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Transportation Research Procedia 00 (2018) 000–000

Transportation Research Procedia

www.elsevier.com/locate/procedia

World Conference on Transport Research - WCTR 2019 Mumbai 26-31 May 2019

# Assessing and Modelling Perceived Safety and Comfort of Women during Ridesharing

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**Abstract**

Ridesharing is one of the effective tools to solve some of the environmental and congestion problems; however, it is not very well used by women in developing countries due to safety and comfort issues. Lack of prior planning of addressing the issues which influence the ridesharing choices of women is one of the main hurdles to the growth of ridesharing practices in developing countries like India. This study is designed to examine the safety and comfort perceptions during ridesharing among women residing in India. A comprehensive questionnaire with six different thematic sections (such as demographic attributes, safety perceptions with different co-riders, the importance given to cost, privacy, etc. and various other situational factors concerning ridesharing for women) is prepared. The data from 293 female respondents are collected through a survey. Factor analysis is performed on the perception variables to find out any underlying correlation; and the results showed a four-factor solution. The factors accounting for safety and comfort perceptions during ridesharing are modelled with an ordered logistic regression approach. The model results suggest that young women due to fear of being victimized and unemployed women due to their less exposure to ridesharing have lesser trust in such facilities. Women feel less safe and comfortable when sharing a ride with unknown males or during night. A focus group discussion is also conducted to validate the results and to obtain in-depth knowledge of safety and comfort issues during ridesharing.


Peer-review under responsibility of WORLD CONFERENCE ON TRANSPORT RESEARCH SOCIETY.

*Keywords:* Ridesharing, Women safety, Comfort, Factor analysis, Ordered logistic regression

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## 1. Introduction

Ridesharing can be described as the sharing of vehicles by a group of travellers to same or nearby destinations to reduce emissions, congestion and trip costs (Wang et al., 2012; Velaga et al., 2012a; Hrncir et al., 2015). There are different versions of ridesharing which include carpool, vanpool, two-wheeler sharing, etc. (Mageean and Nelson, 2003; Enoch et al., 2004; Mulley et al., 2012; Velaga et al., 2012b; Wright, 2013; Velaga et al., 2014). Broadly, these ridesharing forms can be divided into two types: formal and informal. While informal ridesharing involves ad hoc car-pooling and sharing of cabs, the formal ridesharing is practiced mainly through the use of mobile and web applications that allow potential users to register and find ridesharing matches to best fit their requirements (Wright et al. 2014). In India, many forms of ridesharing take place through Flexible Transport Systems (FTS) such as mini-bus, shared taxis, carpool, maxi cab and auto-rickshaws (a transit service which provide shared-ride door-to-door service with flexible routes and schedules, with three-wheels), etc. (Lathura, 2006; MoUD, 2008; Mani and Pant, 2012; Velaga et al., 2012b and Wright et al., 2014). Ridesharing can be considered as one of the best solutions for sustainable transportation systems for counteracting the problems induced by growing urbanization and deteriorating environmental conditions. With the onset of a new era, various ridesharing and car-pooling mobile applications have come up worldwide. “Uber”, “BlaBlaCars”, “Lyft” are the examples of such systems. Some of these online services (Uber, BlaBlaCars, etc.) also serve in developing countries like India, China, Bangladesh and Thailand.

The use of mobile and web-based ridesharing services is very low in developing countries; for example, ‘UberPool’ rides are between 20 and 30% of the total rides offered by Uber in India. This is possibly because of unawareness of these services and fear of safety concerns associated with such arrangements (Indo-Asian News Service, 2017). There has been an increment in crime rates against women in the past few years. For instance, the crime rates in India as reported by National Crime Records Bureau show that, though there is a 5.7% dip in rape cases but 4.8% increment in “attempt to commit rape” and 3.4% increment in “kidnapping and abduction of women” cases in 2015 compared to 2014 (NCRB, 2015). The report by NCRB also showed that every 51 minutes, a woman faces harassment and assault in India’s public spaces (Millennium Post. 2016). These are the reported crime rates; whereas, a survey conducted by the Commonwealth Human Rights Initiative reported that only one in every 13 and one in 9 cases of sexual harassment were reported to the police in Delhi and Mumbai respectively (Chandran, 2016). Further, according to a survey conducted by an international non-governmental organization (ActionAid), the actual crime rates are as high as 79% in Indian cities (Wilkinson, 2016). These increasing crime rates cause insecurity for shared rides among women. In a study undertaken by the Thomson Reuters Foundation in 2014, the transportation sector in Delhi (capital of India), was rated as the ‘fourth most dangerous’ for women (India.uitp.org, 2016). Due to cultural reasons and unpleasant past experiences, women usually avoid travelling alone with male strangers and sometimes even with male friends. Ridesharing is scarce and limited to short distance trips, largely during daytime and preferably with friends and acquaintances. Many taxi and auto sharing schemes, particularly for women, are launched in India. These include plying of special autos (coloured pink or orange) to cater exclusively to women (The Times of India. 2016). These autos have mandatory installation of panic buttons and GPS systems. A citywide carpooling application named ‘Smart-Mumbaikar’, which facilitates car-pooling arrangements in Mumbai, provides preference options to travel with ‘only female commuters’ or ‘at least one female commuter’ (Smartmumbaikar.com, 2016). However, even after launching these schemes for ridesharing, women across the country do not find these services generally reliable; and they are not confident about the safety and comfort associated with ridesharing. The fear of women being victimised in physical assaults and attacks has imposed a big hurdle on implementing the sustainable transportation schemes like ridesharing. Lack of concern for women safety in the initial stage of planning of various transportation settings has resulted in unsafe travelling patterns of women in developing countries.

Therefore, a thorough study needs to be conducted to understand and solve the issues of safety and to enhance the comfort factors for women during ridesharing. This paper investigates the problems faced by women during ridesharing with the help of a survey conducted for 293 women residing in urban regions (majorly in Mumbai and nearby metro cities). The data is used to model the perceived safety and comfort levels of women riders during ridesharing using ordinal regression analysis. A focus group discussion is carried out for validating the survey results and for performing in-depth analysis of these issues to make ridesharing safer and more comfortable for women.

## 2. 2. Literature review

### *2.1. General trend of ridesharing worldwide*

Ridesharing is defined as a service in which two or more trips are conducted simultaneously in a single vehicle if the route and time schedule of the travellers are matching and the travel cost is shared among the individuals travelling in that vehicle (Morency, 2007 and Furuhata et al., 2013). Saving in the travel cost is one of the main advantages of ridesharing (Levin, 1982, Furuhata et al., 2013, Nielsen et al., 2015 and Efthymiou et al., 2013). Moreover, it is found that ridesharing is an attractive and effective alternative which bridges the gap between public transit and private cars (Shaheen et al., 1999). The concept of ridesharing has been more popular in the US, Canada and various European countries such as Germany, Belgium, France, Sweden and Switzerland for the last two decades (Buliung et al., 2009). Nowadays, the ridesharing services are growing in various developing countries such as India, Indonesia, China, etc (Ma et al., 2013; Malodia and Singla, 2016; Natyari and Pradana, 2016). The main aim of introducing the ridesharing is to reduce the increasing private car ownership, congestion and the emissions of Green House Gases (Caulfield, 2009, Buliung et al., 2009, Polk, 2003 and Delhomme and Gheorghiu, 2016).

The evolution of ridesharing has happened in different stages, varying from manually organised ride-matching services to the more advanced technology based ride-matching (Chan and Shaheen, 2012; Nelson et al., 2010; Velaga et al., 2012c). The Demand Responsive Transport (DRT) services such as door-to-door Dial-a-Ride service is the prominent example of such services in various European countries (Nelson et al., 2010). Brake et al. (2004) mentioned that historically, scheduling of such ridesharing arrangements offered the clients some flexibility in terms of routes. However, the booking had to be done much ahead of the ride because of the manual scheduling. With the support of technologies, the services have been improvised in terms of providing flexibilities in routes, vehicle allocation, fleet operator and time of booking (Wright et al. 2014). Nowadays, the ridesharing services have become more popular through the mobile based applications (Amey et al., 2011; Ma et al., 2013; Nielsen et al., 2015). Therefore, the ridesharing arrangements have been fully formalised, particularly in developed countries, with scope to improve the accessibility of ridesharing services to the rural dwellers (Velaga et al., 2012b; Wright et al. 2014). But, in developing countries, the informal ways of ridesharing persist more commonly, particularly in rural areas. Therefore, the challenge in front of developing countries is to adapt and formalise the existing informal ridesharing systems, organise their operations and restructure their capacity (Wright et al. 2014). Moreover, there is a clear need to improve and enhance the size of ITS based ridesharing arrangements in the developing countries (Natyari and Pradana, 2016; Malodia and Singla, 2016).

### *2.2. Gender-specific patterns of ridesharing*

It is well established that the travel patterns of male and female commuters are different (Levin and Faith-Ell, 2014). Men are more likely to rely on private vehicles (Levin and Faith-Ell, 2014), while on the other hand, a majority of women choose public transportation for making trips to jobs, childcare, education and health facilities (Eliasson and Mattsson, 2006; Viswanath, 2013). Listerborn et al. (2005) reported that the number of trips made by women is more than men. Peters (2001) explained that, women are economically less powerful than men and have less money to spend on travel particularly in developing nations; therefore, they choose public transport over private. The other factor which makes women more accommodating of a sustainable transportation system than men by reducing car usage is their attitudinal behaviour owing to the theory of environmentalism (Polk, 2004; Buliung et al., 2009). Campbell (2014) and Arabikhan (2014) mentioned that women change their travel patterns and work schedules, because of the fears of sexual harassment and violence from co-passengers. High levels of crime in public spaces, women's vulnerability to physical assaults and attacks and fear of victimization in transportation settings are the common factors which affect women's decision to use ridesharing services (Loukaitou-Sideris and Fink, 2008; Lynch and Atkins, 1988; Yavuz and Welch, 2010). Loukaitou-Sideris and Fink (2008) documented that if transportation systems are made safer and more comfortable, it is very likely that more number of female commuters are ready to switch to ridesharing services from their current modes.

### *2.3. Women's issue in ridesharing arrangement*

Increased exposure of sexual harassment and growing incidents of violence through media reports have brought the attention of public and government towards women safety in transportation sector particularly in developing countries (Viswanath, 2013). For instance, media coverage of the horrific Nirbhaya case in 2012 and the rape case of a female passenger by an Uber driver in 2014, provoked huge public outrage in Indian cities (Soni, 2016; Viswanath, 2013). Subsequently, Nirbhaya fund of 1 billion INR was launched to boost the empowerment, safety and security of women in India (Firstpost, 2013). Though there has been an improvement in budget allocation and funding, gender-specific policies or facilities are either not in function or not effectively utilised possibly because of the lack of gender disaggregated studies in developing countries like India (Jain and Parida, 2014). Both, public transport and ridesharing, are equally neglected in terms of women safety. Following are the main transportation-related issues for women in India:

- Fear of being victimized in public spaces: Women are having increased fear of getting stared at, harassed, stalked, robbed and raped by the strangers, when they step out for travelling (Jain and Parida, 2014). In some Indian cities like Delhi or Mumbai, women even tend to change their career because of the fear of being victimization (Jain and Parida, 2014). The security concerns also restrict women from using certain public transit services (Rosenbloom, 2006). Therefore, there exist a fear based exclusion from various social activities (Jain and Parida, 2014).

- Scarcely available transport facilities: Reduced availability of transportation services is the main safety concern for most of the women who wish to travel during night hours (particularly in developing countries). For instance, in the Nirbhaya case also the victim could not catch any taxi or auto-rickshaw for going back to her residence.

- Reduced access to privately owned vehicles: In general, women have limited access to privately owned vehicles compared to men and they use slower transport services (Anand and Tiwari, 2006; Jain and Parida, 2014). They spend more time in commuting household trips and have lesser time for work-home trips; therefore, women prefer to work at the places which are at nearer distances to their residences (Anand and Tiwari, 2006). It eventually restricts them to limited mobility and exclusion from basic services and work opportunities.

- Increased inconvenience and discomfort in public transits: Privacy, comfort and convenience associated with the public transit are significantly lower when compared to intermediate paratransit mode or public transit systems (Malodia and Singla, 2016).

Similar issues related to women during ridesharing are also mentioned in previous studies across the world. For instance, a study by Levin (1982) specified that females showed low desirability for driving alone for longer distances; thus females with long commuting trips might be easily encouraged for shared rides if they could be matched with women co-riders. Similarly, Levin et al. (1977), documented that gender of the co-rider was the most important factor in ridesharing arrangement when the co-rider was a non-acquaintance; because female participants feel very unsafe while sharing a ride alone with a male stranger. The study by Levin (1982) also identified some major factors that affect women's feelings of security, such as, knowledge about violence, age, race, sexual orientation, economic status, the frequency of use of mode, activity levels, journey time, street lighting, graffiti and cleanliness. Levin (1982) recommended that the size of the carpool should not be very large which takes longer extra-time per rider and creates inconvenience for women. The other factors which affect the ridesharing are the waiting time and waiting area. Loukaitou-Sideris and Fink (2008) studied the issue of safety, for men and women, most of the respondents in the survey agreed that women are more vulnerable than men particularly when they are travelling alone or at night. It was observed that presence of certain environment factors such as darkness, desolation, lack of opportunities for surveillance, lack of maintenance and poor environmental quality factors also induce fear (Loukaitou-Sideris and Fink, 2008). For example, waiting for a vehicle in dark places, such as underpasses, underground stations and tunnels. pose greater fears than the places which are open and unconfined

spaces (Loukaitou-Sideris and Fink, 2008). The study showed that women preferred reasonably higher comfort levels while travelling - both physically and emotionally because of their more vulnerability.

A general model of perceived safety by Yavuz and Welch (2010) also showed that the perceived vulnerability is higher for women because of their susceptibility to sexual assault and their frequent experiences of various forms of harassment. Wilkowska et al. (2014) studied the general requirements of carpooling users while using a web-based carpooling platform and observed that woman participants insisted more on additional information (such as gender and smoking habits) about the fellow co-passengers. A recent study by Nielsen et al. (2015), explored perceptions about organization-based ridesharing with the help of fifty semi-structured research interviews and five focus groups in Denmark. Their study highlighted some negative and positive perceptions about the ridesharing; and results concluded that safety and privacy concerns are the major barriers to ridesharing, specifically for women riders (Nielsen et al., 2015).

Further, safety is also associated with whether females wish to drive or ride (i.e., being a driver or being a passenger) during ridesharing. Also, the acceptability of ridesharing highly depends on its ability to compete with the largest advantage of a private car: immediate access to door-to-door transportation (Agatz et al., 2011). Such access could highly increase the comfort associated with ridesharing and also save time. Apart from this, there are other feasibility considerations (e.g., smoking habits of the co-rider), that determine if participants would accept a ride-share match or not (Ghoseiri et al., 2011). Many such preferences have largely prevented ridesharing in developing nations where safety concerns are on the rise (Loukaitou-Sideris and Fink, 2008).

Overall, user preferences of female commuters that affect ridesharing are: safety, comfort, convenience, flexibility of schedule and cost (Wilkowska et al., 2014; Yavuz and Welch 2010 and Polk, 2004). But, the most important concerns associated with these services are the safety and security needs of woman riders. Thus, formalization of long trip vehicle sharing is very important and it is gradually occurring through mobile applications that keep track of safety, cost and comfort (Bicocchi et al., 2014).

Though there are a large number of studies on investigating women's issues in ridesharing, research on analysing these issues are still scarce in many developing countries like India (Jain and Parida, 2014, Rosenbloom and Plessis-Fraissard, 2009). As the nature and scale of women safety issues during ridesharing also depend on country geography and its culture, therefore exploring them in developing countries remains a huge scope to look upon.

## 3. Methodology

After reviewing comprehensive literature related to the prevalence of ridesharing concept among women, the variables which affect their decision to involve in ridesharing (e.g. demographic, preferences given to comfort, privacy during riding) were identified. A questionnaire was prepared which sought the details of female participants about most of the aspects which could affect women's safety perceptions during ridesharing. In total, 298 participants were identified for data collection through the questionnaire survey. After filtering the data, factor analysis was performed on perception variables to reveal any latent correlation among the variables. The factors obtained from the factor analysis were then statistically modelled with the help of ordered logistic regression approach. In order to validate the model results, one focus group discussion was also performed; and finally, based on the study findings, the conclusions and suggestions for encouraging ridesharing among women in India were documented. Following subsections describe the participant identification and data collection procedure for the present study.

### *3.1. Questionnaire Preparation and Data Collection:*

The questionnaire was designed using Google Forms. The factors which could affect the safety and comfort perception of the women riders were considered while designing the survey. Various questionnaire designs from previous studies were reviewed for this purpose and most of the variables mentioned in previous studies were directly taken in the present study questionnaire preparation (Efthymiou et al., 2013, Polk, 2004 and Levin, 1982). The questionnaire was prepared in six thematic sections:

1) The first section of the questionnaire focused on demographic details of the respondents: age, household income, occupation, etc.

2) The second section gathered the information about ridesharing details such as whether the participants had ever involved in a ridesharing and the ways through which they chose the ridesharing (i.e., formal or informal way).

3) The third section acquired data for the perceived safety levels during ride sharing (e.g., perceived safety during day and night time). In this section, participants were also asked to rate the perceived levels of safety for different types of partners for ride sharing i.e., female/male friends, female/male strangers and female/male strangers with their ratings and reviews revealed to them before the journey.

4) In the fourth section, the participants were asked to express their opinion on perceived comfort during ridesharing.

5) The fifth section of the questionnaire focused on obtaining the preferences of the riders during ridesharing (i.e., asking them that how much importance they give to safety, comfort, privacy and cost before choosing a shared ride).

6) The last section contained some general details about participant's opinions on the dependence of ridesharing on the distance to be travelled and the size of the group of co-riders.

Participants were asked to express their opinion in terms of ratings on a scale (known as Likert scale with five levels) for the questions related to perception and importance of safety, comfort, etc. For example, the participants were asked to rate their perceived safety levels from 1 (very unsafe) to 5 (very safe). Similarly, importance ratings were scaled from 1 (not important) to 5 (extremely important). Hypothetical situations pertaining to various scenarios of female ridesharing were described to the participants who were new to ridesharing.

The statistical details of the themes considered in the survey questionnaire are illustrated in Table 1.

### *3.2. Participant Identification*

Overall, data from 298 women participants were collected through a questionnaire survey during the time period from October 2015 to June 2016. After excluding the data for missing values and false responses (which were on the opposite extremes of the usual responses and not given the demographic details), a statistical analysis was performed for data from 293 participants. Further, out of 293 respondents, 15 were interviewed face-to-face and rest of the participants responded to the online survey. The main reason for conducting the face-to-face interview was that some of the participants from the older age group were not internet savvy and an online survey was perceived to be difficult for them. The participants for the survey were selected in such a way that the whole dataset covered different ranges of household incomes, occupation and different age categories (from younger to older). Among all the participants, 85% belonged to Mumbai city and remaining 15% were from other nearer metro cities (e.g. Pune and Nagpur).

Table 1 Descriptive statistics of the questionnaire survey

| Themes | Variable | Categories of the variable | Non-ridesharing group | | | Ridesharing group | | |
|---|---|---|---|---|---|---|---|---|
| | | | Mean | SD | Percentage | Mean | SD | Percentage |
| Demographical details | Age in years | 18-25 years | 22.09 | 1.99 | 43.51% | 22.42 | 1.75 | 46.91% |
| | | 26-35 years | 30.43 | 2.94 | 35.11% | 29.30 | 2.79 | 37.03% |
| | | 36-45 years | 40.06 | 3.27 | 13.74% | 40.13 | 2.58 | 9.25% |
| | | 46-55 years | 51.43 | 2.19 | 5.3% | 49.20 | 2.27 | 6.17% |
| | | >55 years | 58.00 | 0.82 | 2.35% | 58.00 | 0.00 | 0.64% |
| | Annual household income in INR | Up to 100,000 | -- | -- | 7.63% | -- | -- | 7.63% |
| | | 100,000 to 500,000 | -- | -- | 22.14% | -- | -- | 32.06% |
| | | 500,000 to 1,000,000 | -- | -- | 35.88% | -- | -- | 51.91% |
| | | 1,000,000 to 2,000,000 | -- | -- | 25.19% | -- | -- | 22.90% |
| | | More than 2,000,000 | -- | -- | 9.16% | -- | -- | 9.16% |
| | Occupation | Unemployed | -- | -- | 18.32% | -- | -- | 38.17% |
| | | Employed | -- | -- | 53.44% | -- | -- | 69.47% |
| | | Student | -- | -- | 28.24% | -- | -- | 16.03% |
| Type of ridesharing | | Formal | -- | -- | -- | -- | -- | 72% |
| | | Informal | -- | -- | -- | -- | -- | 28% |
| Safety perceptions during ridesharing (1 = very unsafe, 2 = unsafe, 3 = somewhat safe, 4 = safe, 5 = very safe) | With co-riders/co-drivers | Perceived safety with female friends | 4.34 | 0.99 | -- | 4.59 | 0.74 | -- |
| | | Perceived safety with male friends | 3.92 | 1.07 | -- | 4.16 | 0.95 | -- |
| | | Perceived safety with female stranger | 3.32 | 1.03 | -- | 3.64 | 0.76 | -- |
| | | Perceived safety with male stranger | 2.01 | 0.90 | -- | 2.23 | 1.06 | -- |
| | | Perceived safety with female strangers with ratings and reviews | 3.65 | 1.15 | -- | 4.03 | 0.79 | -- |
| | | Perceived safety with male strangers with ratings and reviews | 3.02 | 0.96 | -- | 3.15 | 0.85 | -- |
| | | Perceived safety as a driver | 3.20 | 1.01 | -- | 3.57 | 0.87 | -- |
| | | Perceived safety as a rider | 2.79 | 1.13 | -- | 2.86 | 1.03 | -- |
| | Perceived safety while travelling at night | | 1.89 | 0.91 | -- | 2.17 | 1.01 | -- |
| | Perceived safety while travelling during day time | | 3.23 | 1.01 | -- | 3.59 | 0.83 | -- |
| Comfort perceptions during ridesharing | Perceived comfort level of the rider (1=very uncomfortable to 5= very comfortable) | | 3.23 | 1.06 | -- | 2.86 | 1.03 | -- |
| Preferences given during ridesharing (1 = not important, 2 = somewhat important, 3 = important, 4 = very important,5 =extremely important) | Importance of safety | | 4.71 | 0.80 | -- | 4.79 | 0.60 | -- |
| | Importance of comfort | | 4.34 | 0.90 | -- | 4.15 | 0.80 | -- |
| | Importance of privacy | | 3.98 | 1.01 | -- | 3.69 | 1.03 | -- |
| | Importance of cost | | 4.08 | 0.95 | -- | 4.20 | 0.83 | -- |
| | Importance of ridesharing group | | 3.59 | 1.10 | -- | 3.50 | 1.07 | -- |
| General | Safety as a function of distance of rideshare | Safer for short distances | -- | -- | 45% | -- | -- | 44% |
| | | Safer for longer distances | -- | -- | -- | -- | -- | 4% |
| | | Not dependent on distance | -- | -- | 55% | -- | -- | 52% |
| | Size of group of co-riders including driver | | 3.18 | 0.81 | -- | 3.06 | 0.83 | -- |

## 4. Data Analysis

### *4.1. Preliminary Analysis of Questionnaire Survey*

The ridesharing details of the participants showed that 57% of the women had been involved in ridesharing in the past. The descriptive statistics of the 293 respondents are cross-tabulated against two groups: ridesharing group (who had ridesharing experience) and non-ridesharing groups (who did not have any ridesharing experience). The statistics showed that 72% of the ridesharing group had shared rides using informal means for instance, sharing a car with friends or travelling in shared auto-rickshaws/taxis. Most of the participants (86%) among the non-ridesharing group, used public transit services (bus or metro/local trains) for their trips. The number of young participants of age range 18-25 years was relatively high in both the groups, followed by the participants of age range 26-35 years.

Demographic details of the respondents in both the groups revealed that majority of the respondents were employed. The number of unemployed participants was higher than the number of students in the non-ridesharing group. While in the ridesharing group, students were higher in number than unemployed. This showed the higher interest of students towards the ridesharing facility.

Co-riders played an important part in deciding the safety and comfort levels of women during ridesharing. Questions were asked about perceived safety in ridesharing with co-riders/co-drivers in the following three categories: friends, strangers and strangers with revealed reviews and personal information. The data revealed that the women of both the ridesharing and the non-ridesharing group felt safer while sharing the ride with the female friends. Whereas, the ratings given to the safety perceptions while travelling with male friends was slightly lower, especially for the non-ridesharing group (mean rating = 3.92) when compared to the ridesharing group (mean rating = 4.16). The perception of safety was rated unsafe/ very unsafe if the co-rider or driver was a male stranger by both the non-ridesharing (mean rating = 2.01) and the ridesharing groups (mean rating = 2.23). Whereas, if the co-rider's/driver's identity and reviews were known to the participants before the start of the journey then, their safety perception were comparatively high.

While comparing two scenarios in ridesharing (driving a car vs being a passenger in a shared car), it was revealed that the women of the non-ridesharing group felt safer being a driver (mean rating = 3.20) than being a rider (mean rating = 2.79). Similarly, the ridesharing group showed more positive perception in being a driver situation when compared to being a rider situation; possibly because the driver has more control over the vehicle and the overall ridesharing scenario. Being a passenger in a stranger's car was perceived to be more vulnerable because of apparent distrust on a stranger driving the car.

Perceived safety for ridesharing of non-ridesharing group at daytime was high (mean rating = 3.23) compared to sharing a ride during night time (mean rating = 1.89). The ridesharing group also showed similar trend but the safety perceptions for this group were slightly higher than the non-ridesharing group. These values demonstrate the fact that women feel safer during daytime as the public spaces are crowded and help is easily available during day. The lower perception shown by the non-ridesharing groups indicated their higher levels of fear and victimization in the ridesharing arrangement because they actually had not experienced it.

The importance of safety was highly preferred by both the non-ridesharing (mean rating = 4.75) and the ridesharing group (mean rating = 4.24). Similarly, the preferences given to comfort, privacy and cost were also quite high for both the groups. It showed that comfort, privacy and cost involved in ridesharing may also play important roles in making a decision on ridesharing. Further, both the groups gave similar importance ratings to the ridesharing group size. As car, taxis and auto-rickshaws are the mostly used as ridesharing vehicles in India, the preferred size of the group (including the driver) of co-riders varied mostly from 2 to 4. When comparing the preferences for length of a shared ride, it was observed that 45% of the females among the non-ridesharing group felt that ridesharing was safer for short trips while 55% of the non-ridesharing group thought that safety during ridesharing was not depended on the trip length. The views of ridesharing group related to the ridesharing distance were similar to that of the non-ridesharing group.

The ordered logistic approach was used to investigate and quantify the significance of demographic characteristics, various safety and comfort perceptions in different ridesharing situations and various preferences related to ridesharing (e.g., cost, privacy, pool-size, etc.) on overall safety and comfort perceptions associated with the ridesharing among women commuters. As the survey contained numerous perceptions variables, which could be

correlated, factor analysis was performed on all the perception variables before developing the ordered logit model. Factor analysis is generally used in behavioural sciences and economics for describing the heterogeneity among observed correlated variables and extract some of the most comprehensive factors (Nielsen et al., 2015, Bartholomew et al., 2008; Bandalos and Boehm-Kaufman, 2009; Velicer and Jackson, 1990).

### *4.2. Factor Analysis for Perception Variables*

Firstly, Kaiser-Mayer-Olkin (KMO) measure was used for checking the sampling adequacy (Field, 2005). The KMO statistics varies between *0* and *1*; where a value closer to *1* reveals that the patterns of correlations are compact and factor analysis will result in distinct and reliable factors (Field, 2005). The present data resulted in KMO statistics equal to 0.79 and thus showed that factor analysis could be performed on the data. Because the perception variables were in the ordinal form, the Pearson correlation could underestimate the strength of relationships between the variables; therefore, the polychoric correlation was performed (Olsson, 1979 and Baglin, 2014). For factor rotations, the Orthogonal rotation was used which minimizes the relationship between factors (Baglin, 2014). Varimax rotation technique was applied, which maximizes the sum of variance of loadings and used for orthogonal rotation (Efthymiou et al., 2013).

Table 2 shows the factor loadings of each variable in connection with the factors. Here only, loadings with a value higher than 0.3 are shown and the values higher than 0.6 are in bold (Efthymiou et al., 2013). Higher loading represents higher contribution/connection of the variable with the respective factor. As seen in the Table, the factor analysis yielded a four-factor solution which explained 63.53% of the variance. For each factor, the Cronbach's alpha index was computed and found to be greater than 0.6 which indicated the reliability in combining the variables into identified factors. Factor scores were calculated by weighted sum score method (DiStefano et al., 2009). The four identified factors based on the loadings are explained as below:

- *Perceived safety with females / known male passengers*: The loadings obtained from the factor analysis (Table 2) showed that the four variables which were accounting for safety perception of women when they share their ride with female friends, unknown female passenger or with male friends, were correlated with each other. Therefore, these variables could be represented by a single factor and which was named as "Perceived safety with females / known male passengers".

- *Preferences given during ridesharing*: All the variables related to the preferences given by women for ridesharing i.e., importance to safety, comfort, cost, privacy and pool size, were correlated and therefore, they were combined into a single factor i.e., "Preferences given during ridesharing".

- *Safety perceptions in unknown environment*: The four variables related to safety perceptions of women during ridesharing with male strangers without any information about them or the male passengers with revealed reviews and rating and the safety perceptions during the ridesharing at night times, could be represented by a single factor because of the underlying correlation between the said variables. The single factor interpreting these variables could be named as "Safety perceptions in unknown environment".

- *Safety and comfort during ridesharing*: The factors analysis showed that the four perception variables: safety as a driver, safety as a rider, safety during day and comfort perception during ridesharing were correlated and therefore, could be converted into a single factor: "Safety and comfort during ridesharing". When the variables were converted into a single factor; the perception levels of these individual variables (safety and comfort) were combined together and hence the perception levels of the single converted factor were assumed to vary from "very unsafe and uncomfortable" to "very safe and comfortable" in the present study.

Table 2 Factor analysis of variables.

| Variables | Factor 1 | Factor 2 | Factor 3 | Factor 4 |
|---|---|---|---|---|
| Perceived safety with female friends | **0.863** | | | |
| Perceived safety with male friends | **0.816** | | | |
| Perceived safety with female strangers with ratings and reviews | **0.793** | | | |
| Perceived safety with female stranger | **0.607** | 0.555 | | |
| Perceived safety with male stranger | | **0.842** | | |
| Perceived safety with male strangers with ratings and reviews | | **0.673** | | |
| Perceived safety while travelling at night | | **0.601** | | 0.465 |
| Importance of privacy | | | **0.821** | |
| Importance of comfort | | | **0.760** | |
| Importance of ridesharing group | | | **0.722** | |
| Importance of safety | 0.564 | | **0.603** | |
| Importance of cost | | | 0.446 | |
| Perceived safety as a driver | | | | **0.807** |
| Perceived comfort level of the driver | | | | **0.775** |
| Perceived safety as a rider | | | | **0.739** |
| Perceived comfort level of the rider | | | | **0.723** |
| Perceived safety while travelling during day time | | | | **0.610** |
| Latent Factors | Perceived safety with female or known male passengers | Safety perceptions in unknown environment | Preferences given during ridesharing | Safety and comfort during ridesharing |

### *4.3. Modelling Perceived Safety and Comfort of Women during Ridesharing*

As the factor analysis results showed that overall safety and comfort perception of women during ridesharing (both as a rider and driver) are correlated and can be covered by a single factor i.e., “Safety and comfort during ridesharing”. This factor was modelled against the other latent factors mentioned in Table 2 and other non-perception variables mentioned in Table 1 with the logistic model approach. The dependent variable was ordinal in nature, therefore, ordered logit model was assumed to be an appropriate method for conducting the analysis (Train, 2009). The model results are mentioned in terms of the estimated coefficients, their odds ratios, standard error (SE) and significance parameters in Table 3.

Table 3 Results of the ordered logistic regression analysis

| Variables | Coefficients | Odds ratio | SE | Wald -$\chi^2$ | p-value |
|---|---|---|---|---|---|
| Age (RC=>55 years) | | | | | |
| Age 18-25 years | -2.15 | 0.12 | 1.07 | 4.06 | 0.04 |
| Age 26-35 years | -2.10 | 0.12 | 1.05 | 3.96 | 0.05 |
| Age 36-45 years | -2.43 | 0.09 | 1.10 | 4.90 | 0.03 |
| Age 46-55 | -2.53 | 0.08 | 1.16 | 4.79 | 0.03 |
| Occupation (RC=Unemployed) | | | | | |
| Student | 0.64 | 1.89 | 0.48 | 1.74 | 0.19 |
| Preferred pool size (RC=4) | | | | | |
| pool size =2 | 0.45 | 1.57 | 0.31 | 2.11 | 0.15 |
| Involvement in ridesharing (RC=ridesharing group) | | | | | |
| Non-ridesharing group | -0.34 | 0.71 | 0.25 | 1.84 | 0.18 |
| Perceived safety in unknown environment (RC= very safe) | | | | | |
| Very unsafe | -6.03 | 0.00 | 1.60 | 14.29 | 0.00 |
| Unsafe | -4.17 | 0.02 | 1.55 | 7.28 | 0.01 |
| Somewhat safe | -3.37 | 0.03 | 1.55 | 4.75 | 0.03 |
| Safe | -1.29 | 0.28 | 1.54 | 0.71 | 0.40 |
| Intercepts for perceived safety and comfort levels (RC= very safe and comfortable) | | | | | |
| Very unsafe and uncomfortable | -11.25 | 0.00 | 2.06 | 29.83 | 0.00 |
| Unsafe and uncomfortable | -7.78 | 0.00 | 1.97 | 15.65 | 0.00 |
| Somewhat safe and comfortable | -4.83 | 0.01 | 1.95 | 6.14 | 0.01 |
| Safe and comfortable | -1.95 | 0.14 | 1.90 | 1.05 | 0.31 |

RC =reference category

The model results showed that age factor had a significant influence on perceived levels of safety and comfort during ridesharing for women. The negative coefficients indicated that the safety and comfort perceptions of young and middle age groups were significantly lower when compared to older women (age >55). The reason could be more fear of being victimization in public places among young girls and mid-aged women compared to older women (Rosenbloom and Plessis-Fraissard, 2010; Silverman and Della-Giustina, 2001). But, the coefficients of young and middle age groups were similar, which showed that the overall safety and comfort perception were almost equal for both the groups (Caulfield, 2009). Surprisingly, household income did not show any significant effect on safety and comfort perceptions. But, the employment status (occupation) of the participants revealed that students rated the ridesharing arrangements towards higher safety and comfort when compared to the unemployed participants. The odds for higher safety and comfort perceptions were 1.89 times greater for the student category than the unemployed participants. The reason behind this could be that the unemployed women have lower amount of money to spend on their household-trips, therefore they are restricted to walking-trips or longer-trips made by public transit mode (Jain and Parida, 2014). Additionally, the lower awareness about the ridesharing benefits might have resulted in a lower experience of ridesharing for the unemployed women which consequently might have led to lower safety and comfort perceptions (Tanzarn et al., 2014).

The model results indicated that as the size of group sharing the ride decreased, the perceived levels of safety and comfort increased. If the group size was 2 persons during shared ride, the odds of rating the ridesharing as safe and comfortable increased by almost 1.6 times compared to the group size of four persons. This may be because females feel uncomfortable during ridesharing when travelling in compacted environment. This finding is also supported by some previous studies which stated that travelling in crowded vehicles are one of the main safety concerns for women (Jain and Parida, 2014; Thynell, 2014; Hickey, 2014; and Levin, 1982). The other explanation could be the extra travel time added to the trip because of dropping off/picking up the other riders (Malodia and Singla, 2016; Levin, 1982).

As expected, the participants with no experience of ridesharing, perceived it more unsafe and uncomfortable when compared to the women who had opted for ridesharing and had experienced it. Also, it suggests that the inexperience and higher fear about the lesser known arrangement are the main causes for higher insecurity in ridesharing.

Women's safety and comfort perceptions during ridesharing were also depended on their perceptions in strange environment i.e., during night time or with male strangers. The women who strongly felt the ridesharing services as very unsafe/unsafe during night time were less likely to rate the overall ridesharing as safe and comfortable. Gender and information of co-riders also affected the ridesharing perceptions of the women. If the perceived safety and comfort levels were reported very low with stranger males, then the overall safety and comfort perceptions of ridesharing reduced significantly. Both the scenarios (during night and with a male stranger) made women more uncomfortable and thus reduced the overall safety and comfortable perceptions for ridesharing.

## 5. Validation of Results: Focus Group Discussion

To understand the issues of women safety in ridesharing and to validate the results of the survey, a focus group discussion was conducted with 7 young participants (age 21-25 years) in IIT Bombay campus. Each potential participant was approached individually and was briefed about the group discussion. All the participants had experienced ridesharing services either by using dial-a-cab service, car-pooling with friends or shared auto services. Various themes related to safety and comfort during different ridesharing arrangements and travelling situations were covered in the focus group discussion. The discussion lasted for 1.5 hours. Following are the important outcomes obtained against each theme discussed in the focus group discussion:

### *5.1. Theme 1: General ridesharing experience.*

The participants shared their overall ridesharing experience and agreed with each other that they felt safer when sharing a ride in known localities (i.e., their "comfort zone") even with male co-riders. They felt safe with acquaintances (especially friends of friends) because they are not completely strangers. They also mentioned that sharing the rides with female co-riders, with an elderly couple and with families, is safer for travelling in unknown localities; but, it may not be comfortable, because the sense of privacy gets reduced. Low travel cost was the biggest stated advantage of ridesharing.

### *5.2. Theme 2: Experience with mobile application based ridesharing services (e.g. BlaBlaCars, Uberpool and LiftO).*

None of the participants had experienced such mobile based services. Only three people had heard about such services. To continue the discussion, it was explained how these services work and then they were asked if they would ever want to use such services. The respondents mentioned that they will use these services if someone known to them is also travelling with them or if the driver is a female. Even with revealed ratings and reviews of the drivers and co-riders, the participants seemed apprehensive to use these services as they felt that these ratings could be fake and users do not usually rate sincerely. The participants further mentioned that, if the driver or the co-riders had a large number of good reviews, then the chances of opting for such mobile application based ridesharing services would increase.

### *5.3. Theme 3: Improvements required in application-based services to enhance safety and to encourage people to use such services?*

To increase the safety of such services, the drivers' background in terms of education, driving experience and criminal history, should be cross-checked and verified. The car should be tracked through the app. There should be an emergency notification/call system within the car or in the app.

### *5.4. Theme 4: Ridesharing in urban locations v/s in the outskirts/inter-city.*

The participants expressed that sharing a ride in urban locations could be safer because the trips made are smaller, the public places are more crowded, help is easily available and the police patrolling is more in urban locations. Whereas, intercity travelling can be uncomfortable and unsafe, especially when sharing the ride with male

co-riders. It can be made safer through patrolling on common routes at regular intervals, live tracking of shared cars. Moreover, the destinations and preferred route should be fixed by the rider before the start of the journey. Any ambiguity in decided route should raise alarm and the emergency button should connect the rider to the police. However, public transport will be preferred over ridesharing for inter-city travel.

### *5.5. Theme 5: Importance of number of co-riders while ridesharing.*

The participants discussed that the ridesharing vehicle should not be very crowded and ample space should be available to sit comfortably. The participants revealed that importance of the number of co-riders also depends on the duration of journey i.e., more number of riders can be accommodated for shorter trips. If deviations from the route are large, then few number of co-riders are preferred.

### *5.6. Theme 6: Perceptions about women-only ridesharing.*

The participants revealed their concerns toward women only ridesharing services and intimidated that there is an increased fear of being attacked by external criminals especially during night time, as they would recognise the women-only cars. But, for within city travel, to known destinations, the women-only ridesharing would be preferred.

### *5.7. Theme 7: Driving v/s riding while ridesharing.*

While discussing this theme, the participants had mixed arguments. Some of the participants stated that they would drive for a leisure trip and ride for office trips, while others preferred the opposite. The participants also conveyed that the rider-driver arrangement can be alternated for daily trips. But it was also revealed that they will choose driving option over riding during late night hours; because they feel more control over the vehicle during driving.

### *5.8. Theme 8: Any other preferences during ridesharing.*

While discussing the other specific preferences and needs during ridesharing, the participants listed out some of the points. For example, smoking should not be allowed in the car, the speed of the vehicle should be within specified limit and the extra time of picking up or dropping off the co-rider should be reduced. Moreover, the participants also discussed that the boarding from/alighting should be at places where sufficient surveillance and lighting is available; and isolated locations, especially at night, should be avoided.

During the discussions the participants also mentioned that all the employees of the ridesharing services should be trained; irrespective of gender, age or level of employment and they should be made aware of the consequences of wrongdoing. They revealed that campaigns should majorly be done to spread awareness of precautions as well as actions that could be taken if the women are offended. Complaint system should be improved so that women can report the crime without any hesitation.

Overall, from the focus group discussion, it was found that safety during ridesharing also depends on location, time of day, duration of the journey, the gender of co-riders and many other factors. The participants expressed that because of the increased crime against women in India, they do not consider ridesharing as a safer option especially with strangers, and for long distances. But, the participants also mentioned the ridesharing arrangements can be improved by implementing the required policy changes, which can beneficial for the society, both economically and environmentally.

## 6. Discussion and Conclusions

The present study focused on analysing and modelling the factors which affect the ridesharing perceptions of women. A questionnaire survey was conducted in order to collect the views of women living in Indian cities on various aspects of ridesharing. In order to find out the underlying correlations among the variables, factor analysis

was performed on the perception variables. Then the factor accounting for safety and comfort perceptions was modelled by an ordered logit model while considering all other factors and other variables such as demographic attributes, preferred pool size as independent variables.

The present study analysis can help in understanding the existing scenario of ridesharing services in developing countries in term of issues related to safety and comfort of women during ridesharing. The developed model exhibited the relationships between the women's safety and comfort perceptions to their demographic characteristics and their perceptions towards different ridesharing arrangements and situations such as travelling with female/male co-riders, travelling during different time periods, travelling with different group sizes, travelling for different distances, etc. The established relationship indicated towards various important policy changes for the ridesharing services to grow in the developing countries.

The key aspects for policy changes indicated through the model results and the focus group discussion from the present study to increase the ride sharing services amongst women are as indicated below:

- *Formal ridesharing services:* The young and middle-aged women are more reluctant to trust the ridesharing arrangement; therefore, these arrangements should be made in formal ways.

- *Role of women in planning and operating the services:* Also, most important policy improvement is that women should be represented adequately in planning processes of the ridesharing programs and policy initiations. It would enable policy makers to develop solutions towards eradicating harassment of women and achieving gender equity in transportation. Further, women feel safer with female co-passengers, therefore a large number of "women only" ridesharing services should be arranged.

- *Providing cost-effective means:* According to the present study results, it was found that the non-ridesharing group had more negative safety and comfort perceptions towards ridesharing facility. It suggests that the ridesharing services have to be made available to all the sectors of society (including unemployed or lower income groups) by making it cost effective so that they can experience the benefits of ridesharing over the public transport.

- *Presence of surveillance services:* Significant lower levels of safety and comfort perceptions during night time riding and travelling with strangers suggest that the sense of security has to be increased, especially, during night time by minimizing the fear of being subjected to harassment and sexual crime and violence. It can be achieved by increasing police patrolling at certain locations, enhancing the infrastructure and increase the safety of all public (e.g., picking up and dropping off points).

- *Perception of safety:* The focus group discussion suggested that ridesharing services should be provided with emergency or panic buttons so that the women are confident in using the ridesharing services.

The present study results can help in improving the ridesharing services in the developing countries like India. As most of the data was collected from the women residing in Mumbai, where ridesharing services are already in function and more than half of the sample had experienced the ridesharing services in the past. Therefore, the results obtained from the present study can be generalised to other metro cities such as Delhi, Bengaluru, Hyderabad, etc. in India which have similar ridesharing services available to public. Further, the data were dominated by young and mid-age women, therefore the findings may be applicable mainly to these age groups.

### *6.1. Limitations*

The study provides useful insights into the role of demographic attributes and the preferences of women during ridesharing; but, one of the main limitations of the study is that it was conducted mainly in Mumbai city which is a metro city in India. But, the safety perception also changes with the location; therefore, conducting the study on a

larger scale, covering the other cities and rural areas of the nation can give a generic idea of the ridesharing services. Additionally, the educational level of the participants, which could affect the ridesharing perceptions of the participants, was not asked in the questionnaire; therefore, it could not be considered in the analysis.

## References


Agatz, N.A., Erera, A.L., Savelsbergh, M.W. and Wang, X., 2011. Dynamic ride-sharing: A simulation study in metro Atlanta. *Transportation Research Part B: Methodological*, *45*(9), pp.1450-1464.

Anand, A., and G. Tiwari. 2006. A Gendered Perspective of the Shelter-Transport-Livelihood Link: The Case of Poor Women in Delhi. *Transport Reviews*, *26* (1), pp. 63–80.

Arabikhan, F., Kermanshah, M., Postorino, M.N. and Gegov, A., 2014. Examining employees' preference toward telecommuting with an emphasis on women employees. *In 5th International Conference on Women's Issues in Transportation*.

Baglin, J., 2014. Improving your exploratory factor analysis for ordinal data: a demonstration using FACTOR. *Practical Assessment, Research & Evaluation, 19*(5), p.2.

Bandalos, D.L. and Boehm-Kaufman, M.R., 2009. Four common misconceptions in exploratory factor analysis. *Statistical and methodological myths and urban legends: Doctrine, verity and fable in the organizational and social sciences*, pp.61-87.

Bartholomew, D.J., Steele, F., Galbraith, J. and Moustaki, I., 2008. Analysis of multivariate social science data. *CRC press*.

Bicocchi, N. and Mamei, M., 2014. Investigating ride sharing opportunities through mobility data analysis. *Pervasive and Mobile Computing*, *14*, pp.83-94.

Buliung, R., Soltys, K., Habel, C. and Lanyon, R., 2009. Driving factors behind successful carpool formation and use. *Transportation Research Record: Journal of the Transportation Research Board*, (2118), pp.31-38.

Campbell, M., 2014. Gender, income, and transportation mobility in Bangalore's IT sector. *In 5th International Conference on Women's Issues in Transportation*.

Caulfield, B., 2009. Estimating the environmental benefits of ride-sharing: A case study of Dublin. *Transportation Research Part D: Transport and Environment*, *14*(7), pp.527-531.

Chandran, R., (2016). Much crime unreported in Indian cities, sexual harassment complaints ignored: survey. [online] Available at: http://www.reuters.com/article/us-india-women-harassment-idUSKCN0XP2CL [Accessed 19 May 2017]

DiStefano, C., Zhu, M. and Mindrila, D., 2009. Understanding and using factor scores: Considerations for the applied researcher. *Practical Assessment, Research & Evaluation*, *14*(20), pp.1-11.

Enoch, M., S. Potter, G. Parkhurst, and M. Smith. 2004. INTERMODE: Innovations in Demand Responsive Transport, Final Report. http://design.open.ac.uk/potter/documents/ INTERMODE.pdf (accessed on 20/05/2017)

Efthymiou, D., Antoniou, C. and Waddell, P., 2013. Factors affecting the adoption of vehicle sharing systems by young drivers. *Transport policy*, *29*, pp.64-73.

Eliasson, J., & Mattsson, L. G. (2006). Equity effects of congestion pricing: Quantitative methodology and a case study for Stockholm. *Transportation Research Part A: Policy and Practice, 40*(7), pp.602-620

Field, A., 2005. C8057 (Research Methods II): Factor analysis using SPSS. Statisticshell. com.

Firstpost. (2013). Budget 2013 highlights: Rs 1,000 cr each for all-woman bank, Nirbhaya fund - Firstpost. [online] Available at: http://www.firstpost.com/budget/budget-2013-budget/budget-2013-rs-1000-cr-each-for-all-woman-bank-nirbhaya-fund-643148.html. [Accessed 25 Jul. 2016]

Furuhata, M., Dessouky, M., Ordóñez, F., Brunet, M.E., Wang, X. and Koenig, S., 2013. Ridesharing: The state-of-the-art and future directions. *Transportation Research Part B: Methodological, 57*, pp.28-46.

Ghoseiri, K., Haghani, A.E., Hamedi, M. and Center, M.A.U.T., 2011. *Real-time rideshare matching problem*. Mid-Atlantic Universities Transportation Center.

Gupta, N., Solomon, M.J. and Raja, K., 2009. Response rate to a survey in India. *Indian Journal of Physiotherapy and Occupational Therapy-An International Journal*, *3*(3), pp.55-57.

Hickey, G., 2014. Anti-harassment campaigns for mass transit in the 21st century US: A critique from history. *In 5th International Conference on Women's Issues in Transportation*.

Hrncir, J., Rovatsos, M. and Jakob, M., 2015. Ridesharing on timetabled transport services: A multiagent planning approach. *Journal of Intelligent Transportation Systems*, *19*(1), pp.89-105.

http://www.hindustantimes.com/. (2015). Autorickshaws for women, driven by women to ply in city soon. [online] Available at: http://www.hindustantimes.com/mumbai/autorickshaws-for-women-driven-by-women-to-ply-in-city-soon/story-WU2fqxXB1n1VeppaUbN5RP.html [Accessed 11 Aug. 2016]

India.uitp.org. (2016). Women's Safety & Challenges in Public Transport | UITP India. [online] Available at: http://www.india.uitp.org/articles/women-safety-in-public-transport. [Accessed 1 Aug. 2016]

Indo-Asian News Service (2017). Uber to get more Indian cab users ride with 'UberPOOL' in 2017. [online] Available at: http://www.india.com/technology/uber-to-get-more-indian-cab-users-ride-with-uberpool-in-2017-1743199/. [Accessed 19 May 2017]

Karan, J., 2011. How to increase response rate to a questionnaire study. *Indian Journal of Pharmacology*, *43*(1), pp.93-94.

Lathura, A., 2006. Para Transit system in Medium sized cities: Problem or panacea. *ITPI Journal*, Vol 3 (2), pp. 55-61.

Levin, I.P., 1982. Measuring trade-offs in carpool driving arrangement preferences. Transportation, 11(1), pp.71-85.

Levin, I.P., Mosell, M.K., Lamka, C.M., Savage, B.E. and Gray, M.J., 1977. Measurement of psychological factors and their role in travel behavior. *Transportation Research Record*, *649*, pp.1-7.

Levin, L. and Faith-Ell, C., 2011. Women and Men in Public Consultations of Road-Building Projects. In *Transportation Research Board Conference Proceedings, 2*, (46).

Listerborn, C. Friberg, T., Andersson, B. and Scholten, C., 2005. Reflections Room. If gender-coded locations and contexts. *Brutus Östling Publisher Symposium*.

Loukaitou-Sideris, A. and Fink, C., 2008. Addressing women's fear of victimization in transportation settings: A survey of US transit agencies. *Urban Affairs Review*.

Lynch, G. and Atkins, S., 1988. The influence of personal security fears on women's travel patterns. *Transportation*, *15*(3), pp.257-277.

Malodia, S. and Singla, H., 2016. A study of carpooling behaviour using a stated preference web survey in selected cities of India. *Transportation Planning and Technology*, *39*(5), pp.538-550.

Mageean, J F and Nelson, J D., 2003. The evaluation of Demand Responsive Transport Services in Europe. *Journal of Transport Geography*, **11**(4), 255-270.

Mani, A., and Pant P., 2012. Review of literature in India's urban auto-rickshaw sector: a synthesis of findings. Report by EMBARQ India. Available at: http://www.indiaenvironmentportal.org.in/files/file/Review%20of%20Literature%20In%20Indian%27s%20Urban%20Auto%20Rickshaw%20Sector.pdf (Accessed on 20/05/2017)

Ministry of Urban Development (MoUD), 2008. Study on Traffic and Transportation policies and strategies in Urban areas in India. Available at: http://urbanindia.nic.in/programme/ut/final_Report.pdf (Accessed on 20/05/2017)

Millennium Post. (2016). Public and private spaces | Millennium Post. [online] Available at: http://www.millenniumpost.in/NewsContent.aspx?NID=260248. [Accessed 28 Jul. 2016]

Morency, C., 2007. The ambivalence of ridesharing. *Transportation*, 34(2), pp.239-253.

Mulley, C, Nelson, J, Teal, R, Wright, S and Daniels, R., 2012. Barriers to implementing Flexible Transport Services: an international comparison of the experiences in Australia, Europe and USA. *Research in Transportation and Business Management, 3*, pp.3-11.

National Crime Records Bureau, 2015. Crime against Women, *Ministry of Home Affairs, Government of India*, pp81-92. http://ncrb.gov.in/

Nielsen, J.R., Hovmoller, H., Blyth, P.L. and Sovacool, B.K., 2015. Of "white crows" and "cash savers:" A qualitative study of travel behavior and perceptions of ridesharing in Denmark. *Transportation Research Part A: Policy and Practice, 78*, pp.113-123.

Olsson, U., 1979. Maximum likelihood estimation of the polychoric correlation coefficient. *Psychometrika, 44*(4), pp.443-460.

Peters, D., 2001. Gender and transport in less developed countries: A background paper in preparation for CSD-9. In *London, Paper Commissioned by UNED Forum*.

Polk, M., 2004. The influence of gender on daily car use and on willingness to reduce car use in Sweden. *Journal of Transport Geography*, 12(3), pp.185-195.

Rosenbloom, S. 2006. Understanding Women and Men's Travel Patterns: The Research Challenge. In Conference Proceed- ings 35: Research on Women's Issues in Transportation: Report of a Conference; Volume I: *Conference Overview and Plenary Papers, Transportation Research Board of the National Academies*, Washington, D.C., pp. 7–28.

Rosenbloom, S., Plessis-Fraissard, M. (2009). Women's Travel in developed and Developing Countries: Two Versions of the Same Story?, Women's Issues in Transportation – Conference Proceedings 46, Vol. 1. Transportation Research Board of the National Academies, Washington D.C., 2009, pp. 63–73.

Shetaxi - India's First Ever Technology enabled 24/7 Women-Only Taxi. [online] Available at: http://www.shetaxi.in/about [Accessed 31 Jul. 2016]

Silverman. E., and J. A. Della-Giustina. 2001. Urban Policing and the Fear of Crime. *Urban Studies*, *38* (5), pp. 941–958.

Smartmumbaikar.com. (2016). Check this to daily Travel Fast n Smart in Mumbai. [online] Available at: http://smartmumbaikar.com/index.php?route=account/register [Accessed 31 Jul. 2016].

Soni, M., 2016. Rethinking the Challenge of Women's Safety in India's Cities. *ORF-Issue-Brief*.

Jain, T. and Parida, P., 2014. Gender appraisal of mobility patterns and instances of exclusion for working population in Delhi. *In* 5th International Conference on Women's Issues in Transportation.

Tanzarn, N., Babinard, J. and Lema, C., 2014. Lessons learned from Uganda's gender mainstreaming policy in the road sector. *In 5th International Conference on Women's Issues in Transportation*.

The Hindu. (2014). Auto service for women rolled out. [online] Available at: http://www.thehindu.com/todays-paper/tp-national/tp-otherstates/auto-service-for-women-rolled-out/article6157368.ece. [Accessed 11 Aug. 2016]

The Times of India. (2016). New female auto drivers put women's safety in top gear - Times of India. [online] Available at:
http://timesofindia.indiatimes.com/city/mumbai/New-female-auto-drivers-put-womens-safety-in-top-gear/articleshow/50576481.cms. [Accessed 5 Aug. 2016]

Thynell, M., 2014. Gender sensitive-policies in the area of urban transport; between research and international institutions. *In 5th International Conference on Women's Issues in Transportation*.

Train, K.E., 2009. Discrete choice methods with simulation. Cambridge university press.

Velaga, N. R., Nelson, J. D., Wright, S. D. and Farrington J. H., 2012a. The Potential Role of Flexible Transport Services in Filling Gaps in Rural Public Transport Provision. *Journal of Public Transportation*. Vol 15 (1), pp. 33-53.

Velaga, N.R., Beecroft, M., Nelson, J.D., Corsar, D. and Edwards, P., (2012b) “Transport poverty meets the digital divide: accessibility and connectivity in rural communities”. *Journal of Transport Geography*, *21*, pp.102-112.

Velaga, N. R., Rotstein, N. D., Oren, N., Nelson, J. D., and Norman, T. J. F., (2012c) ″Development of an Integrated Flexible Transport Systems Platform for Rural Areas Using Argumentation Theory″. *Research in Transportation Business and Management*. Vol 3. 2012, pp. 62-70.

Velaga, N.R., Nelson, J. D., Papangelis, K., Corsar, D., and Edwards, P., "Designing a Passenger-Centric Information Eco-System for Integrated and Flexible Transport Systems in Rural Areas", *The Journal of Sustainable Mobility*, Vol 1 (2), 2014, pp, 73-82.

Velicer, W.F. and Jackson, D.N., 1990. Component analysis versus common factor analysis: Some issues in selecting an appropriate procedure. *Multivariate behavioral research*, *25*(1), pp.1-28.

Viswanath, Kalpana. "Planning cities as if women matter." Seminar. Vol. 648. 2013.

Wang, C., Quddus, M., Enoch, M., Ryley, T., and Davison, L. 2012. The impact of socio-economic factors on the demand for Demand responsive Transport (DRT) in Greater Manchester: A multilevel modelling approach. Paper presented at 91st Annual Meeting of the Transportation Research Board, Washington DC, USA, January 2012.

Wilkinson, S., (2016). Meet The Heroic Campaigners Making Cities Safer For Women. [online] Available at: http://www.refinery29.uk/women-safer-cities. [Accessed 19 May 2016]

Wilkowska, W., Farrokhikhiavi, R., Ziefle, M. and Vallée, D., 2014. Mobility requirements for the use of carpooling among different user groups.*Advances in Human Factors, Software, and Systems Engineering*, *6*, p.129.

Wright, S., 2013. Designing flexible transport services: guidelines for choosing the vehicle type, *Transportation Planning and Technology*, 36:1, 76-92, DOI:10.1080/03081060.2012.745757

Wright, S., Emele, C.D., Fukumoto, M., Velaga, N.R. and Nelson, J.D., 2014. The design, management and operation of flexible transport systems: Comparison of experience between UK, Japan and India. *Research in Transportation Economics*, *48*, pp.330-338.

Yavuz, N. and Welch, E.W., 2010. Addressing fear of crime in public space: gender differences in reaction to safety measures in train transit. *Urban studies*. 47 (12) pp. 2491–2515.

# Authors' response to review comments

## Paper Reference Number: 439

## Title: Assessing and Modelling Perceived Safety and Comfort of Women during Ridesharing

Authors would like to thank the reviewers for recommending the paper for "Grade B" implying that the paper will be processed for possible publication in a special issue of an academic journal following the WCTR conference.

We also thank the reviewers for their constructive comments and suggestions that helped us to enhance the paper. We believe that the current version of our manuscript is improved. Below are our responses (blue coloured text) to the comments one by one (reviewers' comments are shown in Bold font). For each comment actions taken in the revised manuscript is also illustrated.

# Reviewer: #1

**This is a well-written paper covering an interesting and largely non-researched topic of gender exclusion in transport, which is of high interest in the context of Global South cities as ride sharing options become increasingly available through Uber-type providers.**

**The paper is well-referenced and the literature review covers a wide-spectrum of relevant materials. The sample size is adequate and the methodology is appropriate. The preliminary analysis of the survey data to date is robust. This suggests that the paper will be a good candidate for publication in a journal once the full analysis is completed. As such the paper, is not currently recommended for a Special Issue, but the authors are encouraged to complete their analysis and submit it once this is done.**

**RESPONSE:** Authors would like to thank the reviewer for the detailed review of the manuscript and suggesting improvements. We have incorporated all the suggestions provided by the reviewer and as a result, the quality of the manuscript is enhanced.

ACTIONS TAKEN IN THE REVISED MANUSCRIPT
As advised by the reviewer, the analysis is completed in the revised manuscript. The actions taken with respect to the analysis in the revised manuscript are as indicated below:

A. Firstly, factor analysis was performed on all the perception variables as the survey contained numerous perceptions variables which could be correlated. Factor analysis is generally used in behavioural sciences and economics for describing the heterogeneity among observed correlated variables and extract some of the most comprehensive factors (Nielsen et al., 2015, Bartholomew et al., 2008; Bandalos and Boehm-Kaufman, 2009; Velicer and Jackson, 1990). The results of the factor analysis are presented in Table 2 (as shown below) in the revised manuscript.

Table 2 Factor analysis of variables.

| Variables | Factor 1 | Factor 2 | Factor 3 | Factor 4 |
|---|---|---|---|---|
| Perceived safety with female friends | **0.863** | | | |
| Perceived safety with male friends | **0.816** | | | |
| Perceived safety with female strangers with ratings and reviews | **0.793** | | | |
| Perceived safety with female stranger | **0.607** | 0.555 | | |
| Perceived safety with male stranger | | **0.842** | | |
| Perceived safety with male strangers with ratings and reviews | | **0.673** | | |
| Perceived safety while travelling at night | | **0.601** | | 0.465 |
| Importance of privacy | | | **0.821** | |
| Importance of comfort | | | **0.760** | |
| Importance of ridesharing group | | | **0.722** | |
| Importance of safety | 0.564 | | **0.603** | |
| Importance of cost | | | 0.446 | |
| Perceived safety as a driver | | | | **0.807** |
| Perceived comfort level of the driver | | | | **0.775** |
| Perceived safety as a rider | | | | **0.739** |
| Perceived comfort level of the rider | | | | **0.723** |
| Perceived safety while travelling during day time | | | | **0.610** |
| Latent Factors | Perceived safety with female or known male passengers | Safety perceptions in unknown environment | Preferences given during ridesharing | Safety and comfort during ridesharing |

And the four identified factors based on the loadings are explained as below:

- Perceived safety with females / known male passengers: The loadings obtained from the factor analysis (Table 2) showed that the four variables which were accounting for safety perception of women when they share their ride with female friends, unknown female passenger or with male friends, were correlated with each other. Therefore, these variables could be represented by a single factor and which was named as “Perceived safety with females / known male passengers”.
- Preferences given during ridesharing: All the variables related to the preferences given by women for ridesharing i.e., importance to safety, comfort, cost, privacy and pool size, were correlated and therefore, they were combined into a single factor i.e., “Preferences given during ridesharing”.
- Safety perceptions in unknown environment: The four variables related to safety perceptions of women during ridesharing with male strangers without any information about them or the male passengers with revealed reviews and rating and the safety perceptions during the ridesharing at night times, could be represented by a single factor because of the underlying correlation between the said variables. The single factor interpreting these variables could be named as “Safety perceptions in unknown environment”.
- Safety and comfort during ridesharing: The factors analysis showed that the four perception variables: safety as a driver, safety as a rider, safety during day and comfort perception during ridesharing were correlated and therefore, could be converted into a single factor: “Safety and comfort during ridesharing”. When the variables were converted into a single factor; the perception levels of these individual variables (safety and comfort) were

combined and hence the perception levels of the single converted factor were assumed to vary from "very unsafe and uncomfortable" to "very safe and comfortable" in the present study.

B. Then, the ordered logistics regression model was used to statistically develop the relationship of the perceived safety and comfort levels during ridesharing with the potential explanatory factors such as demographic characteristics, various safety and comfort perceptions in different ridesharing situations and various preferences related to ridesharing (e.g., cost, privacy, pool-size, etc.). The final model is presented in Table 3 (as shown below) in the revised manuscript. And the results of the model are explained in Section 4.3.

Table 3 Results of the ordered logistic regression analysis

| Variables | Coefficients | Odds ratio | SE | Wald -$\chi^2$ | p-value |
|---|---|---|---|---|---|
| Age (RC=>55 years) | | | | | |
| Age 18-25 years | -2.15 | 0.12 | 1.07 | 4.06 | 0.04 |
| Age 26-35 years | -2.10 | 0.12 | 1.05 | 3.96 | 0.05 |
| Age 36-45 years | -2.43 | 0.09 | 1.10 | 4.90 | 0.03 |
| Age 46-55 | -2.53 | 0.08 | 1.16 | 4.79 | 0.03 |
| Occupation (RC=Unemployed) | | | | | |
| Student | 0.64 | 1.89 | 0.48 | 1.74 | 0.19 |
| Preferred pool size (RC=4) | | | | | |
| pool size =2 | 0.45 | 1.57 | 0.31 | 2.11 | 0.15 |
| Involvement in ridesharing (RC=ridesharing group) | | | | | |
| Non-ridesharing group | -0.34 | 0.71 | 0.25 | 1.84 | 0.18 |
| Perceived safety in unknown environment (RC= very safe) | | | | | |
| Very unsafe | -6.03 | 0.00 | 1.60 | 14.29 | 0.00 |
| Unsafe | -4.17 | 0.02 | 1.55 | 7.28 | 0.01 |
| Somewhat safe | -3.37 | 0.03 | 1.55 | 4.75 | 0.03 |
| Safe | -1.29 | 0.28 | 1.54 | 0.71 | 0.40 |
| Intercepts for perceived safety and comfort levels (RC= very safe and comfortable) | | | | | |
| Very unsafe and uncomfortable | -11.25 | 0.00 | 2.06 | 29.83 | 0.00 |
| Unsafe and uncomfortable | -7.78 | 0.00 | 1.97 | 15.65 | 0.00 |
| Somewhat safe and comfortable | -4.83 | 0.01 | 1.95 | 6.14 | 0.01 |
| Safe and comfortable | -1.95 | 0.14 | 1.90 | 1.05 | 0.31 |

RC =reference category

C. Further, the findings obtained from the focus group discussion, which also validated the results obtained from the models, are discussed in Section 5 (Validation of Results: Focus Group Discussion). The themes under which the focus group discussion was held are as below:

- General ridesharing experience.
- Experience with mobile application based ridesharing services (e.g. BlaBlaCars, Uberpool and LiftO).
- Improvements required in application-based services to enhance safety and to encourage people to use such services?
- Ridesharing in urban locations v/s in the outskirts/inter-city.
- Importance of number of co-riders while ridesharing.
- Perceptions about women-only ridesharing.
- Driving v/s riding while ridesharing.
- Any other preferences during ridesharing.

Please see Sections 4.2 and 4.3 in the revised manuscript for detailed explanation of the factor analysis and ordered logistics regression respectively. The outcomes of the focus group discussion are reported in Section 5. Further, Section 6 documents the overall discussion and conclusion of the present study.

# Reviewer: #2

**I suggest including some specific suggestions about how ride-sharing services could be improved to increase levels of ride-sharing amongst women.**

**RESPONSE**: Thank you for the suggestion. As advised by the reviewer, the possible solutions for increasing the levels of ride-sharing amongst women are discussed in "Discussion and Conclusions" section in the revised manuscript.

ACTIONS TAKEN IN THE REVISED MANUSCRIPT
As suggested by the reviewer, the following text is added in the revised manuscript (Section 6):
*"The key aspects for policy changes indicated through the model results and the focus group discussion from the present study to increase the ride-sharing services amongst women are as indicated below:*

- *Formal ridesharing services: The young and middle-aged women are more reluctant to trust the ridesharing arrangement; therefore, these arrangements should be made in formal ways.*
- *Role of women in planning and operating the services: Also, most important policy improvement is that women should be represented adequately in the planning processes of the ridesharing programs and policy initiations. It would enable policy makers to develop solutions towards eradicating harassment of women and achieving gender equity in transportation. further, women feel safer with female co-passengers, therefore a large number of "women only" ridesharing services should be arranged.*
- *Providing cost-effective means: According to the present study results, it was found that the non-ridesharing group had more negative safety and comfort perceptions towards ridesharing facility. It suggests that the ridesharing services have to be made available to all the sectors of society (including unemployed or lower income groups) by making it cost effective so that they can experience the benefits of ridesharing over the public transport.*
- *Presence of surveillance services: Significant lower levels of safety and comfort perceptions during night time riding and travelling with strangers suggest that the sense of security has to be increased, especially, during night time by minimizing the fear of being subjected to harassment and sexual crime and violence. It can be achieved by increasing police patrolling at certain locations, enhancing the infrastructure and increase the safety of all public (e.g., picking up and dropping off points).*
- *Perception of safety: The focus group discussion suggested that ridesharing services should be provided with emergency or panic buttons so that the women are confident in using the ridesharing services."*

**Include the limitations in section 6, rather than giving them as a separate section.**

**RESPONSE**: Thank you for the suggestion.

ACTIONS TAKEN IN THE REVISED MANUSCRIPT:

As advised by the reviewer, the limitations of the study are moved to Section 6 in the revised manuscript. The text included in "Limitations" section is as below:
*"6.1. Limitations*
*The study provides useful insights into the role of demographic attributes and the preferences of women during ridesharing; but, one of the main limitations of the study is that it was conducted mainly in Mumbai city which is a metro city in India. But, the safety perception also changes with the location; therefore, conducting the study on a larger scale, covering the other cities and rural areas of the nation can give a generic idea of the ridesharing services. Additionally, the educational level of the participants, which could affect the ridesharing perceptions of the participants, was not asked in the questionnaire; therefore, it could not be considered in the analysis."*

**Discuss in more detail the extent to which this study is generalizable to other locations.**

**RESPONSE:** Thank you for the suggestion. We have added a paragraph in "Discussion and Conclusions" section in the revised manuscript to discuss about the conditions in which the results are generalizable.

ACTIONS TAKEN IN THE REVISED MANUSCRIPT:

As suggested by the reviewer, we have added the following text in the revised manuscript (Section 6):
*"The present study results can help in improving the ridesharing services in the developing countries like India. As most of the data was collected from the women residing in Mumbai, where ridesharing services are already in function and more than half of the sample had experienced the ridesharing services in the past. Therefore, the results obtained from the present study can be generalised to other metro cities such as Delhi, Bengaluru, Hyderabad, etc. in India which have similar ridesharing services available to public. Further, the data were dominated by young and mid-age women, therefore the findings may be applicable mainly to these age groups."*