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'It's a man's world': a gender-equitable scoping review of gender, transportation, and work

Katie J. Parnell^a, Kiome A. Pope^a , Sophie Hart^a, Erinn Sturgess^a, Rachel Hayward^b, Pauline Leonard^c and Kirsten Madeira-Revell^a

^aHuman Factors Engineering, Transportation Research Group, Faculty of Engineering and Physical Sciences, University of Southampton, Southampton, UK; ^bSchool of Electronics and Computer Science, University of Southampton, Southampton, UK; ^cSchool of Economic, Social and Political Sciences, University of Southampton, Southampton, UK

ABSTRACT

The deeply embedded inequalities in gender which mark most contemporary societies have led to a world shaped by male perspectives. This world fails to accommodate adequately the needs and experiences of women: no more evident than in the transport sector, where a 'default male' perspective dominates the planning and policies that shape our roads, railways, airlines, and shipping. This paper argues that the ways in which masculinity infuses transport systems mean they are integral to debates on gender and work. They impact both the way women experience travel and their access to places of work. A multi-transport domain scoping study has been conducted to review the literature for key gender factors that influence the use of road, rail, aviation, and maritime transport modes. A multi-disciplinary approach is proposed which incorporates perspectives and methods from the social sciences that can help to foster Gender-Equitable Human Factors (GE-HF).

Practitioner summary: This paper seeks to identify the gender issues related to transport and work. A scoping review provides key factors that detail how women are disadvantaged by current transport systems. It presents gaps in knowledge that future research needs to fill. Women must be included in key decisions within the transport sector.

Abbreviations: DfT: Department for Transport; EU: European Union; ECE: European Commission for Europe; HF: human factors; GE: HE: gender equitable human factors; GS: google scholar; WoS: web of science

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1. Introduction

In 1966, James Brown sang 'This is a man's world ...' and over six decades later the world is still designed for men (Criado-Perez 2019) in an economy built by and for men (Marçal 2021). Human Factors (HF) have a vital role to play in changing society so that 51% of the population are no longer marginalised and under-represented in policy, products, protection, and the provision of basic human needs (Madeira-Revell et al. 2021). To do this requires a conscious shift from the 'default male' thinking currently pervasive in society (Criado-Perez 2019; Sanchez de Madariaga 2013). This is an active process that takes time, attention, commitment, and support to develop different ways of working to produce a different outcome.

Transportation networks are central to the economic functioning of society (Cho et al. 2001; Ham, Kim, and Boyce 2005), not least through the kinds of work people can access. The United Nations has incorporated transport accessibility and equality as a sustainable development goal, recognising the influence that transport modes can have on social and economic inclusion (Pooley 2016), especially with respect to gender (Peake 2019). With everyone needing transport for their daily lives, equality of experience across transport modes should be guaranteed. Yet, it is evident that there are gender factors that influence the use and experience of different transport modes (Hamilton and Jenkins 2000; Sanchez de Madariaga 2013; Levy 2013; Vasquez-Henriquez, Graells-Garrido, and Caro 2019). Routinely, it is women who are

CONTACT Katie J. Parnell  k.parnell@soton.ac.uk  Human Factors Engineering, Transportation Research Group, Faculty of Engineering and Physical Sciences, University of Southampton, Southampton, UK

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inconvenienced and suffer from exclusion (Hamilton and Jenkins 2000; Simmons 2019).

There is a growing awareness that future transport equality, and consequentially future economic equality, requires better representation of women's needs within the decision making and planning processes of transport systems (Dobbs 2007; Sanchez de Madariaga 2013; Kuttler and Moraglio 2020; Kronsell et al. 2020; Winslott Hiselius et al. 2019; Madeira-Revell et al. 2021; Read et al. 2022). Their exclusion can, in part, be explained by the lack of women in senior roles within the sector, who may be better able to identify women's imperatives. For example, the European Economic and Social Committee (2015) has highlighted the importance of female perspectives in policy-making which has historically been lacking: female workers comprise only 20% of workers in the UK transport sector, typically occupying lower positions of responsibility and pay (European Commission 2017; DfT 2020a). However, employment in the sector is only part of the picture. Also important to consider is the broad and complex range of factors that produce the systemic gender inequalities which pattern contemporary societies, economies, and policy-making. These include *inter alia*, culture, power and representations, the division of labour and care, and violence against women. This complexity means that we need to know very much more about how both *gender*: the socially produced differences between being feminine and being masculine, such as who takes the burden for domestic duties, who works in which occupations, and so on; and *sex*: the biological differences between men and women, such as pregnancy, menopause, etc., impact on mobility and transport choices.

Overcoming transport's deeply entrenched gendered inequalities will be no quick fix. Within the academic community, we argue that *gender equitable* research is required to aid understanding of, where, and how, gender and sex need to be considered (Nowatzki and Grant 2011; Nieuwenhoven and Klinge 2010; Criado-Perez 2019; Madeira-Revell et al. 2021; Read et al. 2022). In many research areas, the relevance of sex and/or gender may be obvious. Yet, all too often gender has an indirect impact on the area of study, which may not be immediately evident but can lead to significant gender biases further down the line, as is evident in the non-inclusive transport networks we currently have today. For example, Sanchez de Madariaga (2013) highlights that transport planning often prioritises employment-related mobility and its purpose of facilitating travel to and from places of work. Yet, gendered analysis of the reasons

people travel identifies a large portion of travel is for the purposes of care work; activities involved in everyday life including domestic jobs and care for the young, old and sick. These trips are more routinely conducted by women alongside their employment commitments and, as transport planning has traditionally held a default male approach, these trips have routinely been ignored. Sanchez de Madariaga (2013) provides evidence that transport has been developed based on an economy that does not value care work, despite it being a compulsory purpose for travel. Socio-economic barriers further compound the issue, limiting access to jobs and care giving activities (Gates et al. 2019).

HF must do more to understand the gender-related factors that impinge upon work performance. Gaining insight from other disciplines can help to capture a more complex understanding (Robinson et al. 2016). Through a collaboration of HF and Social Science researchers, this paper presents the complementary nature of Sociology and HF approaches to capture a broad societal view of diversity and inequality issues (Ackerley and True 2019). Feminist Social Science in particular takes questions of gender and social organisation as core, rigorously interrogating every aspect of everyday practices through a gendered lens (Holmes 2008). The aim is to expose how assumptions about gender differences infuse social life, but also how women may be rendered invisible (Criado-Perez 2019).

This scoping review aims to map the terrain for the Gender Equitable Human Factors (GE-HF) research now needed in the transport sector. To achieve this, we will review the literature for key gender factors that are relevant across seven transportation modes. Madeira-Revell et al. (2021) identified gender-related factors in transportation that were inferred within the 'EU gender in research toolkit' to outline a checklist for inclusion of gender throughout the research process (Yellow Window 2018). Table 1 provides a description of each of these factors. We aim to use these to (i) understand the current gender-relevant areas across the different transport modes and (ii) identify areas where further research is required to close the 'gender data gap' in transport and work research.

2. Method

A literature search was undertaken to identify the current state of knowledge on gender across various transport modes in relation to the factors in Table 1. A scoping

Table 1. Description of the gender factors related to transportation research.

Gender factors	Description
Family and community roles	Gender impacts on the different roles that individuals have within the family and the community. These often relate to caregiving and domestic work which can impact the mode of transport used between genders.
Safety and perceived safety	Gender impacts on how safe and secure individuals feel when travelling on different transport modes which can lead to different travel choices being made.
Ergonomic standards	Gender impacts on ergonomic measurements which are used to accommodate passengers and ensure their safety.
Mobility needs	Gender impacts on the different needs that individuals may have while travelling due to the different types of trips made.
User behaviour	Gender impacts on the behaviours of individuals, including their perceptions and requirements for systems to perform in certain ways.
Urban structures	Gender impacts on the requirements that individuals have for the design of transport infrastructure and how they interact with it.

Table 2. Method for applying the Arksey and O'Malley (2005) processes of a scoping review.

Scoping review stages	Process
1. Identify the research questions	Q1. What is known from the current literature about the gender factors (in Table 1) across road, rail, aviation and maritime research? Q2. What possible research gaps are there?
2. Identify relevant studies	Search terms were identified (Section 2.1.1) which were then used to search Google Scholar and Web of Science databases.
3. Study selection	Inclusion and Exclusion criteria (Section 2.1.2) applied to all articles that were identified using the search terms. The title and abstract of the paper were read to determine if it should be included in the review, the full paper was read where more detail was required to assess inclusion.
4. Charting the data	Each selected paper was read in full and then documented. The authors, title, year of study and methodological approach, summary of the main findings related to the scoping study research aims were compiled for each selected study.
5. Collating, summarising and reporting results	The findings from the selected studies were reviewed to identify sub-themes that develop the original factors. The findings from the high level factors and sub-themes were mapped onto a matrix presenting the different gender factors across each of the reviewed transport modes. This identified where research gaps exist.

review was conducted to provide an overview of the literature and map it to key factors and themes (Arksey and O'Malley 2005). The four main transportation categories included: road, rail, aviation, and maritime; with road transport including personal road vehicles, pedestrians, cyclists, and buses. Rail transport focuses specifically on trains (trams were out of scope for this review).

2.1. Scoping literature review

The literature was reviewed by experts from each of the transport domains. Researchers in HF, Sociology and Engineering had a combined number of 31 years of experience in road, rail, aviation, and maritime transport domains. Google Scholar (GS) and Web of Science (WoS) were chosen as the search platforms. The scoping review aimed to capture the research that has already been conducted, as well as identify where there are gaps. These gaps may be presented in discussion pieces but not officially researched and published in the academic literature. GS was used due to its liberal inclusion of research material, therefore, we took a broad view of the research material identified from this search platform. GS was used as a starting point to understand the literature available across the different modes. WoS was then used to ensure comprehensive access to peer-

reviewed articles that related to the themes across each of the transport modes.

Due to the nature of a scoping review, research with varying methodologies and approaches was reviewed (Arksey and O'Malley 2005; Pham et al. 2014). This aimed to provide an overview of the literature and map out key areas of relevance to the gender factors across each of the transport modes reviewed. The processes employed in the scoping study, as outlined by Arksey and O'Malley (2005) are presented in Table 2. This approach supports a descriptive approach that can help identify and inform the factors to be considered in a more detailed systematic review.

2.1.1. Search terms

Independent searches were conducted for every transport mode across each of the different gender factors. The search terms were selected following a pilot search by the researchers to review the best terms that captured the transport modes and gender factors. Table 3 shows the terms that were included in the search and those removed following the results from the pilot search. Terms were excluded either due to generating minimal results or being too generic and therefore generating multiple irrelevant themes. For example, 'car' was used instead of 'driving' or 'vehicle'

Table 3. Search terms included/excluded as identified in a pilot search.

Mode/factor	Search syntax	
	Included	Excluded
Transport modes		
Road transport	Gender * car	Gender * vehicle Gender * driving Gender * road travel
Airline passengers	Gender * aviation passengers Gender * air travel	
Cycling	Gender * cycling	
Rail	Gender * rail	Gender * train
Pedestrians	Gender * walking Gender * pedestrians	
Bus	Gender * bus	
Maritime	Gender * ferry Gender * cruise ship	Gender * river transport
Gender factors		
Family roles	* Family	* Mother * Father * Safety
Perceived safety	* Perceived safety	
Ergonomics	* Ergonomics	
Mobility needs	* Mobility needs	* Mobility
User behaviour	* User behaviour	
Urban structures	* Infrastructure	* Urban structures

as these terms have alternative meanings that confused the results with those outside transportation. Only one search term was used per gender factor.

2.1.2. Inclusion/exclusion criteria

The results were first filtered to only include research since the year 2000. When reviewing the remaining search results the research team used set criteria to determine which papers were relevant to the gender factors under review. The criteria stated:

- The transport mode is the main mode under analysis. Studies where interactions between modes or where multiple modes were reviewed were not included.
- Gender is a substantial part of the analysis or the purpose and/or outcome of the study.
- The gender factor is the (or one of a few) primary focus of the paper, i.e. not just a minor variable.
- The text must be in English or have an English translation (due to the native language of the researchers).

As the research team was UK-based, we were also interested in research and discussion across different countries and cultures as ideas in non-Western countries were likely to differ and expose further gaps in research and knowledge. The results were sorted by relevance and only the first 100 papers from these search results in GS were reviewed due to the volume of results. In WoS, all results were reviewed as there were less of them and they were

all peer-reviewed. During the pilot searches, it was deemed that after 100 papers the results became progressively less relevant to the search. As this was intended to be a scoping review, we were interested in the most relevant papers to the search terms to get an overview of the research themes and gender factors. The title and the abstract of the paper were initially reviewed to determine inclusion/exclusion. If it could not be determined from the abstract alone, the full paper was read. If the paper did not meet one of the inclusion criteria stated above then it was excluded. If a paper met all the inclusion criteria, the manuscript was reviewed in full. A working document was accessed by all researchers to record the papers that met the inclusion criteria. The records included the paper title, authors, year, methodological approach, and a summary of the findings related to the gender factor it related to. Links to the full paper were also provided.

2.1.3. Identifying sub-themes

The primary researcher read all the papers that met the inclusion criteria in full. They reviewed their relevance to the factors (using descriptions in Table 1) and then determined common and/or diverging themes that arose within the findings. They then proposed a set of sub-themes that captured the key areas of focus in the literature. These were then discussed and reviewed by all other members of the research team until a consensus was reached on the number of themes, their meaning, and definitions.

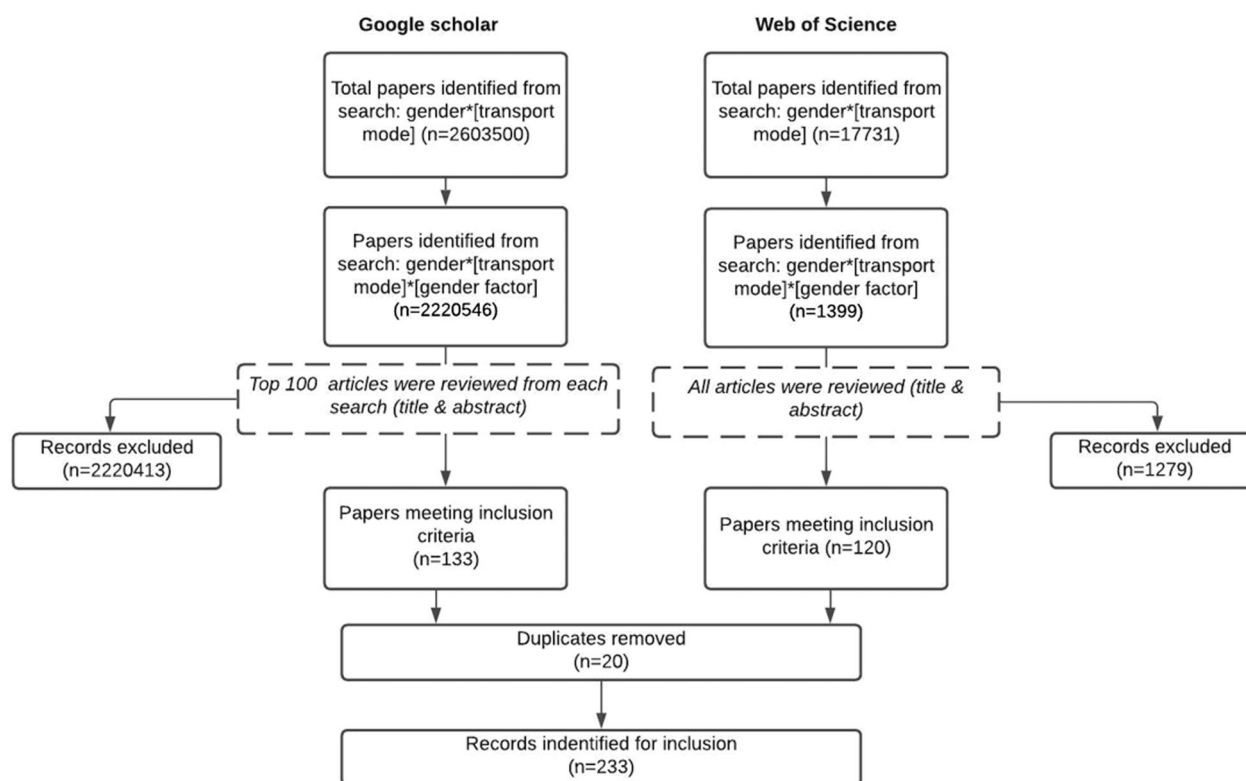


Figure 1. Overview of search results outputs (adapted from Moher et al. 2009).

Table 4. Frequency of results found from the Web of Science (WoS) and Google Scholar (GS) search in relation to gender for each transport mode.

Search terms	Search platform	Road vehicles	Aviation passengers	Cycling	Rail	Pedestrians	Bus	Maritime	Sub-total	Total
Gender * family roles	GS	2	3	1	0	1	0	5	12	38
	WoS	13	2	6	0	3	0	2	26	
Gender * perceived safety	GS	3	12	7	8	2	2	7	8	60
	WoS	4	2	0	0	10	3	0	37	
Gender * ergonomics	GS	3	6	3	2	0	3	3	41	42
	WoS	16	2	2	1	1	0	0	19	
Gender * mobility needs	GS	1	11	1	0	0	0	3	20	34
	WoS	11	0	4	0	2	1	0	22	
Gender * user behaviour	GS	3	5	6	1	2	0	6	16	33
	WoS	5	0	3	1	0	1	0	18	
Gender * infrastructure	GS	1	2	11	0	2	3	2	23	46
	WoS	7	0	12	0	4	2	0	10	
Gender factors total		69	45	56	13	27	15	28	253	

3. Results

3.1. Search results

An overview of the literature search, presented in the 'preferred reporting items for systemic reviews' format set by Moher et al. (2009), is shown in Figure 1. This shows the total number of papers identified in GS and WoS when searching for gender across all the transport modes (sum of searches for the top section of Table 3) and the total number of papers when the search terms for the key factors were applied for all

transport modes (sum of searches for the bottom section of Table 3). The substantial number of initial search results in GS is indicative of the liberal approach and a vast number of non-academic journal sources. GS and WoS identified a total of 133 and 120 papers, respectively that met the inclusion criteria. Removing 20 duplicates meant that 233 papers were included in the scoping review.

A breakdown of the number of papers identified in relation to each of the gender search terms across each of the transport modes is presented in Table 4.

This shows that 'Safety and Perceived Safety' identified the most number of papers ($N=60$) that met the inclusion criteria. With 'Urban structures' identifying the next highest number ($N=46$). 'User behaviour', 'Mobility needs', and 'Family norms' identified the least number of papers, but were very similar with 33, 34, and 38, respectively. Road transport was the mode that had the most number of research papers identified across all gender factors ($N=69$), followed by cycling ($N=56$). While rail ($N=13$) and bus ($N=15$) had considerably less results.

A summary of each of the most cited factors for each of the transport modes is now provided to present how each factor relates to transport use. 'Ergonomics' was the most cited factor in road vehicle transportation ($N=19$). These papers captured the ergonomic design of vehicles which has tended to take a default male approach to the measurement and vehicle testing requirements. The representation of the male body to capture the adult population has been evidenced within the European Commission for Europe (ECE) and has had severe consequences for women who are more likely to suffer from whiplash-related injuries (Linder and Svedberg 2019). Reactive head restraints were found to reduce permanent impairment in male drivers by 70% but increased impairment in females by 13% (Kullgren, Stigson, and Krafft 2013). Furthermore, Bose, Segui-Gomez, and Crandall (2011) reported that females were 47% more likely to suffer a serious injury in the vehicle while wearing a seatbelt than males in comparable crashes.

'Family roles' also identified a large number of citations for road vehicles ($N=15$), more than for any other transport mode. The papers identified reference the use of the family vehicle to perform chauffeuring trips. Men are more likely to have priority over the family car (Naess 2008; Scheiner and Holz-Rau 2012), yet as the number of children in the household increases, the number of car trips that women make increases, while for men it decreases (Vance, Buchheim, and Brockfeld 2005). Boarnet and Hsu (2015) describe this as the 'within-household, female-male chauffeuring gap', finding that women in households with children make over 300% more chauffeuring trips in the car than men who live alone.

'Safety and Perceived Safety' identified several references for the pedestrians ($N=12$) and public transport modes (bus; $N=5$, rail; $N=8$) that cite the enhanced risks women experience when travelling by public transport or walking, especially at night (Vanier and De Jubainville 2017; Ceccato and Paz 2017; Schmucki 2012). Research shows that women often choose more independent and private travel modes, such as vehicles and

cycling, to avoid exposure to potential offenders (Stark and Meschik 2018; Bonham and Wilson 2012). Aviation also had several 'safety and perceived safety' references ($N=14$), yet the citations identified here relate to the safety of the aircraft, with women being more concerned with flight safety (e.g. Boksberger, Bieger, and Laesser 2007; Clemes, Kao, and Choong 2008; Rose et al. 2012). There were also several safety concerns in the cycling literature, with women feeling more unsafe and safety conscious when cycling compared to men (ARUP and Sustrans 2019; DfT 2020b; Haynes et al. 2019). There was also the suggestion that female cyclists were more likely to be involved in dangerous conflicts at intersections (Evans et al. 2018; Stipancic et al. 2016).

The most cited factor in the cycling literature was 'Infrastructure' ($N=23$), providing the greatest number of references for this factor out of all the transport modes. There has been considerable research into bicycle infrastructure that has shown women are more likely to choose cycle routes designed with designated cycle infrastructure (Yeboah and Alvanides 2013; Lusk, Wen, and Zhou 2014) rather than main roads (Heesch, Sahlqvist, and Garrard 2012). This suggests one way of encouraging more female cyclists is to improve cycling infrastructure (Kunieda and Gauthier 2007). Bonham and Wilson (2012) found that women cycled more within inner-city areas compared to the suburbs, which may be due to the enhanced cycling infrastructure within cities compared to more rural areas. Another limiting factor is the restricted baggage that cyclists can take with them (Twaddle, Hall, and Bracic 2010). Women have been reported to carry more personal items with them (e.g. Hwangbo et al. 2015), such as a change of clothes for work, which makes cycling a less attractive option (van Bekkum, Williams, and Morris 2011).

'User behaviour' produced the least number of papers that met the inclusion criteria, however, it was identified by the researchers that they may be slightly more critical of including papers due to the factor being broader. Many of the behaviours already discussed are, to some extent, user behaviour and there were some cross overs with other factors, such as work patterns, commuting, and mobility needs. A key behavioural trend evident across the transport domains was the heightened car use by men and evidence of a male cultural affinity for driving, whereas women are more likely to have a cultural affinity for walking and public transport (Kawgan-Kagan 2020; Ng and Acker 2018; Den Braver et al. 2020; Gill 2018; TFL 2019). There is also evidence that women tend to drive less for environmental reasons (Scheiner and Holz-Rau 2012). In terms of public transport behaviours, women display a tendency to take the bus for frequent, shorter trips, whereas men

use the bus occasionally and generally for longer journeys (Rojo et al. 2011). There are also gender stereotypes prevalent at a societal level, with a 'proper cyclist' viewed as being predominantly male (Aldred 2013). Steinbach et al. (2011) suggest this may be due to men being more inclined to demonstrate their physical capabilities through cycling strength. These reasons may contribute to the evidence that men tend to cycle more than women (Bonham and Wilson 2012).

3.2. Sub-themes

The sub-themes were identified through reviewing the literature for each factor to classify common areas in which gender may affect transport use (see section 2.1.3). The sub-themes allow a more granular level of insight into the different ways that gender influences transport use across domains. For example, when reviewing the literature on family and community roles, research articles could be differentiated by their focus on how transport is used while caring for family members, and the division of work within households that influences what travel was needed.

Table 5 presents each of the sub-themes with their description and main findings from the literature in the scoping review. This table highlights key gender-related findings across all of the different transport domains, giving specific examples of how gender impacts transportation use and access.

Reviewing the gender factors and sub-themes across the different transport domains provides a rich picture of the way that gender influences travel patterns, accessibility, and safety. Bringing research together from various research domains enables a review of the systemic gender factors in transportation as well as highlighting where future research is needed. Table 6 maps where our scoping review found research into the specific gender themes (grey boxes) and where no research was found (white boxes). 'Personal safety/harassment' was the only sub-theme that was found across all of the transport modes which highlights the importance of safety to the gendered review of transport as it is considered across multiple different modes. 'Female body shape' was an evident theme across all modes apart from pedestrians, highlighting how the design of transport must consider the difference in male and female bodies. 'Behavioural trends' and 'infrastructure' also only had one gap, both of which were for rail travel. Again, these themes are integral to transportation access. The cycling literature has the least number of gaps. Pedestrians and rail have the most number of gaps. The gaps identified in

this scoping review suggest areas for future research that needs to consider the ways in which gender influences transport use. Comparisons across the different modes offer opportunities to learn from each other and identify concurrent issues that need to be realised and overcome. The research gaps are discussed in more detail in the Discussion section below.

4. Discussion

This paper presents the first gender-equitable scoping review of the current issues facing the transportation sector, as well as the gaps in understanding that need to be targeted. This scoping review has generated insights into the direct and in-direct ways that gender influences how people experience different transport modes. Identifying the high-level factors and sub-themes presents the systemic gender issues and aims to show how they need to be better understood in relation to all transport modes. Comparisons between transport modes highlight interesting areas for future research to consider on how to close the gender data gap in transportation research. The gaps we have identified in relation to the gender factors presented in this scoping review do not suggest that they are not relevant, but that future research is needed to understand their importance. These are discussed below.

4.1. Research gaps

4.1.1. Family and community roles

Table 6 shows a gap in the literature on rail and bus travel for 'Family and community roles' and both of its sub-themes. It is suspected that there are issues relating to these factors that need to be further uncovered in these domains. For example, one consideration is the relative inflexibility of the location and times of travel in these modes which can be limiting, especially in more rural areas where trains are temporally irregular and further away. Dependability of arriving on time may also be a factor when having to collect children/dependents. Research is needed to gain a better understanding of these issues in this domain.

Research gaps were found across multiple domains for the 'division of work' subtheme, including aviation, bus, rail, and pedestrians. However, as it was identified that women predominantly accompany their dependents, it is expected that travel across these modes may relate also to unpaid care work and domestic duties, such as walking children to school. There could be interesting crossovers with other themes, such as safety here. For example, could safer streets enable



Table 5. Gender factor sub-themes and a summary of the main finding from the scoping review.

Gender factors	Summary of key findings
Family roles Dependants	<ul style="list-style-type: none"> Men are more likely to have priority over the family car (Naess 2008; Scheiner and Holz-Rau 2012). Yet, as the number of children in the household increases, the number of car trips that women make increases, while for men it decreases (Vance, Buchheim, and Brockfield 2005; Boarnet and Hsu 2015). Having children reduces the amount of air travel that women undertake, yet the same was not found in men (Gustafson 2006; Dargay and Clark 2012).
Division of work	<ul style="list-style-type: none"> Airport Transit options for females were likely to be dictated by accompanying dependants (Gupta, Vovsha, and Donnelly 2008). Gendered division of work within the household sees women undertaking more domestic tasks which means they are more likely to trip-chain, make less work-related trips and have shorter commutes (Ng and Acker 2018). This also leads to women walking more to meet their travel requirements; especially for those from low-income areas (Venter, Vokolkova, and Michalek 2007; Srinivasan 2008). Childcare and trip-chaining are also thought to limit females' use of bicycles as a mode of transport (van Bekkum, Williams, and Morris 2011; Bonham and Wilson 2012). Conversely, men's journeys are likely to be longer, work-related, and paid which leads them to prioritise their use of a private car (Den Braver et al. 2020; Sánchez and González 2016).
Safety and perceived safety Time of day	<ul style="list-style-type: none"> Women are more concerned when travelling alone at night on public transport, travelling with small children, and through urban areas with high crime rates (Fundamental Rights Agency 2014; Vanier and De Jubainville 2017). Darkness was rated by women to be a greater barrier to cycling than it was to men (van Bekkum, Williams, and Morris 2011). Women are more likely to take a taxi or drive over public transport at night (Ceccato and Paz 2017) and stick to well-lit areas when they must walk (Schmucki 2012). Peak travel times may appear safer, but in low-income and developing countries, peak times have been linked to heightened cases of sexual harassment and victimisation towards women (Madan and Nalla 2016; Ceccato and Paz 2017). Women often choose more independent and private travel modes, such as vehicles and cycling, to avoid exposure to potential offenders (Stark and Meschik 2018; Bonham and Wilson 2012). Women are more likely to discuss harassment when talking about transport and public spaces (Vasquez-Henriquez, Graells-Garrido, and Caro 2019). In aviation, sexual victimisation of females is on the rise (Federal Bureau of Investigation 2018; Gray 2020; Lucas 2021). Women feel uncomfortable when personal space is limited, such as on aircraft (Wang et al. 2021). As women spend more time walking on the streets, they are more likely to be exposed to dangerous levels of air pollution from idle cars on the road (Tyers and Leonard 2020). Potential for sexual harassment leads to fear, which itself influences travel behaviours and experiences, including heightened anxiety (Cheng 2010), constrained travel patterns (Stark and Meschik 2018), such as only travelling at certain times of the day or when accompanied by others (Ross 2000) and greater planning to avoid exposure to fearful situations (Loukaitou-Sideris 2014). Empty train stations and walking to/from bus stops are fearful situations. Private vehicle travel can limit exposure to these fearful situations but multi-story car parks are still feared due to the enclosed space and limited exits (Loukaitou-Sideris 2014). Females are more concerned with flight safety and experience greater feelings of fear and stress in-flight (Boksberger, Bieger, and Laesser 2007; Clemes, Kao, and Choong 2008; Rose et al. 2012; Oyewole 2001; Martinussen, Gundersen, and Pedersen 2011). Safety concerns are a significant barrier to women using bicycles (ARUP and Sustrans 2019; Department for Transport 2020b; Haynes et al. 2019; Evans et al. 2018).
Personal safety/harassment	<ul style="list-style-type: none"> The default male approach is prevalent in the ergonomic design of transport modes, including safety features that do not provide the same level of protection to females due to their different body make up (e.g. Linder and Svedberg 2019; Kullgren, Stigson, and Krafft 2013; Bose, Segui-Gomez, and Crandall 2011). On trains, the design of fixed bay tables on railway carriages poses a risk of placental abruption to pregnant women due to the table height and thickness (Esat and Acar 2012). Aircraft seating has also neglected the female pregnant body shape, making them unsuitable and uncomfortable (Cui et al. 2020). 'Pink it and Shrink it' has commonly been used in design when developing female equivalents of male equipment, which can limit female comfort in bicycle use (Tilburg et al. 2015; Potter et al. 2008). Assuming female bodies are small versions of the male body can no longer be accepted in equipment design (Thom et al. 2020). Female and male bodies differ in their dimensions and composition (Karastergiou et al. 2012; Schorr et al. 2018). Passenger aircraft flight seats were designed for the 95th percentile male and wrongly assumed they would fit all women when they do not (Miller, Lapp, and Parkinson 2019; Salvendy 2012; Harrison and Robinette 2002). Female metrics have also been neglected in the placement of grab handles (Hwangbo et al. 2015).
Fear	<ul style="list-style-type: none"> The risk of inflicting harm upon a person The physical properties of the female body which differ from male bodies in their size and composition.
Ergonomic standards Injury risk	<ul style="list-style-type: none"> Threatening experiences in response to possible harmful and dangerous situations
Female body shape	<ul style="list-style-type: none"> The risk of inflicting harm upon a person The physical properties of the female body which differ from male bodies in their size and composition.

(continued)

Table 5. Continued.

Summary of key findings	
Gender factors	
Mobility needs and amenities that would be required to assist everyday life.	<ul style="list-style-type: none"> • Mobility needs related to gender include the facilities available while travelling and the characteristics of the trip itself, largely the toilets and hygiene facilities available (Beebejaun 2017). • Female cyclists have reported that they feel a societal pressure to keep up appearances which they struggle with after cycling (Twaddle, Hall, and Bracic 2010). • Few airlines have separate female toilet facilities (Flynn 2015), nor do they cater to female toiletry needs (Westwood, Pritchard, and Morgan 2000). Women report difficulties in maintaining hygiene due to the small toilets onboard aircraft and time pressures felt by people waiting in the cabin. • This is further compounded by women needing the toilets more than men (Westwood, Pritchard, and Morgan 2000): especially true when menstruating, pregnant, or nursing young children (Cui et al. 2020). • Females need to make more frequent trips that are generally shorter than those made by males (TFL 2019). • Females trip chain more (Plyusheva and Schwanen 2018; Maciejewska, Marquet, and Miralles-Guasch 2019; Scheiner and Holz-Rau 2017). • The longer distances travelled by males for work-related purposes transpires to males using the car more often, whereas women are less likely to have a full driving licence (TFL 2019). • Males are also more likely to fly for business trips (Frändberg and Vilhelmsen 2003; Gupta, Vovsha, and Donnelly 2008; Greggi et al. 2013; Tsafarakis, Kokotas, and Pantouvakis 2018). • The method of transfer to and from the airport is also found to differ between genders in ease of transfer and connectivity to the city (Tsafarakis, Kokotas, and Pantouvakis 2018). Males tended not to use public transport as they were more likely to travel for business and therefore would be able to claim expenses, enabling provisions of more expensive travel modes, like a taxi (Chebli and Mahmassani 2003; Choo, You, and Lee 2013).
Trip characteristics	
The features of a journey that influence how it is conducted, its purpose, and objectives	<ul style="list-style-type: none"> • A key behavioural trend was the heightened car use in males and evidence of a male cultural affinity for driving, whereas females are more likely to have a cultural affinity for walking and public transport (Kawgan-Kagan 2020; Ng and Acker 2018; Den Braver et al. 2020; Gill 2018; TFL 2019; Rojo et al. 2011). • Women tend to drive less for environmental reasons (Scheiner and Holz-Rau 2012). • In western society, cycling is perceived to be more male-orientated (Aldred 2013; Steinbach et al. 2011). Yet, in countries where cycling is the more common transport, women cycle more (e.g. Hanoi; Bonham and Wilson 2012; Tran and Schlyter 2010). • Cargo bikes have positive connotations of a 'hip' lifestyle which promote their use and suggest that cycling encumbered does not have to be an issue (Boterman 2020). • When flying, women place more importance on their travel experience e.g. baggage handling, assistance, cleanliness (Weber 2005; Westwood, Pritchard, and Morgan 2000; Park and Almanza 2020; Tahamisaz and Shokuyhar 2020). • Females are more likely to get motion sick (Park and Hu 1999; Turner and Griffin 1999; Turner, Griffin, and Holland 2000) and seasick (Gahlinger 2000). This is notable because it can limit the participation of females in experimental simulation research trials (Matas, Nettelbeck, and Burns 2015), which are common in HF research. • From a passenger experience perspective, females were found to be more tolerant of longer waiting times in the airport compared to males (Gkritza, Niemeier, and Manning 2006). • Women are more likely to travel encumbered due to pushchairs, shopping bags, and small children (TFL 2019) leading to practical issues, with streets not providing easy manoeuvrability, and buses presenting difficulties in getting the pushchair from the kerb onto the bus and negotiating the placement of access poles (TFL 2019). • Women were found to be more likely to use the park and ride facilities, especially when going on shopping trips (Clayton et al. 2014). • Women are more likely to choose cycle routes with designated cycle infrastructure (Yeboah and Alvanides 2013; Lusk, Wen, and Zhou 2014; Kunieda and Gauthier 2007; Bonham and Wilson 2012; Heesch, Sahllqvist, and Garrard 2012). • Women tend to carry more personal items with them, which makes cycling a less attractive option (e.g. Hwangbo et al. 2015; van Bekkum, Williams, and Morris 2011; Twaddle, Hall, and Bracic 2010). • The infrastructure and amount of information in airports are overwhelming and difficult to navigate for pregnant females and those with small children (Cui et al. 2020). • Women were more likely than men (90 vs. 40%) to get stuck in congestion during a ship fire evacuation (Sarshar et al. 2013).
User behaviour	
Behavioural trends	
Tendencies for certain behaviours, often relating to social and cultural norms	
Wellbeing	
The psychological state in relation to comfort, happiness, and stress	
Urban structures	
Encumbered travel	
Infrastructure	
The presence of objects and dependants that limits the ability to move freely.	
The physical and organisational structures that comprise an environment.	

Table 6. Matrix of gender-equitable transport research showing where references found evidence for the gender factor (grey box and x) and where no references were found in the search (white box).

		Road	Aviation passenger	Cycling	Rail	Pedestrian	Bus	Maritime
Family and community roles	Dependants	x	x	x		x		x
	Division of work	x		x				x
Safety and perceived safety	Time of day	x		x	x	x	x	
	Personal safety/harassment	x	x	x	x	x	x	x
	Fear	x	x	x	x	x	x	
Ergonomic standards	Female body shape	x	x	x	x		x	x
	Injury risk	x		x	x			
Mobility needs	Facilities		x	x	x	x		x
	Trip characteristics	x	x					x
User behaviour	Behavioural trends	x	x	x		x	x	x
	Wellbeing		x	x	x			x
	Travelling encumbered		x	x		x	x	
Urban structures	Infrastructure	x	x	x	x	x	x	

more freedom for women as children could walk themselves to school? In the aviation domain, how do women's domestic roles impact the experience of flying? We see overlaps with other areas, such as 'facilities' and 'travelling encumbered' being relevant here also.

4.1.2. Safety and perceived safety

There has been a significant focus on gender with respect to safety, in contrast to the other factors included in this review. There were still, however, some research gaps identified, including how 'time of day' may impact aviation passengers and maritime travel. There are some key questions that need to be asked as travel on these modes often requires travel to/from airports/ports at off-peak times. How do the travel patterns of women/men to and from airports/ports vary late at night or early in the morning? How can a sense of safety be maintained during these hours? Furthermore, airports are often open 24h and require a lot of waiting around in contained areas. How does gender impact the perception of safety in these scenarios? This is likely to be highly linked to 'fear', which was another gap identified within the maritime mode. Other factors may also influence this, such as the environmental conditions for travel at sea, which should be researched through a gendered lens.

4.1.3. Ergonomic standards

The default male approach is heavily evident in the ergonomic design of transport safety systems which has left women at a higher risk of discomfort, injury, and death. Yet, still much more research is needed to understand exactly how male and female bodies differ and how design can be inclusive to all users. This is particularly pertinent to the domain of Human Factors, where toolsets for inclusive design should be employed. This research also needs to be considered in policy and regulation documents to promote change at the highest level. While many modes had evidence to

suggest the ergonomic design of transport modes needs to fit females, there was a gap in how this applied to pedestrian travel. There may be some overlap with the evidence found for urban structures, such as the design of pavements for travelling encumbered. Yet, other factors relating to female shoe design and their ergonomic design for walking longer distances would develop the literature. Often, female footwear tends to be less practical than male footwear.

Notably, in relation to the gender data gap, the generation of female ergonomic data and its inclusion within design processes is a vital way in which gender-equitable human factors must enforce standards and best practise for inclusive design.

4.1.4. Mobility needs

While research across several domains suggests a lack of hygiene facilities for females, no research into similar trends has yet been conducted on the roads. How do service stations provide for female travellers who need more frequent access to toilet facilities and feel unsafe in empty and isolated spaces? Females are also more likely to be accompanied by dependents, as identified in the 'family and community roles' factor, who are also more likely to need enhanced facilities.

There were also several gaps for 'trip characteristics'. While there is an understanding that women perform more trip chaining, how this relates specifically to cycling, rail, walking, and bus travel requires more research. Active and public travel options may restrict the accessibility to certain areas of work and/or care that making trip chaining difficult.

4.1.5. User behaviour

While research has started to look into how transport may impact well-being across genders, more research is needed in this area across all modes. Combining insights, such as evidence that women use the car more as chauffeurs, while men are more dependent on car

travel for commuting, may reveal how these behaviours impact the psychological state of individuals and their employment decisions. Links can be made from other research, such as evidence that driving with young children is a common cause of driver distraction (Beanland et al. 2013). Could women be placing themselves at enhanced levels of stress and risk due to the chauffeuring trips they make? Do they then arrive at work more stressed? Specific gendered analysis linking these effects is missing. We need to design our transport systems to enhance the well-being of all travellers by making them safe, efficient, and resilient. This is something that is now beginning to be understood, with applications already made to children and their experience of transport (Waygood et al. 2020). Further research needs to review this with a gendered lens to identify how men and women interact with different transport modes.

4.1.6. Urban structures

Travelling encumbered is a key area to target with further research. Across many modes, research has failed to consider how gender may influence the type or possessions that passengers may carry and the implications this has for mode choice.

More research is also needed to review rail infrastructure with respect to gender, both within trains themselves and their provision for baggage, push chairs, and bicycles, as well as the platforms and stations. How could interactions with other modes facilitate easier encumbered travel to and from train stations? Crossovers with safety are also important here when considering how infrastructure could be designed to make women feel safer when waiting on train platforms, for example.

4.2. Recommendations for gender-equitable research methods

The research reviewed was multi-disciplinary covering journals focussing on specific transport sectors as well as Sociology, Geography, Business, Health, Manufacturing, Accident Analysis, and Engineering. The breadth of our search highlights the interdisciplinary nature of gender issues in transportation. The methodologies used vary from surveys (e.g. Cheng 2010; Clayton et al. 2014), observational studies (e.g. Schultz and Fricke 2011; Hwangbo et al. 2015), and in-depth interviews (e.g. Steinbach et al. 2011; Gopal and Shin 2019).

Typically, empirical work within the HF domain strives to incorporate the end-user within research, advocating a human-centred approach (Norman and Draper 1986; Karat 1997; Bekker and Long 2000).

However, the evidence presented here shows that this approach can also lead to the exclusion of female participants: the fact that women have more domestic and caregiving responsibilities limits the time they have available to participate in research studies. Further, physiological methods are also limiting. Barriers to studies, such as simulator research, include enhanced motion sickness in females (Matas, Nettelbeck, and Burns 2015), which continues to be the case with new virtual reality technologies increasingly used in research. Stanney, Fidopiastis, and Foster (2020) found this may be due to the interpupillary distance within the technology that is typically set to fit males. Difficulties in physiological data collection include eye-tracking which is less effective with those wearing eye make-up. The placement of heart-rate monitors is also more intrusive for females than males due to their placement on the chest. Due to these reasons, equal sample sizes are often neglected in favour of meeting tight research deadlines and convenience sampling (Madeira-Revell et al. 2021; Read et al. 2022). Such continuations of the 'default male' approach emphasise the need for women to be involved in the design process of new technologies.

Interesting new avenues for research currently underway within the authorial team include data mining and the use of social media content to review and capture gendered opinions towards transport modes in relation to travel to work. Vasquez-Henriquez, Graells-Garrido, and Caro (2019) were able to capture the different ways that women and men discuss transport from a review of social media. This led them to determine the internalised safety perceptions women have towards cycling in contrast to men's externalised views. Research methods, such as this offer much potential for understanding the societal pressures, influences, and understandings of transport and how this differs across individuals. This is critical if we are to meet the European Economic and Social Committee (2015) call to include female perspectives within transportation systems.

5. Limitations and future work

This scoping review was intended to map the terrain for Gender Equitable Human Factors (GE-HF) research in the transport sector. The gender factors that we report are comprehensive but not exhaustive. There are some limitations of the review process that are important to highlight. Firstly, the review was conducted using only two search platforms. WoS was chosen due to the engineering and human factors basis of the review, however, when considering gender, more social science-

based papers may be evident using platforms, such as Scopus. Further work should determine if similar findings are present across different search platforms.

It is also noted that the search criteria were limited to UK-centric terms which may have limited the search. For example, American-English alternatives, such as 'transit' instead of 'bus' and terminologies including 'crosswalk' and 'sidewalk' for pedestrians and pavements. The search was also limited by only including articles predominantly focussed on one mode of transport, greater complexities in mode choice are likely to be evident when looking at research into multiple modes.

This review has focussed solely on gender differences between men and women without looking into other intersectionality influences. It is acknowledged that these will influence some of the reported factors and statements presented in this work. For example, socio-economic status is also a key factor that impacts transport equity (Gates et al. 2019), including where people live, what opportunities are available, and how these opportunities can be accessed. For example, people from lower socio-economic backgrounds are more likely to take the bus and are also more likely to reject job opportunities due to transport barriers (DfT 2017; Gates et al. 2019). Travel patterns also vary with age across genders, with women of a reproductive age making many more journeys than men over the age of 50, whereas male travel patterns are more resistant to changes (Sánchez and González 2016). Different cultures also have different views on the roles of females and the roles that they can fulfill, particularly in relation to employment (Seligson 2019; Kuruppu and Hettiarachchi 2019). Future work should build on this matrix to include intersectionality factors and review how they intersect the themes presented in this paper.

The transport industry is currently at a pivotal moment with pressure from environmental issues and rapid developments in automated technologies. At the same time, the industry's essential role in travel to work is recognised as a major contributor to social equalities. Research into the implementation of automated and electric vehicles must consider who those vehicles are predominantly targeted at and the types of journeys that they will be used for. Men, who rely more heavily on private vehicles, are set to benefit more than women. Opportunities for charging electric vehicles may be more limited when trip-chaining, is routinely conducted by women. Alternatively, investment in a modal shift away from private vehicles to enhance the accessibility of alternative modes will aid

women as well as provide more sustainable modes of transport (Scheiner and Holz-Rau 2012).

6. Conclusion: the importance of gender-equitable human factors and ergonomics

The first verse of the song 'It's a man's, man's, man's world' (Brown and Newsome 1966) describes the historic state of transport, which no longer fits the needs of society today.

"You see, man made the cars to take us over the road

Man made the train to carry the heavy load

Man made electric light to take us out of the dark

Man made the boat for the water, like Noah made the ark"

This paper argues that an interdisciplinary approach to HF, routinely applying a gender-equitable lens, could ensure all forms of public transport meet the varying mobility needs of both the labour market and family and community roles. A Gender-Equitable HF can, for example, make cars as ergonomically crash-proof for women as for men. It can ensure trains, platforms, and stations are designed to encourage high perceptions of safety for all. Considering where and how electric lighting is used would encourage safer active travel, such as walking, running, and cycling, and reduce differences in confidence and perceptions that affect user behaviour. GE-HF could also aspire to create a transport sector with cultures where women are not only attracted to work, but retained to become leaders and decision-makers. Our review has focussed on transport to reveal the essential role that travel plays within debates on gender and work.

In sum, our argument is that if we keep creating and using research focussed on a man's world, it will do nothing to build an equitable future. As our review demonstrably evidences now is the time for a change.

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ORCID

Kiome A. Pope  <http://orcid.org/0000-0001-8076-960X>

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