DRT and Social Exclusion: A Literature Review on Gender, Age and Income Impact

Antonio Russo[1], Tiziana Campisi[1(✉)], Giovanni Tesoriere[1], Chiara Spadaro[1], and Guilhermina Torrao[2]

[1] Department of Engineering and Architecture, University of Enna Kore, 94100 Enna, Italy
tiziana.campisi@unikore.it

[2] Department of Engineering Management, Aston University, Birmingham B4 7ET, UK

Abstract. Demand-responsive transit services (DRTs) have emerged in recent years as a mode of transport capable of improving the efficiency of public transport, respecting scheduled services, and aligning with Agenda 2030 Sustainable Development Goals (SDGs) to provide affordable, accessible, and sustainable transport systems for all. The main socio-demographic determinants for the adoption of DRTs were investigated in this research. In particular, a coherent state of the art on the role of the three studied attributes (Gender, Age, In-come) in the adoption of DRTs was defined, exploring the qualitative and quantitative contributions present in literature, with a focus on modal choice models.

For this study, a systematic literature review (SLR) was conducted through a structured search across various search engines. This approach involved defining appropriate keywords as well as setting inclusion and exclusion criteria to ensure effective search and thorough analysis of the selected studies. Results are classified considering the contribution of the role of the three different attributes. The results show that there is a growing interest in on-demand forms of mobility. Age-related contributions are more numerous and with concordant conclusions, which highlight the positive impact of DRTs on mobility for older people. The role of income and especially gender is less evident, laying the foundation for further research.

Keywords: Demand-responsive transit · Social exclusion · Systematic Literature Review · Socio-demographic attributes · Accessible and Sustainable mobility

1 Introduction

Addressing inequalities stands as a fundamental priority within the United Nations (UN) Agenda 2030 framework. Several Sustainable Development Goals (SDGs) emphasize the urgent need for global action in this area, including SDG1: No Poverty, SDG5: Gender Equality, and SDG10: Reduced Inequalities [1].

Addressing inequalities is transversal and concerns different aspects. In the EU, the risk-of-poverty rate was 14.3% in 2023; in some regions of Southern Europe and French overseas territories the share of people at risk of poverty exceeded 30% [2].

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Wage disparities are significant. According to the European Commission, women in the European Union earned on average 12.7% less per hour than men in 2021 [3].

The average ageing of the population in some countries is generating new challenges that the countries' political systems must address. It is projected that there will be close to half a million centenarians in the EU-27 by 2050; furthermore, ageing seems to be related with a gender difference, as women outnumber men at older ages within the EU-27 population: in 2019, there were more than twice as many very old women (aged 85 years or more) as very old men [4].

At global level, inequalities are even more evident. Almost 700 million people (8.5% of the global population) live in extreme poverty [5] and the gender gap is still far from being filled, despite the progress that is being made in various parts of the world [6]. The development of sustainable cities represents a further challenge that largely overlaps with those presented previously. Agenda 2030 highlights this in SDG11 "*Sustainable Cities and Communities*", with reference to target 11.1 "*By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons*". The UN therefore emphasizes the need to ensure equitable access to transport for all, with particular reference to those in vulnerable conditions.

The issue of inequal accessibility to the transport system is linked to geographical, territorial, and socio-demographic conditions, but also to cultural and political elements, in addition to the obvious infrastructural issue [7–10]. The interest of city administrators, policymakers and technicians is to act on the levers available to the transport system to reduce these differences, considering the characteristics of the territories.

The services called Demand-responsive transit (DRT but sometimes indicated as "on-demand bus service" or "Paratransit") are on-demand services, generally with a semi-fixed route [11]. DRT services can offer direct transport from residents' homes to places such as shops and to health services, thus addressing social exclusion in transportation systems accessibility; they are also widely used within rural areas, where low demand and the geographical dispersion of settlements make fixed systems often inefficient. This study explores the relationship between the diffusion of DRT and three socio-demographic attributes of particular importance in assessing user inequalities: age, gender and income. In the aforementioned Target 11.1, associated with SDG 11, attention to women and the elderly in the expansion of public transport is highlighted. The Target also refers to users in "vulnerable situations"; although it is difficult to model analytically, the condition of vulnerability in the transport sector is often similar to income; this is particularly true especially in the study of public transport, where income can influence the ownership of a private vehicle and, consequently, the use of public transport. For the reasons mentioned, the paper studies to these three attributes. Through a Systematic Literature Review (SLR), this study aims to define the main research trends and critically assess the relationship between the potential and the actual adoption of DRT services and these three variables (age, gender and income). The study seeks to provide a comprehensive reflection on the current state-of-the-art on the opportunities that on-demand transport models offer in addressing social, gender, and age-based inequalities.

The paper is organized as follows. Section 2 recalls the main contributions of literature on age, gender and income differences and the relationship with the transport system, in order to provide a background that allows to position DRT within these themes. Section 3 defines the methodology followed in this study. Section 4 describes the results of the research, discussed in Sect. 5. The conclusions are defined in Sect. 6.

2 Background

The transport system is intrinsically linked to both the system of activities and to the territorial system and the nature of the transport demand is that of "derived demand" [12]. Accessibility to the transport system implies participation to essential services, like education, healthcare, work, leisure, by users.. An effective and equitable transport system must ensure that all users have the opportunity to meet their mobility needs, thereby promoting social inclusion and equal access to key services. Spatial and social mobility is deeply intertwined in shaping and perpetuating spatial and gender inequalities within the city and society [13]. Over the years, literature has explored disparities in transport system access, focusing on the socio-demographic attributes of age, income, and gender, as presented next.

2.1 Age

An efficient public transportation system is essential not only for the general population but also for specific groups, including older adults. With aging often comes a reduction in opportunities for independent travel [14, 15]; the aging process brings physiological changes that directly affect mobility, including the lower number of trips made by the elderly compared to adults. Ensuring accessible public transport can therefore help the elderly to maintain their access to essential services and social activities even in absence of private vehicle ownership [16, 17]. Similarly, an age-friendly public transport system should be widespread and flexible, offering accessibility from diverse origins and destinations. While in large urban agglomerations this is often possible, since public transport runs at capacity, this is more difficult to ensure in rural areas, due to lower demand and the territorial dispersion of settlements that make traditional public transport systems often inefficient [18, 19]. The issue of depopulation of rural areas is therefore intertwined with the issue of accessibility to public transport by the elderly: rural areas often experience both population decline and demographic aging. Ensuring the availability of transport services in rural areas is essential for maintaining access to essential services and social participation for elderly populations, ultimately promoting their well-being and quality of life [20–22].

Similarly to mobility challenges faced by the elderly, mobility for young people also presents some critical issues. Behind the limitations on movement there are often legal reasons (at least for adolescents, with differences between different countries) linked to the minimum age for holding a driving license [23, 24]. Beyond the problems of having a driving license, the elderly and young people encounter challenges related to their differing relationships with technology with technology. These differences shape their perspectives on emerging innovations such as Mobility as a Service (MaaS), autonomous

vehicles, and information and communication technologies (ICT) [25–27]. The mobility for young people highlighted in this study mainly concerns teenagers and high school and university students; it does not concern the mobility of children which, for practical and legal reasons, presents different characteristics.

2.2 Income

A user's income can significantly influence various aspects of mobility. A user with a higher income, having greater economic possibilities, can have access to a more favorable position (closer to the attraction poles) and to a greater availability of private cars and less need for public transport.

In literature, the relationship between low-income users and the public transport system is often mentioned. While in general the positive relationship that is established, at a macroeconomic level, between GDP and investments in transport is proven [28], the relationship between poverty and economic policies of transport is less clear, especially in countries like the USA where investments in transport have not seen a simultaneous decrease in poverty [29]. In this regard, studies have highlighted preference for private vehicle use even among lower-income groups in the USA the USA [30]; while in the countries of the Global South, introducing subsidies to support the mobility of users is seen as an often-necessary choice [31].

Studies have highlighted the positive contribution of investments in public transport in improving accessibility to the transport system by low-income users [32]; however, the ambiguities that have emerged and the contamination with other attributes, both individual (e.g. ownership or not of a vehicle) and aggregate (e.g. geographical area of reference, political and cultural structure) make the analysis of the relationship between income and transport more complex.

2.3 Gender

The gender gap is the relative disparity between women and men; it si reflected in several sectors of society, including social, political, intellectual, cultural, or economic elements [33]. Gender differences are also present in the transport sector and can influence access to transport services.

Lecompte et al. [9]highlighted differences in women and man trip habits; often, women tend to travel less than men, but spend more time on transport; despite this, their journeys are often shorter. This translates into less accessibility to workplaces for women. Furthermore, gender differences are more pronounced in areas characterized by a low socioeconomic level.

The recent pandemic has further exacerbated this gender gap [34] pushing a modal shift towards walking [35].

Research in the collective transport sector and in particular in the public transport sector highlights the presence of a series of critical issues that influence women's modal choice, namely the greater propensity to being exposed to acts of violence, abuse and sexual harassment [36–38].

Several studies suggest what may be the influencing factors of public transport service design when considering the social problem; they provide strategic hypotheses for

improving the design and enhancement of public transport services. The goal is to reduce the fear of crime compared to those based simply on crime prevention [39].

Exposure to sexual harassment and feelings of fear affect women and students in particular during commuting trips [38, 40]. Furthermore, the extent to which this affects their life satisfaction often remains ignored in literature.

The findings of a study conducted by [41] indicate six factors that contribute significantly to increased risk of violence, namely age, marital status, type of public transport used, travel time, facilities and management of public transport services.

In recent years, there has been a greater need to address gender equity among the necessary elements in transport planning [42–44].

Technological evolution, such as the increased presence of sensors and apps instead of on-board controllers, reduces the feeling of safety, as does the presence of poorly lit waiting areas and the presence of trained personnel (e.g. bus drivers). Several studies recommend the implementation of services with innovative means to maintain and improve women's safety, while pursuing technological change [45].

Torrao et al. [46] examined how artificial intelligence (AI) could be leveraged to improve transport safety, particularly for women and other at-risk users, such as while waiting for a bus service.

Recent advancements in AI offer new solutions that can enhance women's safety on public transport through various applications, such as Smart CCTV/AI-powered CCTV and crime hotspot prediction [47].

Therefore, cities must prioritize the development of gender-sensitive public transport plans and policies that address the specific needs of women and girls, and vulnerable groups, ensuring their safety, accessibility, and inclusion within the transport system.

3 Methodology

The methods used for the systematic literature review conducted in this study involved following major steps:

- Identification: Search methods, scope, search engines and keywords were defined.
- Screening: Screening of the records with exclusion of unavailable or out-of-place papers
- Eligibility: Definition of inclusion and exclusion criteria for the literature studies
- Inclusion: Selection of literature papers matching the inclusion criteria considering year of publication, peer review publications, English language, open access and relevance for the thematic areas being investigated.

3.1 Research Motivation

The research questions guiding this study are as follows:

- Research Question 1: What trends have emerged in recent years regarding research on DRT and socio-demographic attributes?
- Research Question 2: Which countries are primarily involved in producing works on this topic?

- Research Question 3: What key considerations does literature highlight in relation to the adoption of DRT and Gender/Age/Income? Is it possible to identify similarities and differences among these attributes?

3.2 Information Sources, Database, Keywords and Search Strategy

This SLR was performed considering two search engines: Web of Science and SCOPUS. These two databases were used for this paper because they represent the two main bibliographic indexing platforms internationally recognized for the high quality standard in the selection of sources; in particular, both cover a wide spectrum of disciplines relevant to the topic of the relationship between on-demand transportation and sociodemographic characteristics of users, including transportation engineering, urban and territorial planning and transportation economics. To refine the search results, by limiting the search to the entries "Title, Abstract, Keywords".

This approach ensures that the selected papers contain the searched words among the title, the abstract, or keywords and are relevant for the aim of this study.

The different searched keywords and combinations adopted in this SLR are presented in Fig. 1.

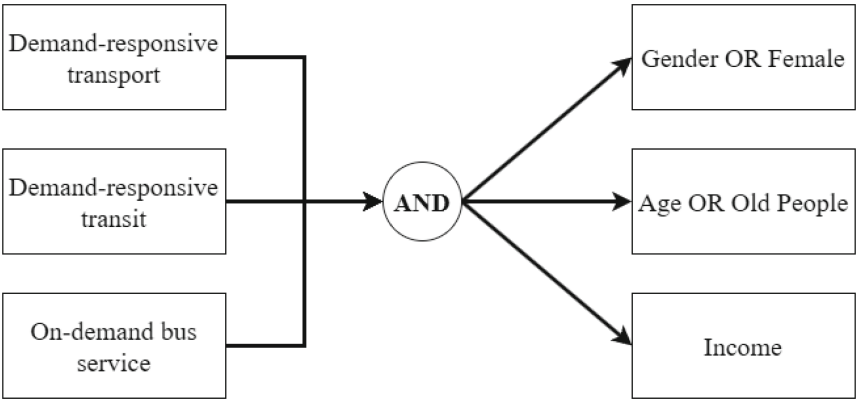

Fig. 1. Keywords combinations and boolean operators.

The searched keywords are obtained by combining in the search a term that refers to the DRT, represented in the left part of the image, and a term that refers to one of the three socio-demographic factors investigated.

3.3 Exclusion Criteria

Criteria for the definition of subset of items analyzed are considered. For this research the following criteria are defined:

- Duplicate papers (resulting from more than one search engine) have been excluded;
- Papers for which the full text could not be obtained have been excluded;
- Off-topic papers have been excluded;

- Papers that are on topic but do not provide findings useful for research purposes are excluded;
- Editorials are excluded.

3.4 Quality Assessment and Data Extraction

- The SLR search led to the selection of preliminary records that were further access against the eligibility criteria as explained next. Overall, N = 98 papers were found from Web of Science (WOS) and N = 35 papers from Scopus, for a total of 134 results.
- Reports removed before screening: this group contains papers removed before the screening phase. Overall, 27 results were found in both search engines. Duplicated studies (N = 27) were removed.
- Records screened: these are the records subjected to the screening phase. Overall, N = 107 were found.
- Reports not retrieved: includes papers that are not available with open text to the authors. N = 43 papers were found.
- Records excluded: this subset includes all papers verified and reviewed by the authors but which do not fit the search criteria. N = 18 papers were found as part of this subset. The high number can be explained because the search and extraction are performed semi-automatically and consequently, the search can find results that do not fit the inclusion criteria fit. There are also papers in which the importance of, for example, DRT for the elderly is declared in the abstract, but the topic is not explored in depth in the text.
- In total, N = 46 records were assessed for eligibility.
- Excluded reports are editorials. No editorials were found in the search (N = 0).

  – Studies included in the review. The final 46 papers are limited to papers in which at least one of the three elements emerges among the findings: a positive relationship between sociodemographic: Age, Gender, or Income and DRT adoption/Propensity to use DRT; a negative relationship between sociodemographic: Age, Gender, or Income and DRT adoption/Propensity to use DRT; the positive relationship between sociodemographic attributes (Age, Gender, or Income) and DRT adoption/Propensity to use DRT is hypothesized but the analysis shows it is not significant.

Table 1 illustrates the relationships between the various recorded papers and the excluded papers throughout the systematic literature review (SLR) process.

4 Discussion

The subsequent analyses are referred to the 43 papers of the group “Studies included in the review”. The papers obtained were classified according to year of publication (Subsect. 4.1), university or research center distribution (Subsect. 4.2) and presence of Age, Gender, and Income attributes (Subsect. 4.3).

Papers included in this study to explore the relationship between the diffusion of DRT and the above socio-demographic attributes are those referenced as [48–91].

Table 1. Subsets of literature records found through the SLR

Subset name	Items	Relations
A -Records found	134	
B - Records removed before screening (Duplicated)	27	
C - Records screened	107	C=A-B
D - Not retrieved	43	
E – Records Excluded	21	
F – Reports assessed for eligibility	43	F=C-D-E
G – Reports excluded	0	
H – Studies recorded for this review	43	H=F-G

4.1 Temporal Distribution

The selected literature papers included in this study analysis were classified by year of publication. In Fig. 2 the temporal evolution of the works is represented. In order to obtain significant intervals, the papers were aggregated on a five-year basis. A notable increase emerges in the five-year period 2020–2024. An exponential trend is evident, with the regression curve (in red in Fig. 2) indicating a value of R^2 close to 1. This suggests a nearly perfect exponential growth in the number of the paper publications.

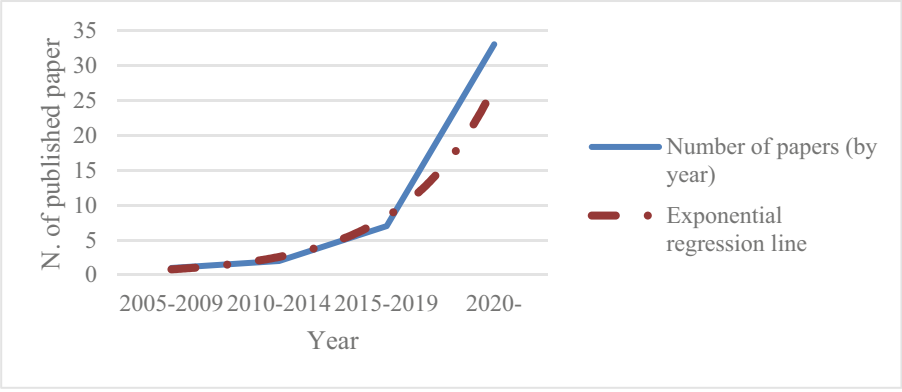

Fig. 2. Number of published papers by year (Color figure online)

4.2 Geographic Distribution

Figure 3 shows the distribution of the number of papers by country of origin. The highest number of papers was found in the USA (9 papers), followed by China (6 papers) and Canada (5 papers).

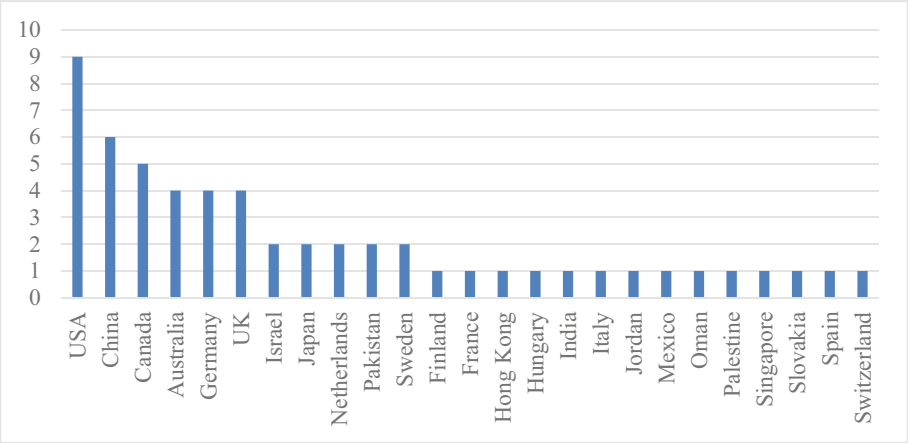

Fig. 3. Number of papers by country

It is noteworthy to highlight the collective contribution of the EU countries, 13 contributions in total, across 8 member states; Germany emerges as a leading contributor with 4 papers, ranking fourth overall, while the UK (outside of the EU) also accounts for 4 publications. Overall, the EU + UK have published 17 papers, underlining the significant emphasis placed on the topic discussed and the ongoing efforts to combat social exclusion in transport provision within the European territory.

4.3 Thematic Analysis

Figure 4(a) illustrates the number of literature papers that that reference one of the three sociodemographic attributes considered in this study. Age, consistently remains the most frequently studied attribute.

Figure 4 (b) provides a more detailed breakdown, showing how the papers are distributed in terms of socio-demographic attributes. It emerges that the largest share of attributes is linked to works in which the significant conclusions refer exclusively to age.

This observation aligns with previous research, mainly aimed at the study of accessibility for the elderly.

The main results obtained from the selected literature studies are described below.

Age. One of the characteristics recalled of DRTs is that they are services designed "for the elderly". This element is already recalled by [48]. The literature analyzed, also highlights two groups. The first defines papers in which the positive potential and the greater adoption of on-demand services by the elderly are underlined; in the second, the lower adoption/propensity is explained, and is linked to defined characteristics.

Several results agree on the relationship between age and on-demand transportation. Older people are generally interested in on-demand transport services and the possibilities they can offer in terms of mobility [49–58]. It should be noted that ageing and the consequent lengthening of travel times can be a determining factor in the choice of on-demand transport modes [59].

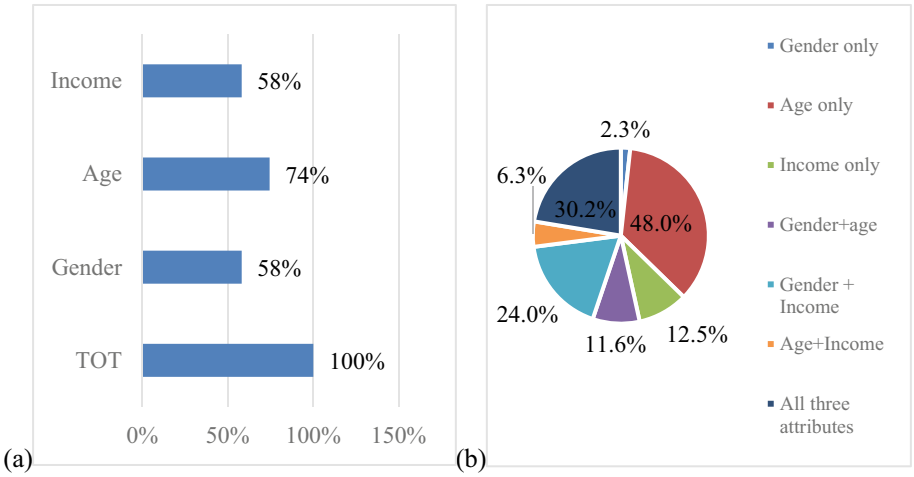

Fig. 4. (a) Number of papers by socio-demographic attributes as percentage of total number of papers; (b) Distribution of socio-demographic attributes across the selected literature papers (percentage of total)

It is highlighted how the age factor often determines the adoption of DRT by the elderly [60]; and that access to the transport system, often complicated by barriers for the elderly, would be simplified by the adoption of DRT [61, 62]. suggests that age was a driver that determined a greater adoption of DRT during the pandemic phase [63]. underline how paratransit can improve mobility for older people and other disadvantaged groups.

Some studies have instead highlighted a lower or mixed propensity of older people to use on-demand services, if compared to younger categories [64–69], for reasons mainly related to the type of travel: older users, moving less for systematic reasons related to work, will generate fewer trips. Other reasons also emerge behind lower adoption. Some studies underline the greater propensity of young people [70–72] and lower satisfaction of older people [73]; these latter points are linked to greater enthusiasm of young people towards technologies [74]. highlighted how the elderly are more concerned about safety-related aspects [75]. highlighted the technological barriers that the elderly must face in using the system [76]. highlights how the elderly are fewer among the users of the analyzed service, probably because they make fewer night trips; furthermore, they highlight the technological adoption gap between elderly and young [77]. indicate the elderly among shared-mode opponents.

Some studies have reported a non-significant relationship for older user groups and the adoption of on-demand services, although they are smaller in number and linked to context specificities [78].

Income. The literature seems to be generally in agreement on the positive relationship between DRT and greater opportunities for low-income users.

Only a few papers have shown a non-significance, or low relevance, of the income attribute in the adoption of the defined transport mode [67, 76, 79]. In one case, it is

highlighted how the service rates are competitive enough to guarantee acceptance of the service regardless of income [80], making the service more accessible for everyone.

Most of the contributions, however, focus on the positive relationship between the adoption of on-demand services and low-income users [53, 68, 69, 72, 73, 81–84]. In these works, the role that on-demand services have in guaranteeing access to activities to low-income users or users from a more economically disadvantaged area emerges [85]. have defined a lower predisposition to use these services by higher-income users. Similarly, [51] underline how income negatively impacts the probability of changing transport mode; higher income users will tend to make fewer modal shifts.

Thakuriah et al. [86] highlighted a higher probability for the unemployed to use DRT compared to public transport. High income also translates into a lower concern for safety in the case of Autonomous DRT [74] and a general lower interest in on-demand services [71]. In one case it is highlighted how the Income attribute can overlap with the Age attribute [87]. It is emphasized how the areas with a higher average user's age are also those with greater widespread well-being; developing services in areas with a higher average user's age could, therefore, determine an increase in social exclusion phenomena.

Gender. The literature analyzed highlights the presence of two groups of internally consistent papers. In the first group, females show a greater preference for DRT when it increases safety (DRT compared to public transport; when used for commuting, and when traveling in the evening). In the second group, females prefer individual transportation options, such as private cars and taxis, over DRT. Specifically, in the first group, some studies have explicitly addressed the possibility that the perception, use or adoption of an on-demand transport service may vary with the public. However, these studies have not yielded significant findings [53, 57, 60, 70, 79, 82, 85].

Several studies have highlighted how safety concerns are particularly more relevant for women in terms of autonomous DRT [74, 88], while other authors have highlighted how the gender effect is often due to a lower perceived safety by women feeling less secure when using shared transportation options [62, 77, 83, 89].

Even when the topic of safety is not expressly mentioned several papers underline how men show a greater acceptance of DRT systems compared to women [51, 69, 72].

It is interesting to note how in the indicated papers, the on-demand service "partially or totally shared" is compared to a private vehicle or a private taxi. In these cases, the above-mentioned result emerges: a lower female preference for DRT-type systems compared to the private alternatives.

In the second group, some works indicate a greater preference of women for DRT compared to men for different travel reasons [55] [76]. highlighted an increase in female use of on-demand transportation services [68]. similarly highlighted a greater female preference for integrated services compared to public transport, and a similar result was obtained by [78], with respect to the paratransit services studied [73]. showed greater satisfaction with community on-demand services, but the analysis is limited to the university population.

Moreover, [90] suggested that the relationships between gender and age are intertwined in the adoption of DRT. Accordingly [71] male and high-income housewives prefer using private cars.

5 Conclusion

The results presented in the previous section show a high interest in the topic discussed. Some considerations can be examined immediately:

This study analysis is based on a systematic literature review that included 43 selected papers aimed at assessing the potential relationships between three key sociodemographic attributes (age, gender and income) and the adoption of Demand-responsive transit services (DRTs) services. The analyses carried out made it possible to answer the three research questions posed in Sect. 3. The answers are:

- Answer to RQ1 (General trends temporal distribution and trend): The increasing number of publications on the topic indicates a growth interest, particularly in relation to sustainability issues highlighted by UN Agenda 2030. The topic has shown a high level of interest in recent years. It is significant to recall how the distribution of papers has grown exponentially; in particular, the particularly high number of contributions made from 2020 to 2024 suggests that the COVID-19 pandemic may have made a significant contribution to the deepening of the topic.
- Answer to RQ2 (Geographic distribution): The papers are transversal to many countries, even those that are culturally and politically diverse. Most of the contributions come from the USA; but also China, several countries of the European Union and United Kingdom are indicated among the most prolific authors. This therefore denotes that the scientific interest is shared at a global level;
- Answer to RQ3 (Thematic distribution): Although Income is examined slightly more frequently, the magnitude of research on age and, especially, gender is comparable. There is significant interest in these attributes as well. The interest in age and especially gender is significant. This research has highlighted how the DRT services described can help to reduce the income, gender and age gaps. The services can provide a valid alternative in areas where mass transit is less economically accessible and provide comprehensive assistance to the elderly and individuals with mobility challenges. The relationship between willingness to use DRT and gender is more complex: depending on the context, DRT would seem to be safer, for women, than public transport, yet it is perceived as less safe than private cars or taxis. This aspect should be further investigated through a careful comparison of the modal choice models proposed in literature.

The results obtained push us to consider DRT as viable services to promote the reduction of inequalities and address the phenomena of social exclusion.

This study marks an initial step to explore the proposed research questions. However, it acknowledges certain limitations. The methodologies are not directly compared and a quantitative comparison between the attributes of the modal choice models is not proposed. Both these elements are currently defined as future developments for this research.

The study is of interest to different stakeholders: researchers and academics, as this work provides a first extensive review contribution on the impact that the three sociodemographic attributes have on the use of on-demand transport modes, thus representing a consolidated basis for those working in this field; policymakers and planners, as from the paper they can derive what are some of the most widespread critical issues related

to the use of the transport system by users in vulnerable conditions, and define policies accordingly.



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Disclosure of Interests. N.t.d.

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