Article

The Concept of Fairness in Relation to Women Transport Users

Yvonne Hail [ID] and Ronald McQuaid *[ID]

Stirling Management School, University of Stirling, Stirling FK9 4LA, UK; yvonne.hail1@stir.ac.uk
* Correspondence: ronald.mcquaid@stir.ac.uk

Abstract: This paper discusses the concept of 'fairness' in transport, specifically regarding women using public transport, future autonomous vehicle taxis or bicycle sharing. Women generally have varying and complex mobility patterns compared to men and suffer disproportionate fairness issues when using transport. Different concepts of fairness are explored, including: equality of opportunity, equity and justice (including procedural, social and distributional justice). While each of these concepts has different implications for women using transport, it is also recognized that fairness principles should apply to all people (regardless of sex, gender or other characteristics). Analysis of the different forms of mobility, as represented by public transport, autonomous vehicles and bicycle sharing, illustrate a variety of specific fairness issues. Factors such as safety and security, cost, physical design of infrastructure and vehicles, and characteristics such as low-income or childcare responsibilities arise in each case. The three cases also indicate a range of both horizonal fairness factors (similar people being treated similarly) and vertical fairness factors (such as more disadvantaged people receiving greater support). Further research is required into setting frameworks for a more comprehensive inclusion of, and balance between, different concepts of fairness and their interactions in both transport policy and practice.

Keywords: fairness; equal opportunity; equity; social justice; women; public transport; autonomous vehicles; bicycle/bike sharing

1. Introduction

In many countries, including the UK, fairness in transport has been based on the principles of formal equity with an emphasis on treating people equally in terms of no one suffering the costs or getting the benefits disproportionately, and ensuring at least minimal levels of transport provision [1]. However, while justice and fairness have become increasingly important in sustainability and transport policy for decades, the definition of fairness and how it should be incorporated into transport decision making and planning remains unclear [2–4]. While, the concept of fairness in a society varies over time and circumstances, and may be based on individual subjective reasoning and experiences, it is important for people's acceptance of more sustainable travel modes across society [5]. Hence fairness for public transport users is likely play a significant role in achieving a more environmentally and socially sustainable future.

This paper explores the concept of fairness on issues relevant to women's experiences when using different forms of transport. It analyses the specific fairness issues faced by women's use of three different forms of mobility and transport available to the public: public transport (such as railways and buses with large number of passengers per vehicle and often operating at a macro-regional level), autonomous vehicle (AV) taxis (individually responsive potential future systems), and bike/bicycle sharing (a form of micro-mobility where the infrastructure and bicycles are publicly available for individual travel).

Socio-demographic characteristics affect people's views and use of transport modes and are hence important to achieve more sustainable travel [6]. Due to specific mobility needs for some groups of women, there is a need for gender-responsive transport design and infrastructure [7]. In aggregate, men and women often differed in their transport

behaviour with regard to both the modes of transport chosen and the times of travel [8–12]. Women, especially those with childcare responsibilities, tend to travel less for work than men [13] and make multiple, shorter and more complex journeys compared to men, who take longer and more single journeys at different times of the day [9,11]; although increasingly younger women have travel behaviour more similar to men [14,15]. Of course, women are not a homogenous group and there are various sub-groups with which women identify, based on characteristics such as age, disability, ethnicity, parental and caring responsibilities, so it is important for research and policy to reflect this complexity of women's multiple social identities.

The research process involved two phases. Phase 1 involved an initial traditional literature review on fairness and transport followed by interviews, focus groups and interactive meetings with professionals and researchers in transport, to validate the broad issues identified. This included face-to-face and online meetings with over twenty organisations who represented local and national government, rail and transport employment specialists and rail delivery services in various European countries. Building on this, Phase 2 of the research then carried out a scoping review to capture additional relevant scientific literature on the current facilitators and barriers faced by women in the chosen three forms of transport.

The next section presents the results of Phase 1, by discussing the concept of fairness in transport, especially: equality of treatment, equality of opportunities, equity and social justice, and which groups are particularly affected by fairness issues. Section 3 presents the methods used in Phase 2. The scoping review results are reported in Section 4, seeking to identify relevant scientific literature on the current facilitators and barriers faced by women in the three areas of transport, public transport, autonomous vehicle (especially taxis) and bicycle sharing. These are followed by conclusions in Section 5.

2. What Does Fairness Mean?

An initial view of "fairness" in transport includes equal treatment for all individuals using or affected by a transport service or system. However, there are different aspects of "equal treatment" including issues of equal opportunities, equality of outcomes and social justice. Folger and Cropanzano [16] suggest that individual judgements relating to fairness are based on people's perceptions of themselves as being in an "aversive state" whilst comparing themselves with others in a more "beneficial state", therefore raising questions regarding who or what could be made accountable for such differences. They also highlight how notions of fairness can be more difficult to measure than they first appear, by discussing the variations in the degrees of fairness and/or unfairness felt by individuals and argue that it is the gap between the outcome and the individual's evaluation of the perceived "unfairness" which determines the magnitude of their feelings. Hence fairness can be seen as being based partly on individual perceptions, which may be influenced by factors such as a person's: socio-demographic characteristics, background, social position, views on justice, understanding or perceptions of what affects transport outcomes amongst others.

Using a more structural definition of fairness, focusing on the societal issues that influence the outcomes of decisions, O'Brien et al. [17] claim that to be truly fair, those who are disadvantaged, for example through poverty, ethnicity or gender, should be provided with all additional resources that would ensure they are not excluded from opportunities that are available to those who are not defined as being disadvantaged. They suggest that the "non-discriminatory treatment of individual users and of disadvantaged groups generally ... having access to resources which ensure[d] adequate opportunities ... the promotion of rights of indigenous, minority and disadvantaged groups" (p. 151). Here fairness is a concept correlated with social justice and equality of outcomes which are inclusive for all irrespective of age, ethnicity, gender, or social class.

Although referring to computer processes, Friedman and Nissenbaum [18] set out a useful definition of a process being biased (and so potentially unfair) "if it systematically

and unfairly discriminate against certain individuals or groups of individuals in favor of others. A system discriminates unfairly if it denies an opportunity or a benefit or if it assigns an undesirable outcome to an individual or a group of individuals on grounds that are unreasonable or inappropriate" (p. 332). This definition suggests that differences such as income, disability, caring responsibilities, etc. need to be considered as well as the issue of sex or gender.

Different transport issues may result in different notions of fairness. For instance, in terms of traffic accidents, it would not be seen by most people as being fair that certain groups are more likely to be injured or die (such as car driver versus pedestrian death rates). In contrast it may seem fair to some that all those aged over 65 get free bus travel, while others may think it unfair as a wealthy older person would be able to travel for free when a young poor person could not. Similarly toll roads may be accepted by those who feel that those who can afford a speedy trip should be able to use a faster road if they value that compared to those who could not afford the toll. These examples illustrate that different aspects of fairness may apply to different issues, in different circumstances or to different groups.

Views on fairness in transport are closely associated with the concepts of equal opportunity, equality (or equal outcomes) and social justice, with the terms sometimes being used interchangeably. In the main, the terms "fairness", "equality" and "justice" tend to be used to describe both: how decisions are made and how various individuals are treated across a community; and the outcomes of such decisions. Here we suggest a broad definition of fairness in transport as: a state in which people are treated similarly, unimpeded by prejudices or unnecessary distinctions or barriers, except they can be explicitly justified. To consider various aspects of fairness in more detail, the issues of equality of opportunity, equality of outcomes, justice, and fairness for whom are now considered.

2.1. Equality of Opportunity

Equality of opportunity can be considered as a state of fairness in which all groups of people are treated similarly, unimpeded by prejudices or unnecessary distinctions or barriers, except when they can be explicitly justified (e.g., cheaper fares for children or low-income people) [19]. In other words, equality of opportunity should provide fair opportunities for people with a variety of different characteristics to access safe, secure, effective, and efficient transport systems that meet their daily needs. With its roots in the wider concept of social justice, equality of opportunity therefore supports the idea that opportunities should not be restricted for different groups of people. Substantive equality of opportunity (substantive justice, with transport policies and their implementation being fair) implies that a "fair" system seeks to minimise both explicit discrimination and indirect discrimination.

From a transport perspective, it has been argued that fairness mainly relates to equality of opportunity [20]. For instance, if adequate transport access to services or destinations, such as education or employment, is difficult then this can increase income or other inequality. Therefore, adopting an equality of opportunity approach relates to an acknowledgement that there are differences amongst groups of people and accepts that discrimination creates patterns of inequality that a purely equal treatment approach, where every person is treated identically, cannot address.

A transport policy can therefore be defined as fair, or fairer, if it distributes transport investments and services in ways that reduce inequality of opportunity. While aiming to enhance overall levels of accessibility, transport policies should also prioritise vulnerable groups and thereby mitigate morally arbitrary disadvantages that systematically reduce their accessibility levels, such as being elderly, disabled, or being from an ethnic minority or financially disadvantaged background. This approach supports the setting of minimum standards of accessibility to key destinations, guaranteed by governmental social or transport policies. Further, an accessibility-type approach suggests that fairness in

transport involves providing equal access to opportunities to participate in activities, that an individual values, at a minimum level (such as health, employment and education) [21].

For a fair exchange the benefits must come back, in some way, to the users and potential users of transport (distributional justice). For example, an equitable exchange between the government (giving subsidies) and rail companies must also take into account train passengers and those suffering externalities (like noise or air pollution for those living near the railway lines) and non-users (who may be put off travelling due to timetables, inaccessible station locations or costs, etc.). Such fairness needs to be accompanied by good governance, high levels of accountability and transparency to all interested groups. This means taking account of the social costs and benefits, as well as financial ones, of poor transport [22].

Even if such formal equality of opportunity (and lack of formal discrimination) between groups exists, there may be a need for relevant policies if indirect discrimination exists. For instance, those who have primary responsibilities for young children when travelling should have full access to services (for example people using pushchairs for their children). This 'fair access' should be the case irrespective of the gender of the person responsible for the child, but in most cases currently, this would be a woman. Hence this particular barrier mainly (but not solely) affects women and under the umbrella of equality of opportunity, a 'fair' transport system would seek to remove the barrier. While this paper focuses mostly on fair access to transport for women, it is important to remember that 'fairness' applies to all people, and certain types of unfairness disproportionately affects people with certain characteristics regardless of sex or gender.

2.2. Equality of Outcomes or Equity

Bowling [23] argues that while fairness can never be perfect, the equality of outcome approach, or equity "focuses attention on the outcomes or end results of policies and programmes, imposing an expectation that an absence of inequity of any sort would be a hall-mark of a fair system" (p. 23). Litman [24] suggests that the terms fairness, equity and justice refer to the same concept, considering the "distribution of impacts (benefits and costs) and whether they are appropriate" (p. 2). This translates into notions of equity or fairness which can have a variety of impacts on diverse groups at specific times including the delivery, operation and planning of public transport services.

In order to robustly explore cases of inequality, Litman suggests utilising two distinct forms of equity or fairness, horizontal equity and vertical equity [24]. Horizontal equity relates to the egalitarian concept of equal treatment of equals and vertical equity relates to social justice and social inclusion. Horizontal equity means that those groups of people who have the same abilities and needs, receive equal treatment in terms of resources allocation and the costs and benefits of the transport policies (for instance, similar women are treated similarly). Vertical equity means that those groups of people who are more disadvantaged receive different or additional compensation or support from policies and have a priority over the other groups (for instance, public transport should be more focused on the needs of lower-income than higher-income women). There is a focus in these forms of equity on diversity and the differences (in need or ability to use transport system) between and within groups, for example transport policies which favour disadvantaged groups such as people with low incomes. From this perspective inequitable or unfair transport policies and planning can have diverse and significant impacts on various groups at various times, especially on individuals' economic and social opportunities. Hence, the operationalisation of equity and fairness means that there are suitable transport systems in place to provide services and activities that the local community require, so providing a form of intergenerational and inter-group equity.

Fairness involves both the opportunities and the processes for developing the policies to achieve greater fairness [25,26]. Rawl's equalitarianism includes fairness in terms of equality of opportunity, especially for the most disadvantaged [25]. Sen's capability approach focuses partly on an individual's well-being and might suggest minimum transport

standards for all so they have the opportunities and ability to take those opportunities that they have reason to value (for example, they may value access to a particular service) [26] (for further applications of the Capability Approach see: [27]).

Pereira, Schwanen and Banister use the theoretical frameworks of Rawls' egalitarianism and Sen's Capability Approaches to argue that the distributional effects of transport policies (and hence distributive justice) are important and concerns over transport disadvantage and social exclusion should focus on accessibility as a human capability [4]. This suggests that transport policies should explicitly consider their distributional effects and also set minimum standards of accessibility to key destinations (such as employment, education or healthcare). Policies should also prioritise disadvantaged groups, reduce inequalities of opportunities and mitigate transport externalities (e.g., noise, or people having to move house to make way for new transport infrastructure), while respecting individuals' rights. They argue that a fair distribution of accessibility should include that individuals' basic rights and their liberties should never be violated or sacrificed on the grounds of improving the accessibility levels of others. Therefore, distributive justice is important in a fair transport system and achieving fairer accessibility, but so is the processes and procedures by which the key decisions are made.

Transport can be considered in terms of accessibility with characteristics and principles distinct from other goods or services [28]. Accessibility, has been of intermittent policy interest in the UK and elsewhere over recent decades, often concerned with the potential for interaction, and so includes not just movement to, for instance, a facility or service someone wishes to access, but also their ability to access it (which may include issues such as opening times, cost, etc.). This includes people's unmet, as well as met, mobility requirements or needs [29]. Accessibility to services and jobs, including links to land use patterns, are important. For instance, the spatial mismatch hypothesis identifies inadequate transport links between poor inner-city residents and the growing numbers of jobs in the suburbs, resulting in higher unemployment and relatively fewer job opportunities for such residents [30]. Mobility justice may also include wider spatial justice and equity and multi-level issues (for instance from the local individual and urban levels to national and global scales, particularly in relation to major global issues of climate sustainability, urbanisation and refugees) [31].

Substantive and prescriptive justice (a normative perspective on what 'should' be, for instance, in a fair transport policy) is important in transport [28]. Lee, Sener and Jones develop the equity theory further and introduce five separate types of equity, which they argue are related specifically to fairness with regard to public use of and access to public transport [32]. These are: Social equity which analyses social groups (using characteristics such as income, race, sex and age, etc.); Spatial equity considering the geographical of where inequality is taking place [32], which is important to transport policy planning "because the effects of public policies tend to cluster around specific physical locations" (p. 213); Procedural justice (such as fairness in the process of allocating resources) focusing on the policy making process in contrast to the outcome of policy, with equity related to having fair and equal evaluations within the policy making decision process; Modal equity, ensuring safe access for all groups to the full range of local transport modes and their interaction, for example [32], "because walking and bicycling have higher mortality rates from vehicle accidents than driving, modal equity strategies would seek to restrict driving in order to slow or reduce vehicle traffic" (p. 215); and Distribution equity, related to how transportation costs and benefits are distributed across society.

These can be extended to issues such as distributional equity, which is often evaluated for fairness by examining the accessibility to transport infrastructures but excludes sufficient evaluation of how safely and easily people can travel to the station (see for instance, [33]. Modal equity approaches can be extended to consider the effects of using modes (e.g., the consequences of accidents at different speeds on pedestrians) and which may disproportionately affect certain groups (e.g., children). It is partly the basis for in-

troducing lower speed limits (for instance 30 km/h) in many cities, such as Edinburgh in Scotland [34].

However, it is important to recognise that according to equity theories, that some differences may be seen as being 'fair'; such as off-peak pricing, elderly or family discount fares, etc. In these cases, the services may be seen as different (the same train journey during rush hour is not the same as during off-peak times); or biases for one group such as discounts for the elderly may be thought to reflect, albeit perhaps ineffectively, ability to pay.

2.3. Justice

The concept of "fairness" can also be influenced by its relationship to a variety of justice concepts. These include: procedural justice (the extent to which people are treated in a fair and just way by those in authority); social justice (for instance people having fair or equal access to transport or other services); distributive justice (society ensuring that benefits and liabilities are distributed among its members in a fair and just manner); retributive or corrective justice (punishments are perceived to be fair and just); and compensatory justice (people are fairly compensated for their injuries by those who have injured them in, for instance the effects of transport noise or air pollution or accidents) (see for instance, [35]). As discussed above, which principles of justice should apply in different transport situations is not always clear.

Lucas et al. [36] argue that access to suitable mobility options should be accepted as part of all of our human rights, but claim that there are times that these rights can be compromised particularly "for women who face physical, economic, cultural and psychological" (p. 41). limitations, suggesting that fair access for disabled and elderly (women) in public transport is impacted negatively by "infrequent and irregular services" which can prevent them from accessing social life and in particular health care. Placing transport access in terms of human rights also fits with models of justice such as distributive justice which looks to ensure that the benefits and liabilities of transport structures are distributed among the population in a fair and just manner.

When views in society differ regarding allocation of resources to different groups or when decisions have to be made about how benefits and liabilities should be distributed among a group of people, questions of justice or fairness inevitably arise. When trying to enhance inclusiveness for women, it is important not to see women as being discriminated against simply because they have less participation. Hence it is important to now consider fairness for whom.

2.4. Fairness for Whom?

This paper is primarily concerned with fairness in relation to women, although the concepts and principles can apply to all people. Arabikhan et al. [12] argue that providing access to a fair public transport system suited to the needs of women is of particularly importance for those women who they claim have "less access to cars" (p. 80) and are therefore limited in their opportunities for travel. Low access to cars is currently prevalent across many northern European countries [28,37], for many groups (including increasingly the young [15], and suggests that the inclusion of a gendered perspective on future public transport infrastructure and planning is required to provide fair treatment and equality of outcomes for women accessing public transport. It is important to note, however, that there are variations between different socio-economic groups, for instance with middle- or high-income women having more access to cars than those on low incomes.

The definition of women used is also important, as gender-based definitions (as opposed to the biological sex class definition of women) relate the concept of women as a social construction which changes over time and space [38,39]. Employing a gendered approach to the definition of women would suggest considering fairness for both biological women and those who self-identify as women. Women are also not a homogeneous group, with each women's lived experience being shaped by, amongst other things, their social

class, their ethnicity and their geographical location as well as by factors such as age, childcaring responsibilities, etc. [40]. Therefore, an understanding of the complexity of women's multiple social identities is important.

There are differences in fairness in terms according to what transport element is being considered, for instance in terms of mobility, accessibility, efficiency, cost, privacy, sustainability, or accidents. From an operational perspective traffic control technology has social justice implications issues such as these [41]. This highlights the intersections of movement with wider socio-economic and policy issues and disadvantage among different people and groups in terms of wider accessibility as well as purely transport issues. After considering the methods used, the paper explores how the concepts of fairness discussed above relate to women as transport users, drawing on examples from railway use, autonomous vehicles and bike sharing schemes.

3. Methods

Following the traditional literature review on the themes of fairness discussed above, a scoping review to explore the broad topics with the three areas of transport (public transport, autonomous vehicle taxis and bicycle sharing) was carried out. In the main, scoping reviews are utilised in order to examine and map the range of research in a specific area and to identify research gaps in the existing literature [42,43]. They are used to explore and synthesize the potential nature, extent and scope of heterogeneous research literature around a topic, and are less question based than mapping reviews or specific than systematic reviews [43,44].

A scoping review can assist in exploring the wider scientific literature and provide added value [43], particularly when authors are looking to produce "evidence to inform practice" (p. 3), and is appropriate for this paper in respect of identifying and mapping current research which examines the barriers and facilitators to women using public forms of transport. The following steps were used in this scoping review: identifying the research question; utilising wider search terms than typically used in a systematic review to gather a wider range of literature; identifying relevant studies; study selection; charting the data; collating; summarizing; and reporting the results [45].

Before the search for documents began, the authors established the search terms to be used for the literature search and the inclusion and exclusion criteria that would be used to distinguish documents of relevance. The inclusion framework for documents for this paper was based on:

- English language documents
- Both qualitative and quantitative research methodologies
- Publication date 2000 or later
- A focus on the sex and/or gender in relation to transport users
- Field work being conducted in either, Europe, North America, Australia and New Zealand, as the main interest is in the EU.

The exclusion framework included:

- Papers where the field work was conducted in low-income countries
- Papers referring to transport users but did not disaggregating by sex and/or gender
- Papers published before 2000.

In addition, some other papers were identified using expert knowledge and contacts. To identify relevant documents, the University of Stirling data base management systems were searched and included WOS, BCI, CCC, DRCI, DIIDW, KJD, data bases in February 2020, using the following search terms:

Women + public transport + users + NOT drug users.

This resulted in the return of 188 documents, which was reduced to 176 when duplicates documents were removed. A further 74 documents were excluded as not suitable after reviewing the abstracts and conclusions of each document. 102 documents were then

fully assessed for eligibility before a further 90 were deleted resulting in the inclusion of new 12 documents suited to the paper.

Autonomous + Cars + women.

This resulted in the 15 papers being identified. An additional two papers were found via snowballing from the original papers. There were 17 documents after duplicated documents were removed. These were then screened, and 6 further documents were removed as not being suitable. 11 documents were fully assessed for eligibility and a further 5 documents were removed as not being suitable. This resulted in 6 new documents being identified as being suitable.

Bike (Bicycle) sharing + Women + Users.

This resulted in 15 documents were identified, 5 additional documents were found by snowballing the references of the original documents identified. After removing duplicate documents there were 20 documents. These 20 documents were then screened, and a further 7 documents were removed as not being suitable. The remaining 13 documents were assessed fully, and no further documents were removed which resulted in 13 new documents being identified as suitable.

Ethics approval was provided by the GUEP ethics panel of Stirling University. The results of the scoping review are presented next.

4. Fairness in Transport Used by the Women

4.1. Public Transport

Fair and equal accessibility to public transport includes the availability of, and physical access to, the transport system (e.g., stations and other facilities and vehicles, etc.); service levels of the system (e.g., cost of travel, comfort, travel time); the spatial distribution of activities, including the location of services and facilities people are seeking access to (e.g., availability to those in low income but low use areas or to those dependent mainly on public transport); and cultural diversity [46]. Further, policies often lack clarity in defining equity and how it should be integrated into the transport planning processes [3,47]. They suggest that those who must rely on public transport need special consideration rather than planning focusing an equal distribution of resources across all groups. A number of issues particularly relate to many women's experience of public transport (and to many men's experiences also), each issue illustrating a combination of equal opportunities, outcomes and justice.

Personal safety has been identified as one of the most importance factors in women's travel decisions, including their perceptions of safety and security whilst accessing, waiting for and travelling using public transport [48]. This may relate to the quality of transport stations, including information provision and waiting times, with, particularly young women feeling less safe than men when waiting at train stations [12]. Chowdhury [49] found that "perceived safety at stations was the only significant variable for female riders" (p. 855), highlighting that fear of crime was a prominent factor in women deciding on whether to use public transport and at what times to do so. They claimed that with the presence of security guards, "women were three times more likely to ride a route compared with males who were two times more likely" (p. 862). Therefore, safety issues raise wider concerns regarding the levels of equality of opportunity and equity for women using public transport.

In terms of public transport service quality, there appears to be a difference in the expectations of quality between men and women regarding the levels of service they expect [48]. The focus on quality of service should entail a closer examination of waiting times, walking times, the availability of information on transfers, the visible presence of security guards, and the availability of covered walkways within each station [49].

The cost and affordability of public transport affects fair access [50]. It is claimed [51] that in particular "a significant proportion of low-income households (71%) experienced disadvantage due to travel cost" (p. 198). The barriers faced by people from low-income households have larger repercussions on their ability to participate in wider social life

including access to education and employment, therefore creating a form of transport disadvantage and raising concerns around concepts such as social and distributive justice [28]. In addition, one of the main aims of all public transport systems is to provide equal access to transport for all in our communities, particularly those on low incomes, and argues that a gendered analysis of costs when planning public transport would ensure that women and those with a lower income have fair and equal access to a transport system that is both reliable and affordable [49]. With a worldwide acknowledgement that there is still an existing gender pay gap between men and women [49], partly due to occupational segregation and mothers' greater likelihood of working part-time, we can therefore hypothesise that women are in the main, more affected by the affordability of public transport.

Some characteristics (for example sex, gender, child caring responsibilities especially but not solely when travelling with children, income, age, etc.) may mean that certain groups are less likely to have equal opportunities to access public transport. Embedding notions of equity, both vertical (how much transport access do women have compared to the rest of the population) and horizontal equity (do all groups of women have the same access) in transport planning and delivery should help ensure that women with similar ability and need, and those who are transport disadvantaged, have equal access to suitable public transport systems which support their ability to take part in social life. Procedural justice suggests that a detailed analysis of the distributional effects of public transport policies should take account of the setting of minimum standards of accessibility to key destinations and the extent to which these policies respect individuals' rights and prioritise disadvantaged groups, reduce inequalities of opportunities, and mitigate transport externalities. Distributive justice suggests that fairness may involve ensuring that different groups people will have similar real opportunities and not have disproportionately worse outcomes in access to or use of public transport.

4.2. Autonomous Vehicles

The use of autonomous vehicles can be seen as a future form of public transport in the case of autonomous taxis (building upon existing online platforms such as Uber). while everyday use of AVs in the UK will remain relatively low until sometime after 2030 [36], there are currently a number of fairness-related issues that apply to AVs in general, but that may also apply to AV taxis.

Potential advantages of AVs (generally as well as taxis specifically) include the potential to reduce road accidents and produce a safer and more efficient and effective transport system [52,53]. Another economic and environmental based argument for AVs is that fuel consumption is claimed to be decreased due to more efficient driving [36,52,54].

However, that does not necessarily take into consideration the initial cost of the ownership and maintenance for AV ownership, or fare levels for AV taxis, which may prevent those on lower incomes from achieving ownership or from using AV taxis, and so affect equality of opportunity and equity for low-income people. Policy also needs to consider the potential negative effects on other transport modes if many people shift to AVs. For example, low-income people may have to rely on a reduced public transport system if they cannot afford public use AVs. Additionally, policy and transport management around the introduction of AVs into mainstream use will require "enormous changes in the way infrastructure is designed, operated, regulated and used" (p. 10), and it is unclear who will pay for and who will benefit from these policy and management choices [52].

One reason why women may feel less accepting of AVs is linked to the physical characteristics of vehicles, as cars have traditionally been designed for male bodies in terms of seating, posture and the seatbelt safety. For example, it was noted that until 2011 most American car manufacturers were using a crash test dummy based on male biology to conduct safety tests [54].

Some AV occupants may feel a of lack of control and may experience unease about a 'computer' rather than a person controlling the vehicle, with suggestions [54] that a lack of confidence in the technology used in AVs means that currently "more than half of the US

population would rather retain total control of their vehicles, even at the cost of increased safety" (p. 105). This lack of confidence or trust in the technology is also correlated with comfort levels of individuals using AVs [52]. Other fears (which may apply to all genders, of course) include fears of potential hacking or other people taking unauthorised control of the vehicle, which may be a greater worry for parts of the population, including some women. A further security issue for AV taxis specifically is the lack of a driver for personal protection should there be a problem during the journey, such as a breakdown, or a feeling of less security when walking from the taxi to the destination entrance at the end of the journey when there is no driver.

Fairness issues in the fundamental design of AVs include the algorithms used in their design and operation which may include significant biases. Therefore, taxis may use algorithms based on databases which reflect past biases in car or taxi use rather than fairness across the potential population of users (e.g., in terms of driving speed or smoothness of the journey, etc.). Bias can be included or amplified by the software systems, leading to decisions that are unfair regarding sensitive attributes such as ethnicity or gender [55,56]. The use of algorithms may improve public safety but should also satisfy an important aspect of equality: that all individuals are held to the same standard, irrespective of race or gender [57]. Yet there are well recognised issues with AVs such as not equally recognising pedestrians of different colours [58]. In 2019 the European Commission published a report which set out their guidelines to promote fair and trustworthy AI, including that trustworthy AI should respect all applicable laws and regulations, as well as a series of requirements and specific assessment lists aim at helping to verify the application of each of the key requirements [59]. These may help form a basis for dealing with some aspects of fairness to be considered when designing and creating policies for AVs.

Hence major issues around taxi AVs include safety and security, comfort, mobility, economy, environment, and design issues and women's acceptance of AVs. In terms of procedural justice, organisations should work together to develop a set of standards for fairness and non-discrimination in machine learning. These standards should be industry specific, and where existing human rights and ethical standards exist, should be tied into those established frameworks. There is also a need during, design and vehicle operation, for regular audits and audit trails, accountability via participating in open-source data and algorithm sharing where appropriate. To improve social justice, inclusive coding practices and audits for accuracy need to be created and acted upon. In terms of equality of outcome, there is a need for transparency in algorithmic decision-making and the development of technology that is socially responsible and takes account of variables such as ethnicity and gender.

4.3. Bicycle/Bike Sharing

Bicycle or bike sharing are important components of shared micro-mobility and involves shared public infrastructure and vehicles [60]. The first free bicycle sharing system was recorded in the Netherlands in 1965 with a second wave of coin operated sharing schemes established in the 1990's and the current third wave based on a docking station IT based system [61,62] with over 1000 bicycle sharing schemes across the globe [63]. There are many reasons cited for the recent increase in cycling including a renewed focus on, and commitment to, more sustainable travel modes [64], a greater general awareness of the benefits of cycling to people's health and to the environment [65,66], and as a method of bringing transport equality to disadvantaged communities [67]. However, it is suggested that barriers to bicycle sharing are based on sex, income status, ethnicity, and educational status, mirroring the general findings of the bicycle share literature which claims many users are white, middle class, men [67]. Cost is another barrier with not everyone having access to a credit or debit card to pay electronically as currently required [68,69]. Therefore, fairness issues related to the under-representation of different groups, including women, utilising bicycle sharing is important [70]. The cost in relation to bicycle share schemes, before discussing how the individual locations of docking stations, the condition of bicycles

and the availability of safety equipment provided also have an impact on the number of users is important [64]. However, their findings are not presented by gender and it is difficult to separate which variable had greater impact on men or women.

Many of the existing bicycle share schemes across Europe are membership based, which means that full membership must be applied for and received before individuals can access local bicycles. However, this membership process has itself been identified as a barrier for many potential users [67,71] and is linked to a lack of knowledge regarding how to become a member, the processes involved, such as providing identification, and the monthly or even yearly subscription single payments which prevent people from low-income areas being able to access the schemes.

Important components of bicycle sharing are docking stations, which are the collection and drop off points for bicycles across a variety of locations and can allow flexible and fair access to a fleet of shared bicycles. While 'free-floating', smartphone-operated, non-dock/station-based bicycle hiring are becoming more popular and offer new opportunities for more flexible use, they may still suffer from many of the problems of dock-based systems and are, so-far, mostly commercial (and so are less likely to target groups with low cycling participation rates). This raises equity issues, such as the low usage by women and older people and a lack of parking facilities often leads to nuisances for those in areas where bicycles are parked but who may not be bicycle users [62,72].

With claims of the environmental and socio-economic benefits of cycle sharing prevalent in the research findings [65,73] how can all members of the community have fair access to and use of these services? A first step could be to define what fair access looks like in relation to bicycle share facilities. A synthesis of existing research to support transport planners in addressing equity in transport outcomes [32] argues that transport projects do not always include a consideration of equity in their design or outcomes and are in the main focused on the experience of "middle class suburban neighbourhoods" (p. 212). With regard to ongoing evaluations of fairness, they claim that current evaluations are in the main based on measuring the distribution of the actual geographical locations of transport facilities in terms of the distribution of docking station sites (spatial equity), but fail to include an examination of the financial costs to users (social equity). This process, they claim, "fails to capture equity effects" (p. 220) robustly in terms of whether or not the people who live near to a docking station are financially able to use the facilities.

In terms of equality of opportunity, certain characteristics (e.g., age, disability, income and childcaring responsibilities, social constraints limiting women's cycling activities, etc.) mean that some groups are less likely to have real opportunities to access bicycle sharing facilities. In relation to equity, notions of both vertical and horizontal equity (as discussed above) are required to ensure all women from across the various characteristic based groups have similar and equal access to suitable bike sharing facilities (location, costs, timing, safety, suitability of types of vehicle, bicycles suited to those accompanied by children, etc.) which support their ability to take part in economic and social life. Providing this level of access would support improved distributive justice by improving the match between the distribution of bicycle sharing services and the need for them. Procedural justice would prioritise disadvantaged groups, reduce inequality of opportunities, and should help mitigate some of the transport externalities.

5. Conclusions

The concept of fairness in transport incorporates many aspects including equal opportunity, equity and justice (procedural, distributive and social justice), each of which has implications for transport planning and policy. Although reflecting similar overall fairness concepts, the three cases of public transport, autonomous vehicles taxis and bicycle sharing illustrate differences in key fairness issues between them as well as similarities. They also indicate a range of both horizontal fairness factors (i.e., similar people being treated similarly) and vertical fairness factors (such as more disadvantaged people being supported more), that need to be taken into account to ensure that greater overall fairness

is achieved. It is also important to consider the interaction of different modes or forms of transport and concepts of fairness when seeking a fairer transport system (for example, taking account of speed limits and road safety when considering accessibility for different groups such as autonomous vehicle users and those using bicycle sharing).

These issues were illustrated in the three cases explored in the paper. In public transport significant fairness issues for women were found to include: physical access to the transport system (e.g., stations, facilities and vehicles, for those with young children); service levels of the system (e.g., comfort, frequency, timetables); the spatial distribution of facilitates and services; and crucially safety and security issues, including perceived personal safety. For autonomous vehicles, particularly potential AV taxis, significant fairness issues include their physical design (e.g., for comfort of journey and safety); costs and affordability; potential impacts on other public transport (such as increased AV usage leading to a reduction in bus services for people reliant on them); algorithms used in their design and operation, which may be biased against women and others; feelings of a lack of control in the vehicle; and personal safety issues. For bicycle sharing fairness issues, especially in terms of equity, or fairness of outcomes, are suggested by current usage in terms of sex, income status, ethnicity, and educational status, with significant issues such as: location of facilities (e.g., in relation to low-income and other low-use groups); suitable infrastructure (e.g., for those with children); membership systems; and overall cost. Importantly, factors such as safety and security, physical designs of infrastructure and vehicles, cost, and women's characteristics such as low-income appear to arise in each of the cases studied here.

A broad working definition of fairness needs to balance the different aspects of fairness identified and should reflect equal treatment of people, unimpeded by prejudices or unnecessary distinctions or barriers, except where they can be explicitly justified. Some justifications may be relatively uncontentious, such as having low rail fares for children; however, others may be more contentious, such as free bus travel for those over 65 years old, as not all of these will have low-incomes (suggesting the need for potentially different policy solutions based on procedural and distributive justice). It is, however, important to recognise that, while generally women disproportionately face fairness issues in transport, many men are affected by similar issues and fairness may involve favouring disadvantaged groups regardless of sex or gender.

This paper has presented a broad analysis of issues related to fairness in different forms of transport, but has limitations of course. While the paper builds on earlier literature reviews carried out by the authors, a full systematic review may identify further key issues. Considering other modes of public transport and private transport, together with detailed effects on different groups in the population, would add to a richer analysis; as would greater consideration of the roles of external factors (such as environmental impacts, planning, employment opportunities and pecuniary and non-pecuniary transport costs). Finally, different philosophical approaches for considering fairness could be considered but are beyond the scope of this paper.

Current transport systems and policies often do not adequately incorporate concepts of fairness (such as equalities of treatment, opportunity, outcomes and justice) when planning and delivering services; particularly as they affect women in general and certain sub-groups of women specifically (such as those caring for children or those with low-income). Balancing the various aspects of fairness is difficult and will vary according to different contexts, modes, and socio-economic characteristics of people. Further research is needed into the use of fairness concepts in transport from both theoretical and ethical perspectives and into developing frameworks for a more comprehensive inclusion of, and balance between, different concepts of fairness and their interactions in both transport policy and practice.

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