accessibility and distance accessibility are not equivalent. The choice of transport mode significantly influences the time cost of a journey (Li & Zhao, 2019). For the same distance, bus travel typically takes longer than door-to-door transportation options such as private vehicles or taxis. Buses often spend additional time picking up and dropping off passengers and may follow indirect routes to connect designated stops. Moreover, passengers must walk to the bus stop and wait for a bus, further extending the travel time.

Frequent stops, fixed routes, and potential transfers can substantially increase journey duration. As a result, elderly individuals across different income levels are often compelled to make trade-offs when selecting transport options - exchanging lower financial costs for longer travel times. Even among residents of the same peripheral neighborhoods, those who rely on public transportation tend to experience lower time accessibility compared to those who travel by private or more direct modes. Accordingly, the following two equations are introduced to quantify these dynamics:

$$\text{TravelDistance} = \alpha 1 + \beta 1 \times \text{HousePrice} + \gamma 1 \times \text{HousePrice} \times \text{DistancetoCentre} + \varepsilon 1, \tag{2}$$

$$\text{TravelTime} = \alpha 2 + \beta 2 \times \text{HousePrice} + \gamma 2 \times \text{HousePrice} \times \text{DistanceToCentre} + \varepsilon 2. \tag{3}$$

Where:

TravelDistance represents the average journey distance for each resident within a community, while TravelTime captures the average duration of a trip for each resident in a given neighborhood.

Beyond the significance of individual parameters assessed using the t-test and the coefficient of determination ($R^{2)}$, the primary model validation metric employed is the Akaike Information Criterion (AIC). The AIC offers a standard for evaluating and comparing statistical models by balancing model fit with complexity, thus ensuring robust model selection.

The data used in the analysis stem from a 2024 survey involving 365 elderly residents of Bari. Participants were selected through purposive sampling based on age and geographical area of residence. Housing price data were obtained from the Revenue Agency's Real Estate Market Observatory, which provides property prices for each municipality's defined homogeneous territorial area. These prices include the minimum and maximum market and rental values on property type and condition, expressed in euros per square meter.

Regression results, presented in Table 1, reveal that, in terms of accessibility, commutes from more affordable neighborhoods are significantly shorter (− 0.210***). The interaction term in the regression model indicates that the marginal effect of socioeconomic status on distance accessibility intensifies as the distance from the city center increases. Similarly, individuals from higher socioeconomic classes tend to have shorter MOD commute times (− 0.024***). Moreover, the marginal impact of socioeconomic status on travel time grows in tandem with increasing distance to the city center.

Table 1. Relationship Between Socio-economic Status of the Elderly and MOD Accessibility

	Average travel distance				Average travel time			
	Coefficient	Beta	Standard error	Significance	Coefficient	Beta	Standard error	Significance
House prices	-0.210	-0.537	0.016	***	-0.024	-0.160	0.007	***
Distance to the city center (km) # House prices	0.021	0.872	0.001	***	0.004	0.002	0.002	***
Constant	4186.644		173.134		3753.552	63.546	88.722	
R^2	0.7994				0.863			
AIC	9532.743				8543.652			

Discussion

One of the pressing challenges with emerging transport systems is how technology-based initiatives are likely to enhance - but also disrupt - traditional public transportation systems that have been in use for decades (Smith et al., 2018). When new transport modes are integrated into public transit networks, travel patterns and their societal consequences are expected to become more complex and less predictable (Qiao & Yeh, 2023a). Critical questions arise: Will new MOD (Mobility on Demand) systems benefit the elderly while marginalizing others? Or will they exacerbate existing inequalities, reinforcing urban marginality, social exclusion, and spatial injustice?

This study employed multi-agent-based modeling to simulate various MOD scenerios, focusing on two dominant MOD types: Shared Mobility (SM) and Mobility as a Service (MaaS). Travel behavior was extracted through direct questionnaires and mobile phone data to capture current conditions (e.g., travel time and distance). These served as the baseline against which hypothetical MOD scenerios were assessed. To evaluate the local impact of MOD implementation on spatial justice at the local level, the relationship between travelers' socioeconomic status and MOD accessibility was quantified. The primary contributions of this study - each with significant implications for spatial justice in MOD public transit reform - are outlined as follows. First, MOD inaccessibility disproportionately affects economically disadvantaged populations who typically reside in the peripheral areas of metropolitan districts. The study finds that MOD accessibility declines as socioeconomic status decreases. Wealthier residents are generally better positioned to leverage alternative transportation options, such as private vehicles, enabling them to reach their destinations more efficiently - even though residents in outer districts tend to travel longer distances. This observation aligns with previous studies showing that low-income individuals tend to have limited spatial mobility and fewer opportunities for diverse activities (McKane & Hess, 2022; Qiao & Yeh, 2023; Zhai et al., 2021; Zhao & Li, 2016, 2019; Qiao & Yeh, 2023a).

Second, all MOD scenarios tested in this study demonstrated improved urban transportation efficiency. Specifically, the use of standard buses, floating modes, and MaaS models led to a significant 22% reduction in average journey times compared to the current system. When other variables remain constant, MaaS outperforms SM in reducing travel time and distance, minimizing fleet size, and decreasing the empty distance traveled by vehicles. Conversely, SM proves more effective in reducing walking distances and increasing vehicle occupancy rates. These findings further support the notion that integrating urban rail transit can meaningfully enhance overall urban mobility and efficiency (Hasselwander et al., 2022; Shaheen & Chan, 2016).

ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Third, in an ideal implementation, a MOD system combining stop-based modes (where passengers wait at designated bus stops) with MaaS (linking directly to metro lines) can help reduce socioeconomic disparities in neighborhood mobility. However, the current reality remains that economically disadvantaged elderly populations face persistent barriers in accessing MOD services, whether through SM or MaaS. This finding is consistent with global evidence from MOD pilot projects (Weckström et al., 2018). Floating modes face particular limitations in low-demand areas, as scattered pick-up and drop-off points make ridesharing coordination difficult (Huang et al., 2021).In contrast, high-demand urban centers and affluent neighborhoods receive better service coverage, resulting in unequal service delivery when compared to stop-based MaaS systems.

Conclusion

This study investigated the implications of MOD public transport reforms on the mobility of elderly populations across different socioeconomic strata, echoing the approach of Qiao and Yeh (2023a). Rather than focusing narrowly on who is underserved, the emphasis was placed on where MOD systems succeed or fail in meeting accessibility needs.

The findings indicate that a hybrid MOD system - incorporating stop-based modes with strong MaaS integration - holds the most promise for closing mobility gaps particularly for low-income individuals. Such systems align with prior expectations that MOD innovations, when well-integrated, can improve transit equity by extending the reach of rail networks and offering efficient neighborhood-level services. These benefits are especially relevant for individuals with limited access to private vehicles, those traveling at off-peak hours, residents in low-density areas, and non-emergency medical travelers.

Given the demonstrated benefits of a stop-based MaaS mode, it is recommended that public transportation authorities take a leading role in funding and managing MOD initiatives. Specifically, transit agencies should independently operate new MOD bus fleet while integrating services with the metro system. This approach fosters both equity and efficiency.

In addition to the well-known and economical PPP method, in which transportation network companies (TNCs) control the right to operate buses, the public sector should serve as the primary driver of MOD integration and development. This model allows the MOD service to deploy a fleet of buses in a stop-based mode comparable to the conventional bus operation system, while offering flexibility in routes and schedules.

This public-sector-led paradigm has the ability to prevent TNCs from leveraging their advantages to negotiate unfair market terms. In their pursuit of maximum corporate benefit, TNCs may dominate the market. Such dominance could exacerbate social isolation and disadvantages caused by algorithm pricing and service allocation mechanisms. In the era of MaaS and emerging mobility solutions, public transportation sectors are advised to assume a leading role, beyond their traditional responsibility of providing fixed-route services.

It is important to note that the scenarios examined in this study do not account for every possible trip outcome. In practical, multiple transportation modes in a city may be complementary or competitive. To assess the potential impacts of new MOD configurations, these complexities were simplified in the analysis. Furthermore, the study did not evaluate the effect of transportation costs on travel choices and assumed universal accessibility once a new mode is introduced. Future research should explore the substitution effects created by various pricing strategies across multimodal transport systems. The influence of market competition among different operators also warrants further investigation, as competition may result in selective subsidies that influences users travel behavior.

Conflict of Interest: The authors reported no conflict of interest.

Data Availability: All data are included in the content of the paper.

Funding Statement: The Author acknowledges co-funding from Next Generation EU, in the context of the National Recovery and Resilience Plan, Investment PE8 – Project Age-It: “Ageing Well in an Ageing Society”. This resource was co-financed by the Next Generation EU [DM 1557 11.10.2022].

References:

1. Brown, A. (2019). Redefining car access: Ride-hail travel and use in Los Angeles. Journal of the American Planning Association, 85 (2), 83–95.
2. Enright, T. (2019). Transit justice as spatial justice: learning from activists. Mobilities, 14 (5), 665–680. https://doi.org/10.1080/17450101.2019.1607156.
3. Feigon, S. & Murphy, C. (2016). Shared mobility and the transformation of public transit. Transit Cooperative Research Program, Transportation Research Board, National Academies of Sciences, Engineering, and Medicine. ISBN: 978-0-309-44582-5, DOI: 10.17226/23578.
4. Guzman, L.A., Oviedo, D., Arellana, J., & Cantillo-Garcia, V. (2021). Buying a car and the street: Transport justice and urban space distribution. Transportation Research Part D: Transport and Environment, 95, 102860 https://doi.org/10.1016/j.trd.2021.102860.

5. Hasselwander, M., Bigotte, J.F., Antunes, A.P., & Sigua, R.G. (2022). Towards sustainable transport in developing countries: Preliminary findings on the demand for mobility-as-a-service (MaaS) in metro Manila. Transportation Research Part A: Policy and Practice. 155, 501–518.
6. Huang, G., Qiao, S., & Yeh, A.-G.-O. (2021). Spatiotemporally heterogeneous willingness to ridesplitting and its relationship with the built environment: A case study in Chengdu, China. Transportation Research Part C: Emerging Technologies 133, 103425.
7. Karner, A., London, J., Rowangould, D., & Manaugh, K. (2020). From transportation equity to transportation justice: Within, through, and beyond the state. Journal of Planning Literature. 35, 440–459. https://doi.org/10.1177/0885412220927691.
8. Kong, H., Zhang, X., & Zhao, J. (2020). How does ridesourcing substitute for public transit? A geospatial perspective in Chengdu. China. Journal of Transport Geography 86, 102769.
9. Li, S.A., Zhai, W., Jiao, J., & Wang, C.K. (2022). Who loses and who wins in the ride-hailing era? A case study of Austin, Texas. Transport Policy 120, 130–138.
10. Litman, T. (2013). Transportation affordability: Evaluation and improvement strategies. Victoria Transport Policy Institute. https://www.vtpi.org/affordability.pdf.
11. Litman, T. (2017a). Evaluating transportation equity. Victoria Transport Policy Institute.
12. Litman, T. (2017b). Transportation affordability. Victoria Transport Policy Institute.
13. Maharani, N. (2025). Effect of Public Transportation Accessibility on Employment Rates in Indonesia. *International Journal of Sociology*.
14. Martens, K. (2017). Transport justice: designing fair transportation systems, New York/London, Routedge.
15. McKane, R.G. & Hess, D.J. (2022). Ridesourcing and urban inequality in Chicago: Connecting mobility disparities to unequal development, gentrification, and displacement. Environment and Planning A: Economy and Space 54 (3), 572–592.
16. Nazari Adli, S. & Donovan, S. (2018). Right to the city: Applying justice tests to public transport investments. Transp. Policy 66, 56–65. https://doi.org/10.1016/j.tranpol.2018.03.005.
17. Nazari Adli, S., Chowdhury, S., & Shiftan, Y. (2019). Justice in public transport systems: A comparative study of Auckland, Brisbane, Perth and Vancouver. Cities 90, 88–99. https://doi.org/10.1016/j.cities.2019.01.031.

18. Pereira, R.H.M., Schwanen, T., & Banister, D. (2017). Distributive justice and equity in transportation. Transp. Rev. 37 (2), 170–191. https://doi.org/10.1080/01441647.2016.1257660.
19. Qiao, S. & Yeh, A.-G.-O. (2021). Is ride-hailing a valuable means of transport in newly developed areas under TOD-oriented urbanization in China? Evidence from Chengdu City. J. Transp. Geogr. 96, 103183.
20. Qiao, S. & Yeh, A.-G.-O. (2023). Is ride-hailing competing or complementing public transport? A perspective from affordability. Transportation Research Part D: Transport and Environment. 114, 103533.
21. Qiao, S. & Yeh, A.-G.-O-. (2023a). Mobility-on-demand public transport toward spatial justice: Shared mobility or Mobility as a Service, Transportation Research Part D 123, 103916.
22. Rawls, J. (1999). A Theory of Justice, Revised Edition. Harvard University Press.
23. Shaheen, S. & Chan, N. (2016). Mobility and the sharing economy: Potential to facilitate the first-and last-mile public transit connections. Built Environment. 42 (4), 573–588.
24. Smith, G., Sochor, J., & Karlsson, I.C.M. (2018). Mobility as a Service: Development scenarios and implications for public transport. Research in Transportation Economics. 69, 592–599. https://doi.org/10.1016/j.retrec.2018.04.001.
25. Vanoutrive, T. & Cooper, E. (2019). How just is transportation justice theory? The issues of paternalism and production. Transportation Research Part A: Policy and Practice. 122, 112–119. https://doi.org/10.1016/j.tra.2019.02.009.
26. Venezia, E. (2011). Sustainability in cities: greater responsibility and efficiency. Venezia, E. (ed.), Urban sustainable mobility, 2011, Milan, Franco Angeli, ISBN 978-88-568-3742-1.
27. Venezia, E. (ed.) (2019). The decision-making process for infrastructural investment choices, Milan, Franco Angeli, ISBN 978-88-971-9081-1.
28. Venezia, E. (2023). Hedonic prices and economic evaluations of green areas and transport infrastructures incidences on real estate values, AIP Conference Proceedings 2928, 130009, https://doi.org/10.1063/5.0170814.
29. Verlinghieri, E. & Schwanen, T. (2020). Transport and mobility justice: Evolving discussions. Journal of Transport Geography. 87, 102798 https://doi.org/10.1016/j.jtrangeo.2020.102798.
30. Victoria Law Foundation (2019). The Principles of Justice: Equality. Fairness & Access A collection of case studies, Melbourne.

31. Weckström, C., Mladenović, M.N., Ullah, W., Nelson, J.D., Givoni, M., & Bussman, S. (2018). User perspectives on emerging mobility services: Ex post analysis of Kutsuplus pilot. Research in Transportation Business & Management. 27, 84–97.
32. Xu, Y., Santi, P., & Ratti, C. (2022). Beyond distance decay: Discover homophily in spatially embedded social networks. Annals of the American Association of Geographers. 112 (2), 505–521.
33. Zhai, W., Liu, M., & Peng, Z.-R. (2021). Social distancing and inequality in the United States amid COVID-19 outbreak. Environment and Planning A: Economy and Space 53 (1), 3–5.
34. Zhao, P. & Li, S. (2016). Restraining transport inequality in growing cities: Can spatial planning play a role? International Journal of Sustainable Transportation. 10 (10), 947–959.
35. Zhao, P. & Li, P. (2019). Travel satisfaction inequality and the role of the urban metro system. Transport Policy 79, 66–81.