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The cover image is Rue de Rivoli - an emblematic street of Paris connecting Bastille to Concorde – that since May 2020 has been reserved for bicycles and pedestrians, Paris, France, Saturday, Nov. 6, 2021.

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Logit and probit models explaining perceived cycling motives, barriers, and biking trip generation in Lahore, Pakistan

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Abstract
Cycling as an attractive mode of transport is a challenge, especially in developing countries like Pakistan. Previous research on cycling in developing countries is insufficient to answer that how people can be encouraged to bike in different regions and cultures. This research, therefore, directs two research questions based on the perceptions of the people of Lahore. The first research question addresses the perceived motives of everyday biking trip generation and the second question addresses the perceived barriers in biking in the city of Lahore. The data sample of 379 subjects was collected through self-reported questionnaire across different socioeconomic groups. The questionnaire was designed to discuss the motives for biking such as affordability, reliability, and accessibility as well as to identify the barriers such as cultural issues, gender problems and non-availability of infrastructure for biking. Along with descriptive statistics, Multinomial Logistic was used to analyze perceived motives, Binary Logistic for perceived barriers and Ordinal Probit for biking trip generation. The obtained results are very interesting and provide various insights about the perceptions of people regarding biking trip generation, motives, and barriers with various factors involved. The results are beneficial to urban developers, city planners, transport planners, policy makers and other stakeholders.

Keywords
Bicycle; Biking perception; Sustainable transport; Urban mobility; Pakistan.

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1. Introduction

In the recent years, biking has emerged as the most sustainable mode of transport, yet, in developing countries such as Pakistan, it has always been a challenge to compel public to use it as a preferred mode of travel. Even though a lot of research on biking determinants has already been a topic of interest among researchers, practitioners, and policy makers, but the influence of region-specific barriers, motives and biking-trip generation factors that daunt back common public to use bicycle as a preferred mode are understudied, hence, need a due consideration. The population of the city of Lahore is diverse with a mixed land use, high commuting and urbanization rate and a wide range of modes of traffic used by common public. Unlike many other metropolitan cities of low-income countries, biking is neglected for a long time and is not taken into account whilst planning for common public living in urban areas of Pakistan. There could be many reasons behind its' unpopularity particularly in the context of Lahore. Therefore, this paper focuses on the perceptions regarding barriers, motives, and biking trip generation in Lahore, Pakistan, to promote the use of bicycle whilst supporting sustainable urban transport policies.

Among many others, usually, in high-income countries such as UK, three main factors i.e. environment, health and wellbeing, and mobility are considered as motives in promoting biking (Jones et al., 2016). Also, in high-income countries such as US, roads' infrastructure, passenger safety and environmental factors are considered as barriers in biking (Fowler et al., 2017). Other than this, there could be many other aspects such as social and personal barriers and motives, bicycling skills and lack of confidence (Grimes et al., 2020), differences in trends of biking between genders, health conditions, physical travelling distances and time to destinations, provision of bicycling facilities, cultural norms, safety and personal preferences (Snelgrove & Wood, 2010; Yin et al., 2018) are prominent biking determinants.

Studies from the neighboring countries of Pakistan show that, the importance of bike as a sustainable mode is either completely neglected or poorly underestimated, which in result caused very less availability of published literature. The situation is no different in Pakistan. A usual belief is that when people do not have access to public transport or power to afford any other traffic modes then people walk or bike. Same applies to Pakistan as well where low-income socioeconomic groups are more inclined towards biking compared to other socioeconomic groups (Aslam et al., 2018) and have very limited to almost no option available to use other modes of transport. Therefore, one way or the other, they are compelled to use bicycle as a travel mode which is not "by choice biking". It is worth considering that how people can be motivated to bike (or not) who do not have biking as the only available option.

In low-income countries like India, studies show that biking itself is considered as a health determinant, but is not given due attention (Moser et al., 2017). In China, it is recently realized that bike-sharing is a considerable determinant to bike, therefore, the trend of bike sharing is booming at a high pace with the newly developed interest of policy makers and city planners (Guo et al., 2017). In Iran socioeconomic behaviors of public, authorities' use of system, availability of infrastructure and involvement of needs of people whilst planning for biking are the main biking determinants (Jahanshahi, Van Wee, & Kharazmi, 2019).

Past studies have considered many variables such as socioeconomics, education, owning a bicycle, commuting needs and distance, cultural values, gender, social perspectives of gender, presence of infrastructure to support biking, health, well-being and physical activity, sustainable environment, purpose of trips and respective travelling distance etc. as the most influential factors in promoting or demoting the use of biking (Cai et al., 2019; Grimes et al., 2020; Jain & Tiwari, 2019; Raustorp & Koglin, 2019). Yet, there is no definite answer to date to understand that how people can be encouraged to cycle because it varies across cultures, regions, and personal characteristics. Biking determinants are different in different contexts and are region specific too. Therefore, it is important to understand behaviors, needs, capabilities, perceptions, resources, and personal abilities of people living in specific areas along with other prevailed conditions to determine that what factors engage people in biking through certain incentives. This study focuses on cycling motives, barriers

and trip generation from the people's perspectives to understand the causes that are refraining people from biking and what is lacking in urban policies that if looked after effectively, then can encourage people to bike frequently.

The objective of this study is to investigate about perceived motives, barriers, and indicators of biking trip generations in the metropolitan city of Lahore (Pakistan) that encourage or discourage people to use bicycles whilst having multi-purpose trips. The marginal task is to compare results with the differences and similarities of high-income countries in terms of perceived barriers to cycling, motives of cycling and biking trip generation in Lahore.

The first section gives a general overview of the topic and motivation behind conducting this study. It also highlights the main objective of the study. In the second section, a review of the literature presenting the results from the past studies on the topic of biking motives and barriers. It also covers the methodological considerations of similar past studies from the developing, south Asian and neighboring countries to report on the methodological consistencies and variations of this study that directs to the next section of the methodology. The next section presents the study findings based on the inferential analyses. The findings lead to generate a discussion section where the results of this study are compared with the literature findings, particularly those emerging from the developed world. The last section concludes this study based on findings and discussion.

2. Literature Review

There could be many types of motives that can affect cycling and generate trips. Some of the motives involve psychological, physical, social, health and goal achievement motives but they may value differently for genders and cross-cultures (LaChausse, 2006). Facilities and technology such as GPS and maps are helpful in preferment of cycling to provide online delivery services (Korver, 2018). A study from Poland (Biernat, Buchholtz, & Bartkiewicz, 2018), mentioned that people who are poorly educated, less wealthy and rural area dwellers are the ones who bicycle because of their certain socio-economic conditions and that they cannot afford or approach other modes of transport. Hansen suggested that some of the main determinants to biking for longer distances are that commuters prefer to cycle to enhance their physical activity followed by reduced cost and time of travel (Hansen & Nielsen, 2014). Charity cycling is also used to promote cycling activities (Snelgrove & Wood, 2010). Sports related or special event cycling can be supported by considering determinants such as socialization, event attractiveness, personal motivation, escape and relaxation and event attributes (Streicher & Saayman, 2010). Some developed countries are persuading common public to use e-bikes for commuting as a substitute to other motorized vehicles (Plazier et al., 2017). There exists a school of thought that e-biking could be a solution to indulge people in cycling. Also, that e-biking is desirable compared to conventional biking because it does not take much of an effort to ride / drive and produces no carbon but does not serve the purpose of health because it is treated as another vehicle to ride and people have to put very less effort in it compared to the conventional biking (Jones et al., 2016). Therefore, the focus of this paper is limited to conventional biking.

Studies from developing countries show that they usually lack proper physical planning and infrastructure in their cities and built neighborhoods which could be a barrier in biking. For example, a study (Erik De Castro, 2013) shows that how specific details of built environment can motivate or demotivate people to cycle or walk. There are many other barriers and motives of biking in developing countries. The problem exists with the non-realization of importance of biking which has led this mode as understudied in developing countries. In the recent times, developing countries have started exploring strategies to investigate biking determinants to make this mode popular and wishful by common people. It is found that with a focus on biking in developing countries, well designed and easily available facilities, short distance travels, increased accessibility, improved personal security and safety (such as transport safety and reduced fear of injuries and accidents), improved

esthetics and natural sceneries, increased comfort levels and bike supporting facilities are significant motives (De Castro, 2013). Also, lack of space and poor socioeconomic conditions are managed through bike sharing schemes (Bauman et al., 2017). Tan (Tan et al., 2019) found that smaller trip distance and lesser biking frequency are motives to bike because they are desirable traits whilst longer travel durations are not welcomed through biking. Zhao (Zhao et al., 2018) found that high mixed level of land use and good proximity environments increase biking. In addition, younger generation requires substantial encouragement to guide them to cycle more. Similarly, low education, low- and middle-income groups should be encouraged to keep on biking too. To encourage biking, these aspects as motives and barriers are commonly applicable to most of the developing countries and need to be addressed in detail.

Developed countries have overlooked the benefits of biking for a very long time too and focused more on planning for motorized transport and building infrastructure accordingly. Since a decade, policy makers and researchers have acknowledged that biking is the most sustainable mode of travelling with environment and health friendly profile (Pucher & Buehler, 2017). Studies from developed countries are laying basis for developing countries to consider biking as an important part of transport policy. Developing countries like Pakistan have not defined sustainable modes for travel-oriented policies so far. In contrast, developed countries are designing transport policies with a significant focus on walking and biking. Also, the recent biking policies focus on the safety of bikers especially when they interact with fast pacing motorized vehicles and for longer travel distances with the provision of exclusive biking lanes/right of ways and synchronized signals. In neighborhoods, safety is ensured by providing traffic calming devices and implementing required restrictions such as speed to make biking more efficient and safer (Tan et al., 2019). Sun (Sun, 2017) suggests that biking on shared basis, if included in policies can solve last mile problem in public transport and may encourage people to bike more. There is need to revisit and redefine policies with the inclusion of biking. Bike focused policies are also required to consider the needs of social inclusion and equity, especially for women, children and senior citizens to persuade and facilitate them to bike too.

South Asian countries are denser in population and are expanding haphazardly with significant growth in urbanization and transportation. According to global report on human settlements 2009 (Ansari, 2009) South Asian countries as being developing countries have lesser resources, more population, poor urban transportation policies and inconsistent land use, therefore, requires revisiting of urban planning. The trends of biking are not same in all South Asian countries but varies because of many factors such as national policies of each country. It is also important to understand that the needs of the bikers are taken well care of whilst devising policies for biking because a better biking experience will make the rider more willing to bike.

Literature from South Asian countries shows that the importance of biking as a reliable transport mode is well appreciated by some of them. However, barriers such as environment, safety and security, integration of transport modes, mixed urban traffic, convenience, weather, health and poor infrastructure are biking discouragers (Nawaz, 2015). A study from Bangladesh emphasizes to amend transport policies to accommodate increasing rate of bikers despite of many biking barriers such as poor road performance, high traffic density and from very less to almost no room for bikers in the existing infrastructure (Rana et al., 2017). Nawaz (Nawaz, 2015) also suggests that In a poor and overly populated country like Bangladesh, bicycling can give a congestion free roads, therefore, urban planners should avail this opportunity whilst planning for cities.

Taiwan itself is considered as a biking tourist destination. A study from Taiwan suggests that with the provision of comfortable environment, segregated biking facilities and improved road surface and pavement more biking tourism can be attracted in comparison to the neighboring tourism attraction countries (Lee & Huang, 2014). Chen (Chen & Lee, 2017) from the study of biking in Taiwan, draws an example, and offers many ways to promote bike tourism globally. This can be done by prioritizing bike service enhancements and improvements such as renting a bike at one station and dropping off at another designated location. In addition to these, provisions of nanny vans to accommodate bikers, biking related information centers, bike trainings and guides,

guided tours, creative bike touring routes according to the rider's capabilities, friendly environment and travel insurance policies are huge biking trips generators.

In China and similar countries, along with rising concerns about health, fitness and wellbeing, biking is considered as a tool to achieve health goals. Therefore, biking encouraging motives are included as a part of national policy. In China, bike sharing was introduced in 2008 to promote biking in major cities, which declined later in 2010 because of the barriers such as poor maintenance of bikes, larger distances between biking stations and poor infrastructure. Later, bike sharing was taken on IT based system that gave an immediate boom to biking. The reason behind were the motives such as improved infrastructure, easy check-in and check-out, efficient biking docks and easy credit card payments (Guo et al., 2017; Useche et al., 2019; J. Zhao et al., 2014). Thailand is adopting IT based biking too, to facilitate tourists and its own public (Islam et al., 2018).

A Korean study shows that social, physical, economic and environmental factors and perspectives are not enough to define biking trip generations, motives and barriers but there are psychological perspectives too (Kim et al., 2017). The study (Kim et al., 2017) also suggests that psychological factors can impact public bike sharing user's attitudes and revealed that environmental concerns influenced people's perception of public bike sharing. Also, that biking can be promoted by increasing awareness about the positive or negative effects of biking on the environment, in case, if there occurs no biking activity. In short, South Asian countries are pacing up to include biking in transportation planning and policies.

In general, the methodologies adopted to study biking and its determinants in the neighboring of Pakistan is through self-reported questionnaires and the results are interpreted through descriptive and statistical analysis. Most of the studies on cycling are published in social sciences literature. With the changing world and its dynamics, data collection and analysis methods are changing too. Recent studies on biking shows a variety of data collection and analysis methods. For example; (Rana et al., 2017) collected data through physical and user opinion surveys to evaluate of bicycling environment for urban mobility and analyzed data by implying situational analysis. Other than this, Castro (Castro et al., 2019) collected data through online surveys on seven different European countries to draw a difference between conventional cyclist and non-cyclist with electric bikers. In another study a descriptive analysis based study in which online surveys were used to collect data from 20 different countries including Latin America, North America and Europe (Useche et al., 2019). Kirkpatrick (Kirkpatrick, 2018) used a mixed methods approach in which in-depth telephonic interviews were conducted and ground theory was applied to conceptualize the overall research design and data analysis. The interviewers were employed through snowball and chain sampling techniques. It is a common practice to use either or both primary and secondary survey data to do detailed studies related to biking e.g. identify the demand of biking in the city. Similarly, Nawaz used secondary data and focus group through judgmental sampling technique to find motivation behind cycling in the city of Sylhet, Bangladesh, and found that health, safety, convenience and weather are the deterrent factors in biking (Nawaz, 2015).

Other than surveys and interviews, Nickkar (Nickkar et al., 2018) used GIS-based equity analysis to develop a population-density-normalized bike equity index to quantitatively assess the spatial distribution of city's bicycle infrastructure supply and how it serves the transit dependent communities. Tan (Tan et al., 2019) conducted empirical study on big data in which data was obtained from mobile phone application programming interface. The extracted data was then analyzed by using principal component analysis method to develop a neighborhood social disadvantage index with 5 sub-indices including income, housing, occupation, education, and population. Yin (Yin et al., 2018) used consumers' data to find out what can improve and facilitate promotion of bike-sharing and it was found that in addition to cultural and psychological motivations of consumers, practicing social norms is also important. Liu (Liu et al., 2016) used advance biking load prediction and optimizer algorithms to create a balance between biking demand and biking infrastructure supply (i.e. pick and drop) on the docks. In last but not least, with the varying biking conditions, policies, preferences,

perceptions, demands and determinants new methods are evolved and implied quite often. The next section explains the methodology used in this study.

3. Methodology

The methodology of the present study was designed to answer the following questions: (1) what motivates people to cycle in large cities of Pakistan and how are they defined? (2) what are the main correlates of perceived barriers of cycling in Large cities of Pakistan? And (3) what are the predictors of bike trip generation in large cities of Pakistan?

This paper presents the findings of an empirical analysis based on a data collection in Lahore, Pakistan. With 11.13 million inhabitants (2017), Lahore was taken as a representative of Pakistani large cities and also several large cities in the region. The survey was undertaken in spring 2018 by direct questioning method in several districts of the city.

After validation and data cleaning, 379 subjects remained in the sample. The interviews were conducted in three socioeconomic stratas including lower, medium, and higher, the basis of which was on accessing to different socioeconomic levels of shopping areas such as older bazaars, uptown bazaars, and pedestrian malls. The survey instrument was short so that it facilitates fast interviews with people on the streets. It contained nineteen questions, according to which seventeen categorical or binary variables and two continuous variables were developed. There were also two open-ended questions in the questionnaire that have not been involved in the present paper. In general, the individual and socioeconomic attributes as well as the preferences of people were targeted by the questions. Thus, most of the questions led to the generation of categorical or dummy variables. Even for making it more comfortable for the respondents, the question targeting their monthly income were asked in a categorical fashion. These categorical/dummy variables were location, gender, age, income, preferred mode of choice irrespective of time, knowing how to ride bicycle, commuting by bike, frequency of bike trips, barriers of biking, motives of biking, education, preferred distance to travel using cycle, preferred time to travel using cycle, preferred trip purpose to travel using cycle, purpose of majority trips, preferred mode in general, and using cycle in addition or split of other modes. The categories of the categorical variables can be observed in Fig.1. The continuous variables were household bike ownership and the number of bicycle users in household. The full details of the results of the survey have already been published in another peer-reviewed journal paper (Aslam et al., 2018).

To answer the first research question of this study about the perceived motives of biking, the variable of perceived motives of biking was taken as dependent variable, the data of which was based on the question "which of the following do you think is the leading motive to drive you to travel by bicycle every day?" and three options of affordability, reliability, and accessibility were given to the interviewees. The interviewers had already given extra oral explanation about the meaning of these options to the respondents. The affordability refers to the bearable buying and maintenance cost of the bike, reliability refers to the dependence (and trustworthiness) on bike as a mode of travel and accessibility refers to ease in approaching various land uses whilst biking. Since being informed about the importance of accessibility as a motivation for bicycling is essential for urban planning and policy making, this variable was taken as reference so that the odds of selection of the other two choices are compared to it.

For modeling this variable, Multinomial Logistic (MNL) regression modeling was employed and the first model was run using 17 variables, then the procedure was repeated by eliminating the insignificant variables one by one to reach the best model including the most significant variables. MNL was applied because of the categorical nature of the dependent variable. The modeling was undertaken 12 times and the following variables were omitted from the model: preferred mode choice, irrespective of time, biking in addition to using other modes, gender, education, age, location, number of cycle users in the household, income, preferred time to travel by cycle, preferred distance to bike, and knowing how to bike. The final model included 6

variables. In order to test the validity of the model Likelihood Ratio Test was conducted, where P-values of less than 0.05 were regarded as a significant model. The Goodness-of-Fit test results of Pearson and Deviance with P-values more than the significance level of 0.05 indicated a good fit of data and model. Finally, Nagelkerke Pseudo R^2 values were calculated to show the power of the model to predict the variance of the motives of biking.

In order to answer the second research question about the perceived barriers of biking, the outcomes of the question "what do you think are the hindrances not letting you cycle?" with six choices including health and fitness, weather and environmental conditions, culture, gender, family (travel dependent family member(s)), and non-availability of facilities (e.g. bicycle lanes, etc.) were targeted. The choice related to the family was eliminated from the model because it included few subjects. Two types of models were developed to analyze different types of barriers, firstly a model was developed for non-availability of biking infrastructures against all other choices, and the second model was allocated to issues related to culture and gender against all other options. For both models, Binary Logistic (BL) modeling was used, while the barriers in investigation (non-availability of infrastructures and culture/gender problems) were taken as reference. BL modeling was employed because of the dummy nature of the dependent variables, which was resulted after transformation of the options.

The modeling was done 13 times for the absence of biking infrastructure and the last model, including four variables produced the highest number of significant variables. The eliminated variables were respectively motives of biking, preferred biking time, preferred biking distance, income, preferred mode choice, preferred mode choice irrespective of time, bike trip generation (frequency), using cycle in addition to other modes, knowing how to bike, age, biking use for commuting, and gender. For testing the validity of the model, Omnibus Test and Hosmer and Lemeshow Test were applied, where P-values of less than the significance level of 0.05 indicated a valid model for Omnibus test and the P-values of more than this level indicated validity in Hosmer and Lemeshow Test. Like MNL model, high Nagelkerke Pseudo R^2 of the BL model showed the power of the model to predict the variance of the dependent variable.

The same procedure was applied for developing a BL model for culture and gender. Before starting to model, the two categories of perceived barriers related to culture and gender were merged into one group and other choices were transformed to one variable, so a dummy dependent variable was generated. The model reached its best performance after eliminating only four variables of the motives of biking, preferred biking trip purpose, preferred biking time, and preferred biking distance. The model validity tests applied for this model were the same as the infrastructure model.

For investigation of the bicycle trip generation or in other words frequency of bike travels, sought by the third question of this paper, the respondents were asked "what is the frequency of your cycling routine?" and they were given options: daily, weekly, monthly, occasionally, and need-based. The ordered nature of the dependent variable, ranging from daily (coded 1) to need-based (coded 5) facilitated the generation of an Ordinal Probit (OP) model (which was taken because of the ordered nature of the dependent variable). It was assumed that biking on need-based manner is scarcer than using bike occasionally. After eliminating insignificant variables, the twelfth model produced the best results. The eleven eliminated variables were respectively age, the purpose of the majority of the trips, gender, income, using cycle in addition to other modes, education, preferred distance for biking, preferred mobility mode, knowing how to bike, preferred purpose for biking trips, and the number of cycle users in the household. Omnibus Test was run to check the validity of the model, whereas P-values of less than 0.05 indicated a significantly valid model. The proportion of deviance value to degrees of freedom was calculated to test the goodness of fit, whereas ratio values of less than one indicated a good fit of data and model.

4. Analysis and results

Most of the variables of this study were categorical or dummy so the descriptive statistics of the findings related to them are illustrated in the form of frequencies and percentages in Fig.1.

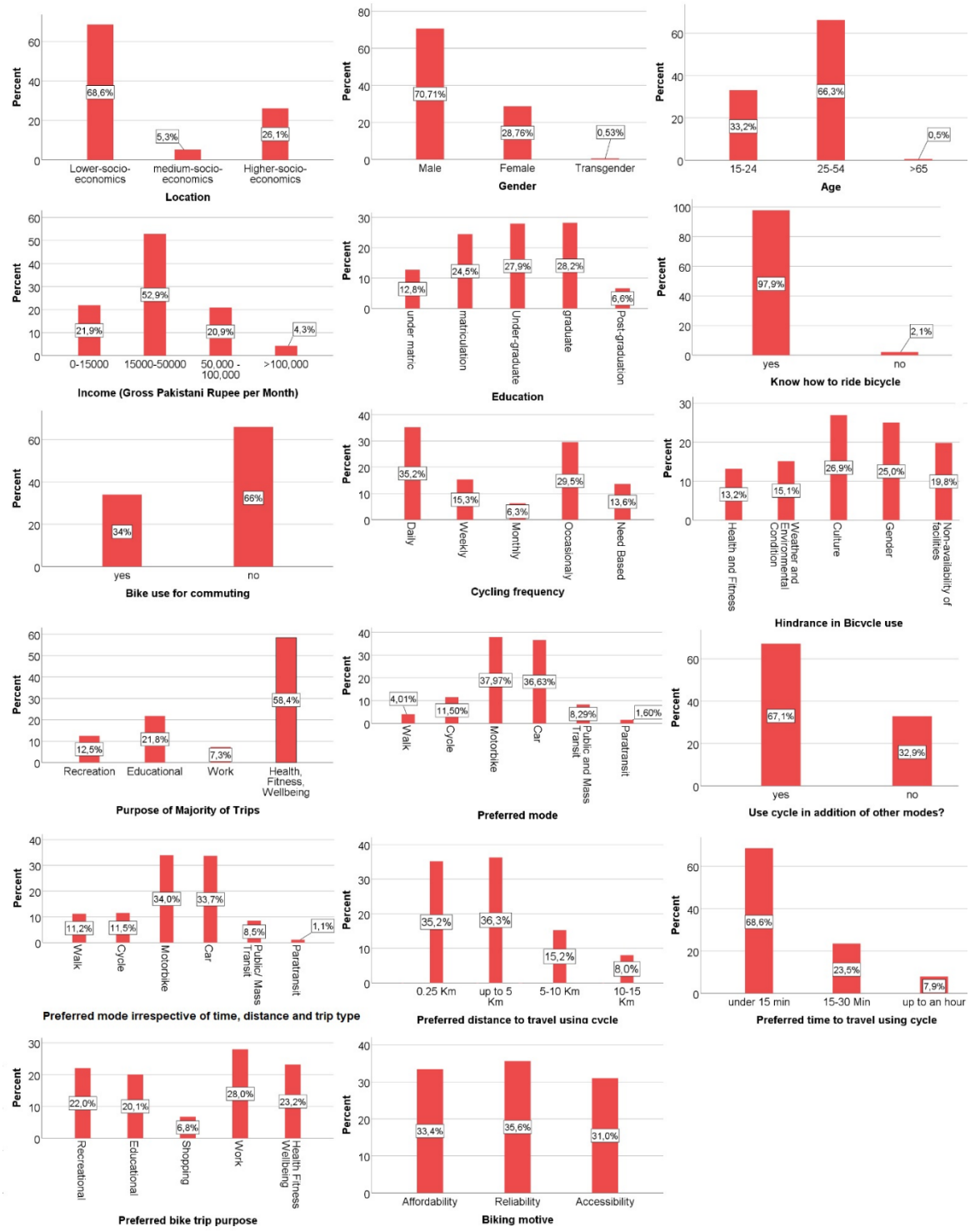


Fig.1 The frequencies of categorical variables such as age, location, gender, income, cycling frequency and preferred distance, mode and time of travel

In this study, as one of the variables under investigation was the perceived motives of biking that have been chosen by respondents almost uniformly, while accessibility has reported to be important of interviewees slightly less than affordability and reliability.

The highest frequencies of perceived barriers (hindrances) of biking are cultural issues with about 27% and gender problems with 25%, followed by non-availability of biking infrastructures with less than 20%. This is interesting that people in a city with considerably less active transportation infrastructure mention lack of such facilities as a main barrier of biking. This refers to their awareness about the necessity of facilities for improving the safety, security, and practicality of cycling. The third studied variable is bike trip generation. More than 35% of the respondents use bike in a daily manner, while less than 30% of them use it occasionally. Less than 14% of them bike irregularly and in a need-based fashion.

The respondents were mostly male (71%) and living in areas with lower socioeconomic statuses (69%). More than 66% of the respondents aged between 25 and 54 years and 53% had a gross monthly income of 15,000 to 50,000 Rupees (107€ to 356€, as of 1st of May, 2018). The most frequent education levels were related to graduates (28%), undergraduate studies (28%), and matriculation (25%).

It seems knowing how to bike is not a decisive issue in the sample as 98% of the respondents knew how to do it, indicating that the presence of the elderly or maybe some women who were less likely to not know biking is not considerable.

An interesting point shown by the descriptive findings is that two-thirds of the respondents do not bike for commuting, which shows that the bicycle has not become a serious mobility mode in Lahore. This is confirmed by the question regarding the purpose of bike trips: 58% of the bike trips are done for fitness, health, sport, or wellbeing and 13% bike for recreational purposes. The overall mode choice shares are also in line with the above: bicycle was the main choice of 12% of people, while motorbike and car were the main mode of 38% and 37% of the respondents respectively. However, the interesting point is that two-thirds of the respondents use bike in addition to other modes. The preferred mobility mode irrespective of trip time was also asked from interviewees, whereas motorbike and car were yet chosen by most of the respondents. Most of the respondents preferred to use bicycle for distances upto 5 km (36%) followed by 0.25 km (35%). Two-thirds of the respondents preferred short bike travel times of under 15 minutes. Finally, 28% of the respondents preferred to use a bike for commuting, while other non-work purposes like fitness, health, and wellbeing (23%) and recreational activities (22%) were the other important biking purposes.

4.1 Multinomial Logistic model for biking motives

While the descriptive statistics indicate slightly less importance of accessibility compared to reliability and affordability as motives of cycling in Lahore, the results of the MNL model show there are some limited numbers of significant or marginally significant correlations between choosing or not choosing a bike as a mobility mode based on priority of motives.

Choosing accessibility as the reference of the model, lets us compare the probability of biking because of priority of affordability or reliability over accessibility. The model, outlined in Table 2, shows that respondents who have chosen biking as their usual mode are considerably less likely to bike because of affordability relative to accessibility compared to those respondents who have chosen paratransit as their dominant mobility mode. Although paratransit has been taken as the reference mobility mode, it is possible to see that frequent bikers are 17% more probable to bike compared to car users motivated by the affordability of biking relative to accessibility (β=6,8E-17/4,1E-16=0.166). In other words, in comparing the biking motive of bikers with that of car users, affordability has more importance than accessibility. There are also some significant correlations in the relations between bike trip purposes. For those respondents who bike for recreational activities, it is 2% more probable to do it because of affordability rather than accessibility, compared to those who bike for fitness, health, and well-being (P=0.017).

This refers to the nature of biking for recreation and leisure, where people do not intend to reach a destination as fast and rapid as possible. The above two findings about the priority of affordability over accessibility is more understandable when we know 69% of the respondents live in districts with lower socioeconomic statuses. Finally, people whose main trip purposes are recreational are 10.6 times more likely to bike because

of reliability rather than accessibility compared to those whose main purposes are fitness, health, and well-being. This finding is marginally significant (P=0.06). Although, the model has not yielded so many significant coefficients, but it has a good Nagelkerke value of 51% (Tab.3). The model fitting criteria (P<0.001) and goodness-of-fit test results (P for deviance=0.366) show a valid model with good fit of the data. Lack of the number of significant correlations can be explained by the small difference between the number of respondents who have chosen the three biking motivations (affordability: 33%, reliability: 36%, and accessibility: 31%). In samples with more differences in the frequencies of groups, better results may be yielded.

Variables/Category	Biking Motive	B	Wald	P	β	Biking Motive	B	Wald	P	β
Household bike ownership		0.575	1.8	0.180	1.778		0.435	1.045	0.307	1.544
Bike use for commuting=yes		38.059	430.3	<0.001	3.E+16		-0.460	<0.001	1.000	0.631
Bike use for commuting=no		36.007	450.1	<0.001	4.3E+15		-1.997	<0.001	1.000	0.136
Cycling frequency=daily		0.321	0.095	0.758	1.379		-1.487	1.808	0.179	0.226
Cycling frequency=weekly		0.725	0.498	0.480	2.065		-0.430	0.163	0.686	0.651
Cycling frequency=monthly		-17.924	<0.001	0.995	1.6E-08		-1.281	1.017	0.313	0.278
Cycling frequency=occasionally		-0.021	0.001	0.982	0.979		0.072	0.005	0.942	1.075
Cycling frequency=need based		Reference					Reference			
Purpose of majority trips=recreation		0.837	0.412	0.521	2.310		2.360	3.534	0.060	10.586
Purpose of majority trips=educational		-0.092	0.013	0.909	0.912		0.734	0.69	0.406	2.083
Purpose of majority trips=work		-1.573	1.671	0.196	0.208		2.838	2.992	0.084	17.075
Purpose of majority of trips=health. Fitness. And wellbeing	Affordability	Reference				Reliability	Reference			
Preferred mode choice=walk		-35.909	785.1	<0.001	2.5E-16		-18.66	<0.001	0.999	7.9E-09
Preferred mode choice=cycle		-37.231	815.4	<0.001	6.8E-17		-0.432	<0.001	1.000	0.649
Preferred mode choice=motorbike		-37.531	1090	<0.001	5.0E-17		0.658	<0.001	1.000	1.930
Preferred mode choice=car		-35.442	913.2	<0.001	4.1E-16		2.128	<0.001	1.000	8.397
Preferred mode choice=public and mass transit		-35.324		1	4.6E-16		<0.01	<0.001	0.999	1.4E-08
Preferred mode choice=paratransit		Reference					Reference			
Preferred bike trip purpose=recreational		-3.993	5.669	0.017	0.018		-1.757	1.116	0.291	0.173
Preferred bike trip purpose=educational		-0.920	0.56	0.454	0.399		0.050	0.001	0.969	1.051
Preferred bike trip purpose=shopping		-1.939	1.672	0.196	0.144		-3.492	2.516	0.113	0.030
Preferred bike trip purpose=work		-0.750	0.406	0.524	0.472		-0.141	0.013	0.909	0.868
Preferred bike trip purpose=health. Fitness. and wellbeing		Reference					Reference			

Tab.1: Results of Multinomial Logistic model for biking motives (Reference: accessibility)

Likelihood Ratio Tests				
Effect	**Model Fitting Criteria**	**Likelihood Ratio Tests**		
	-2 Log Likelihood of Reduced Model	**X²**	**df**	**P**
Household bike ownership	167.12	2.18	2	0.336
Bike use for commuting	172.06	7.13	2	0.028
Cycling frequency	178.96	14.02	8	0.081
Purpose of majority trips	177.19	12.25	6	0.057
Preferred mode choice	205.21	40.27	10	<0.001
Preferred bike trip purpose	178.65	13.7	8	0.090
Model fitting information				
Model	**Model Fitting Criteria**			
Null	242.19			
Final	164.94	77.25	38	<0.001
Goodness-of-Fit				
Measure	**Chi-Square**	**df**	**P**	
Pearson	152.29	134	0.133	
Deviance	139.02	134	0.366	
Pseudo R-Square				
Nagelkerke	0.513			

Tab.2 Specifications of Multinomial Logistic model for commute mode choice

4.2 Binary Logistic models for perceived biking barriers

For analyzing the perceived barriers of biking, two models were generated as explained in the methodology section: once non-availability of bicycling infrastructures were taken as the reference and in the second model, cultural and gender issues were taken as reference group. In the first model, as seen in Table 4, a BL model was developed, in which people who live in districts with medium socioeconomic statuses (people who access uptown bazaars) are 13% less probable to perceive issues other than biking infrastructures as barriers of cycling. In other words, they are 13% more likely to not bike because of lack of biking infrastructures and facilities. This finding is marginally significant (P=0.076). Education including all of its groups is generally a highly significant predictor of biking barriers (P=0.002). Two of the education classes are significantly coordinated with perceived biking barriers. Having an undergraduate university education is a highly significant predictor (P=0.004). If a respondent has undergraduate education, it is 15% more likely that he/she do not bike because of unavailability of biking facilities. This means for this group of people, biking infrastructure is a more important obstacle than others. If the education is more advanced (graduate), it will be 20% more probable to not to bike because of unavailable infrastructures compared to the other reasons. This refers to the importance and effectiveness of providing biking facilities like bike tracks, routes, sharing systems, bike pools, etc. in encouraging educated people to biking. The number of cycle users in the household is also a highly significant predictor (P=0.005). One cycle user more in a household will increase the likeliness of not biking because of unavailability of facilities by 34%. A family with three cycle users is 68% more probable not to bike because of no facilities compared to a family with one biker. Finally, household bike ownership is significantly, strongly correlated with perceiving unavailable infrastructures compared to other reasons. When there is one more bike in a family, the odds of not biking because of unavailable infrastructures relative to other reasons increases 2.38 times (238%). The validity test results of this model are also seen in Table 4. The results of the Omnibus Test (P<0.001) and Hosmer and Lemeshow Test (P=0.833) both confirm the validity of the model. The model predicts about 61% of the variance of the dependent variable (Nagelkerke Pseudo R^2=0.607). By changing the reference from non-availability of biking infrastructures to a combination of cultural and gender issues, new results emerge. As seen in Table 5, location is still a decisive variable group (P=0.042), but surprisingly when people live in districts with lower socioeconomic status like areas located near to traditional bazaars accommodating poorer residents, it is less likely that people do not cycle because

of cultural and gender issues (P=0.021). This is perhaps because other barriers are even more powerful in their case. However, as expected, being male reduces the odds of not biking because of cultural and gender problems compared to other reasons (P=0.013). These problems also affect younger people aged between 15 and 24 years. When people get older and fall in the next age class, it will be 7 times more probable that they do not cycle affected by the mentioned problems. As expected, income is a significant variable group (P=0.034), three out of four variable classes of which are highly significant. The households having the first three income groups (0-15,000 Rupees, 15,000-50,000 Rupees, and 50,000 – 100,000 Rupees) are highly significantly probable to not bike because of these problems. However, there is no relation between the perceived biking barriers of families earning a gross amount of more than 100,000 Rupees per month (712.22€ as of 1st of May, 2018) and cultural and gender problems compared to other reasons. People with lower education (under matric and also those having matriculation) as well as people with undergraduate university education are significantly less probable to not bike because of these issues. Those who say they know how to bike as well as people who commute by bicycle are more likely to perceive such issues as a barrier. The respondents who bike daily, monthly, and occasionally are more likely to perceive these issues as biking obstacles. When the number of bikers per household increases, the odds of perceiving culture and gender as obstacles highly significantly decrease (P=0.007). The reason lies in the sub-culture of the families. Those who recognize biking as a legitimate and useful way of mobility, do not see culture and gender barriers of cycling. Likewise, families who possess a higher number of bikes are less likely to not bike because of these problems. This finding has marginal significance (P=0.063). The connection of education with perceptions of biking barriers is also seen in the trip purposes: the respondents whose main purpose of majority of trips is education are more probable to not bike because of culture and gender. This shows the sensitivity of university students and pupils against such obstacles. Some of the preferred mobility modes for daily trips are also connected to the perceived biking barriers. People whose preferred modes are walking, biking, motorbike, and personal car are less likely to not bike because of cultural and gender obstacles compared to other reasons. However, such a relationship does not exist between the perceptions of public transportation and paratransit users. If time element is controlled in the analysis, public transit and paratransit users will also have a negative significant correlation with not biking because of culture and gender, but instead the relation of the mode of bikers with perceiving these issues as barriers becomes insignificant. The results of the Omnibus Test (P<0.001) and Hosmer and

Lemeshow Test show that the model is valid and performs well. More than 90% of the variance of the dependent variable can be predicted by the model (Nagelkerke Pseudo R^2=0.902).

Variables	**B**	**S.E.**	**Wald**	**df**	**P**	**β**
Location			3.220	2	0.200	
Location= lower-socio-economics	-0.154	0.514	0.089	1	0.765	0.857
Location= medium-socio-economics	-2.025	1.140	3.156	1	0.076	0.132
Education			16.904	4	0.002	
Education=under matric	-0.272	0.711	0.146	1	0.702	0.762
Education=matriculation	0.091	0.678	0.018	1	0.893	1.095
Education=undergraduate	-1.884	0.654	8.305	1	0.004	0.152
Education=graduate	-1.625	0.640	6.443	1	0.011	0.197
No. Of cycle users in household	-1.069	0.384	7.752	1	0.005	0.343
Household bike ownership	0.869	0.417	4.345	1	0.037	2.384

Omnibus Tests of Model Coefficients				**Hosmer and Lemeshow Test**		
Measure	**Chi-square**	**df**	**P**	**Chi-square**	**df**	**P**
Step	92.283	9	<0.001	3.705	8	0.883

Block	92.283	9	<0.001
Model	92.283	9	<0.001

Model Summary	
-2 Log likelihood	**Nagelkerke R Square**
118.434	0.607

Tab.3 Test results of Binary Logistic regression model for perceived barriers of biking (Reference: non-availability of biking infrastructures)

Variables	**B**	**S.E.**	**Wald**	**df**	**P**
Location			6.321	2	0.042
Lower-socio-economics	12.6	5.46	5.319	1	0.021
Medium-socio-economics	-9.73	8.93	1.19	1	0.275
Gender=male	-44.8	18.08	6.137	1	0.013
Age=15-24	7.04	2.99	5.547	1	0.019
Income			8.65	3	0.034
0-15,000	-52.2	19.6	7.061	1	0.008
15,000-50,000	-74.4	25.44	8.548	1	0.003
50,000 – 10,0000	-78.59	28.1	7.822	1	0.005
Education			6.108	4	0.191
Under matric	58.78	24.47	5.769	1	0.016
Matriculation	59.95	25.46	5.546	1	0.019
Undergraduate	63.79	26.785	5.673	1	0.017
Graduate	2.22	7.88	0.079	1	0.778
Know how to ride bicycle=yes	-69.16	29.56	5.475	1	0.019
Bike use for commuting=yes	-92.33	37.58	6.035	1	0.014
Cycling frequency			9.313	4	0.054
Daily	16.41	8.97	3.347	1	0.067
Weekly	-93.58	3276	0.001	1	0.977
Monthly	31.49	12.32	6.525	1	0.011
Cycling frequency=Occasionally	52.45	19.096	7.545	1	0.006
No. of cycle users in house	7.29	2.723	7.165	1	0.007
Household bike ownership	11.22	6.047	3.445	1	0.063
Purpose of Majority Trips			4.742	3	0.192
Purpose of Majority Trips=Recreation	9.5	6.117	2.413	1	0.12
Purpose of Majority Trips=Educational	-11.09	5.431	4.169	1	0.041
Purpose of Majority Trips=Work	2.54	9.892	0.066	1	0.797
Preferred mode choice			8.713	5	0.121
Walk	102.2	42.015	5.917	1	0.015
Cycle	104	42.045	6.113	1	0.013
Motorbike	87.99	38.784	5.146	1	0.023
Car	92.2	38.329	5.787	1	0.016
Public and Mass Transit	222.6	3277.71	0.005	1	0.946
Use cycle in addition or split of other modes=Yes	-6.53	4.337	2.271	1	0.132
Preferred mode choice irrespective of time			8.341	5	0.138
Walk	55.38	21.52	6.622	1	0.01
Cycle	19.04	11.567	2.709	1	0.1
Motorbike	30.57	14.425	4.49	1	0.034
Car	43.78	17.114	6.544	1	0.011
Public/ Mass Transit	39.37	15.991	6.061	1	0.014

Omnibus Tests of Model Coefficients		**Hosmer and Lemeshow Test**		**Model Summary**				
Measure	**X²**	**Df**	**P**	**df**	**X²**	**P**	**-2 Log likelihood**	**Nagelkerke R²**
Step	132.074	33	<0.001	8	0.522	1	30.12	0.902
Block	132.074	33	<0.001					
Model	132.074	33	<0.001					

Tab.4 Results of Binary Logistic regression model for perceived barriers of biking (Reference: cultural and gender problems)

4.3 Ordinal Probit model for bike trip generation

For understanding the determinants of the number of bicycle trips generated by people in Lahore, an OP regression model was developed. The final model includes seven variable groups, including location of residence based on socioeconomic status, bike use for commuting, perceived barriers of bicycle use, preferred mode choice irrespective of time, preferred time to travel using cycle, motives of biking, and household bike ownership. Six out of seven variables kept in the final model are highly significant (P at 0.01 level), significant (P between 0.01 and 0.05), or marginally significant (P between 0.05 and 0.1). Nevertheless, not all of the categories under the significant variable groups are significant. The summary of the model indicates that people living in medium socioeconomic statuses are significantly 2.5 times more probable to generate the higher number of bike trips compared to people living in higher socioeconomic statuses (people living in wealthier areas). This finding is not only in relation to money issues, because income has not been a significant variable in the model. However, a wider range of socio-cultural and societal phenomena must be involved in this correlation. A highly significant variable in the model is biking for the purpose of commuting (P=0.005). People who use bicycle as a commuting mode are 47% less probable to generate more bike trips compared to those who do not commute by bike. This shows that biking in Lahore is highly under the influence of non-work purposes rather than commuting. Respondents who perceive gender as a biking barrier are significantly 2.16 times probable to have more bike travels compared to those who say unavailability of infrastructures cause them refrain from biking. This indicates that the effect of non-availability of biking facilities can be stronger than gender issues when we consider only bike trip frequencies. Fig.2A illustrates the descriptive relations between biking frequencies, perceived barriers of biking, and education, whereas it is observable that non-availability of facilities is more important for educated people and may cause their bike travel decrease more than other education groups. Fig.2B shows the descriptive relations between biking frequencies, biking barriers, and bike ownership. Although bike ownership is not a significant variable of the model, the diagram can give us a good image of the relation between the three variables, particularly bike trip generation and perceived barriers. As seen there, there is a consistent and continuous positive relation between biking frequencies from need-based and occasional to daily with bike ownership for people who perceive their gender as a biking barrier. This relation exists with a much steeper slope for people who perceive non-availability of biking facilities as a barrier only for the monthly to daily frequencies.

Parameter	Category	B	S.E.	Hypothesis Test			β
				Wald X^2	df	P	
Threshold	Cycling frequency=Daily	-0.709	1.199	0.349	1	0.554	0.492
	Cycling frequency=Weekly	-0.123	1.197	0.011	1	0.918	0.884
	Cycling frequency=Monthly	0.160	1.197	0.018	1	0.894	1.173
	Cycling frequency=Occasionally	1.367	1.202	1.294	1	0.255	3.925
Location =lower-socio-economics		0.169	0.282	0.359	1	0.549	1.184
Location =medium-socio-economics		0.916	0.395	5.376	1	0.02	2.499
Location =higher-socio-economics				Reference			
Bike use for commuting=yes		-0.752	0.27	7.709	1	0.005	0.471
Bike use for commuting=no				Reference			
Perceived biking barrier=health and fitness		-0.118	0.348	0.115	1	0.735	0.889
Perceived biking barrier=weather and environmental condition		-0.317	0.321	0.973	1	0.324	0.728
Perceived biking barrier=culture		0.326	0.333	0.957	1	0.328	1.385
Perceived biking barrier=gender		0.771	0.380	4.115	1	0.042	2.162
Perceived biking barrier=non-availability of facilities				Reference			
Preferred mode choice irrespective of time=walk		0.431	1.16	0.138	1	0.710	1.538
Preferred mode choice irrespective of time=cycle		-1.089	1.159	0.882	1	0.348	0.337
Preferred mode choice irrespective of time=motorbike		-0.021	1.126	<0.001	1	0.985	0.979

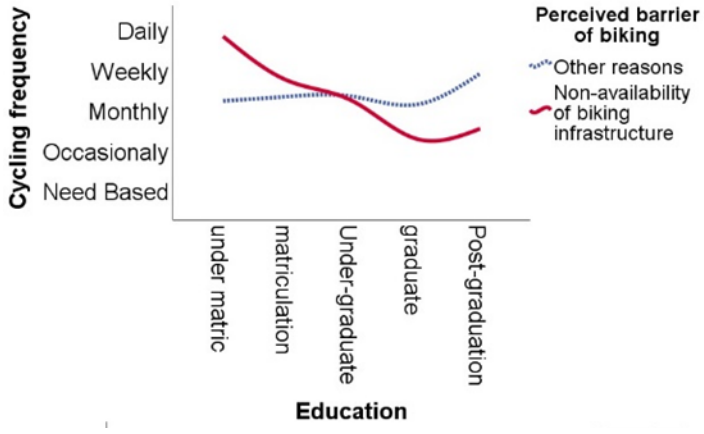
Preferred mode choice irrespective of time=car	-0.154	1.13	0.019	1	0.891	0.857
Preferred mode choice irrespective of time=public/mass transit	-0.014	1.167	<0.001	1	0.991	0.986
Preferred mode choice irrespective of time=paratransit	Reference					
Preferred time to travel using cycle=under 15 min	0.834	0.415	4.027	1	0.045	2.301
Preferred time to travel using cycle=15-30 min	0.461	0.409	1.270	1	0.26	1.586
Preferred time to travel using cycle=up to an hour	Reference					
Biking motivation=affordability	-0.227	0.277	0.674	1	0.412	0.797
Biking motivation=reliability	0.434	0.272	2.529	1	0.112	1.543
Biking motivation=accessibility	Reference					
Household bike ownership	-0.193	0.147	1.720	1	0.19	0.825

Test of Model Effects				**Goodness of Fit**			
Source	**Type III**						
	Wald X^2	**df**	**P**	**Measure**	**Value**	**df**	**Value/df**
Location	5.527	2	0.063				
Bike use for commuting	7.709	1	0.005	Deviance	296.1	419	0.707
Hindrance in bicycle use	11.822	4	0.019	Pearson Chi-Square	434.6	419	1.037
Preferred mode choice irrespective of time	14.507	5	0.013	Log Likelihood	-155.3		
Preferred time to travel using cycle	4.908	2	0.086	**Omnibus Test**			
Aspect driving using cycle	5.828	2	0.054	**Likelihood Ratio X^2**	**df**	**P**	
Household bike ownership	1.720	1	0.190	61.531	17	<0.001	

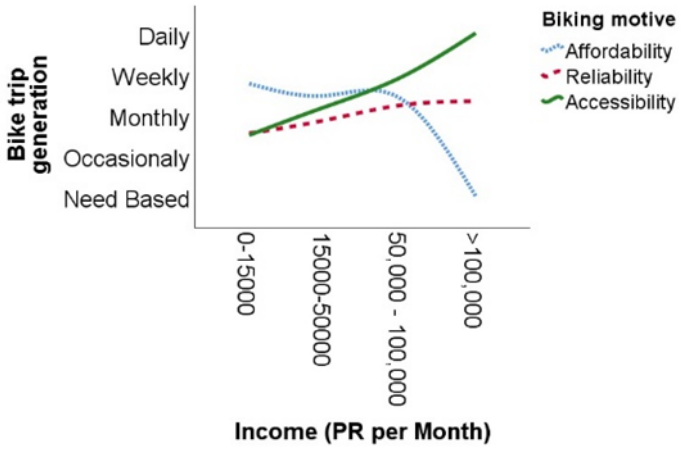
Tab.5 Results of Ordinal Probit Regression model for bike trip generation

According to the generated model, preferred biking time is also important in defining bike trip generation: people who prefer to bike in short times for each trip (under 15 minutes) are significantly 2.3 times more likely to have more bike trips compared to those who find bicycling trip times of up to an hour (P=0.045). The subjects of the sample of this study prefer to have more trips in short trip times like non-work trips around their homes rather than in long-time travels such as commuting travels. The goodness-of-fit test has yielded a deviance value divided by degrees of freedom proportion of 0.707 which indicated a valid model because it is less than 1. The results of the Omnibus Test are also in the same line (P<0.001).

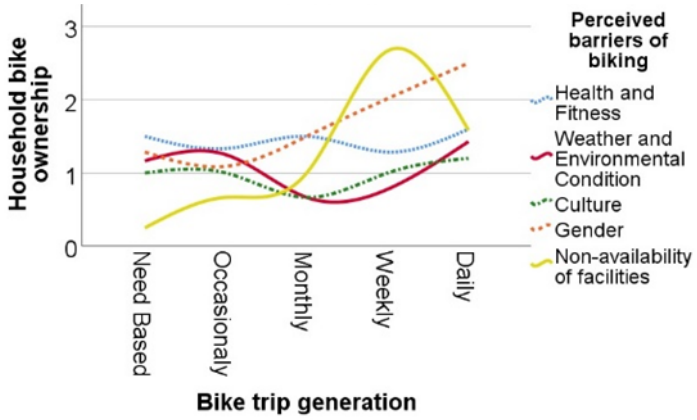
To complete the findings of the model, and to complete the findings of the statistical modeling, it can be mentioned that using accessibility for increasing the motivation of passengers to use bicycle can be used more efficiently for people with average or higher income. This can be seen in Fig.2C, where a steady positive relation can be found between bike trip generation and income for people who declare accessibility is important for their biking activity. Such behavior cannot be observed in people who are motivated by affordability and reliability.



(a)



(b)



(c)

Fig.2 (a) The relation between cycling frequency, perceived biking barriers, and education; (b) The relation between biking frequency, bike ownership, and perceived biking barriers; (c) The relation between biking frequency, income, and biking motives

5. Discussion

In terms of frequency, respondents of the study chose the motives of the biking almost uniformly and not a single motive stands out as the leading one. Reliability ranked the top most stated motive (35.6%) while the accessibility stood the least mentioned (31.0%) motive. The stats do not reflect a significant variation among the motives; nonetheless, it gives some clue regarding the reliability character of the available public mass transportation system in Lahore, which is neither efficient nor integrated (Aslam et al., 2018; Aziz et al., 2018; Imran, 2009; H. Masoumi et al.,2020). Thus, it cannot be regarded as a reliable system, which might encourage people to perceive biking as a more reliable mode of travelling for shorter distances. Our results show that people even prefer biking over paratransit modes mainly due to accessibility concerns. It is in line with the literature findings emerging from the developing countries that accessibility to neighborhood amenities (Houshmand Ebrahimpour Masoumi, 2013) and transit stations (Houshmand E. Masoumi & Mirmoghtadaee, 2016) can increase the active traveling mode trips including the biking trips. The purpose of the majority of the biking trips has been found as work (28.0%) followed by health, fitness, wellbeing (23.2%) and recreation (22.0%). Our findings draw less similarities and more differences with the findings of the studies conducted in the high-income countries. Apart from contextual variations, the other reason for having more differences with literature findings could be that this study included all types of cyclists, whereas many of the international studies have been conducted to explore the travel behaviour of a particular type of cyclists such as commuters, non-commuters, leisure based, competition/event based, females, migrants etc. However, health and fitness either remains the leading motive or one of the main motives for almost all types of cyclists in the developed countries such as in Denmark (Hansen & Nielsen, 2014), Australia (Brown et al., 2009;

Faulks et al., 2008; Zander et al., 2013), Canada (Stuckless, 2010), Germany (GIM, 2008), USA (Herman, 2015). Similar finding has also been reported by some other studies conducted in the context of developing countries such as Ho (Ho et al., 2015) investigated the motives of leisure and recreational cycling and found the physical challenge (fitness) as the main motive among various other motivations in Taiwan. However, in an earlier study, (H. Masoumi et al., 2020) found work and education as the main motives for biking trips in Lahore, Pakistan. This shows the difference in the leading motive of cycling in high income countries as the people in developed countries use cycling as a mode of active transportation for fitness and physical exercise, while in the context of developing countries, the main motives rest with work and education as compared to health concerns. Other leading motives of cycling in high income countries have been found as reduced costs (Hansen & Nielsen, 2014; Jones & Ogilvie, 2012), and economy (Barajas, 2016; De Souza et al., 2014; Sahlqvist & Heesch, 2012). All of these mentioned motives can be grouped in the category of affordability. After affordability, the other important motive reported for cycling in high income countries is accessibility or convenience (Broache, 2012a; Heesch & Sahlqvist, 2013; Izadpanahi et al., 2017; Jones & Ogilvie, 2012). Lesser studies have reported reliability (Barajas, 2016; Jones & Ogilvie, 2012) as the main motives of biking in the developed world. This shows a difference with our finding where people regard reliability more as compared to other motives of biking in Pakistan. This also provides an insight to the public mass transport system in the developed world which people generally perceive as reliable in comparison to other parts of the world. This contextual difference may make up the people in the developed world less considered with the motive of reliability for biking.

This study reports cultural issues as the leading barrier (26.9%) towards cycling in Pakistan followed by gender issues (25.0%) and non-availability of biking related facilities, mainly the infrastructure (19.8%). This finding is in conformity with some other studies conducted in the developing world, such as Masoumi (2019) also found sociocultural issues and absence or lack of biking infrastructure as the main barriers of biking in the cities of Tehran, Istanbul and Cairo. However, this finding is in contrast with the results coming from high income countries. As we have seen that the motives of affordability and reliability are more stated as compared to the motive of accessibility and the purpose of majority of biking trips is work based commuting, cycling, is generally regarded as a travelling mode for poor in Pakistani society. With that general societal mind-set, cultural issues pose a serious hindrance towards cycling practice by middle and upper income classes, however, lower socioeconomic groups perceive cultural issues less as a barrier as it is depicted by our results. Bauman (A. E. Bauman et al., 2008) also reported cultural and social factors as the barrier to cycling in Australian context but with a different interpretation. They referred to the works of Estabrooks (Estabrooks et al., 2003), Popkin (Popkin et al., 2005) and Kavanagh (Kavanagh et al., 2007) to describe it as the reduced access of lower socioeconomic areas to biking supported environment. A similar finding has also been emerged in the context of England, where Christie, (Christie et al., 2011) found environmental and social factors as barriers to cycling for children living in disadvantaged areas. However, our results show that these are the medium socioeconomic areas who perceive non-availability of the supporting infrastructure more as a barrier compared to lower socioeconomic areas. This could because of the reason that biking infrastructure in Pakistani cities is almost non-existent and situation is alike in almost all urban places. Thus, people belonging to better socioeconomic areas and having better educational levels perceive non-availability of biking infrastructure more as a barrier. Nasrudin (Nasrudin, 2014) also reported unsatisfactory cycling tracks as one of the barriers in Shah Alam city of Malaysia. Similarly, the second most stated barrier came out as gender issues, which shows female dependency on the male companions for travelling in Pakistani society thus restricting half of the population not to cycle independently. Though a good portion of female car drivers can be seen on urban roads (Masood, 2018), it is difficult to spot female cyclists due to that reason. These leading barriers are context specific and in contrast with the findings of the studies conducted in the developed world. The third most stated barrier of non-availability of the infrastructure and services is one which finds similarity with the findings of studies conducted in the high income countries such as (Bauman et al., 2008; Biernat et al., 2018;

De Souza et al., 2014; Iwińska et al., 2018; Mackie, 2009; Manaugh et l., 2017; Rijsman et al., 2019) that found infrastructure related concerns as the main barrier/one of the main barriers towards cycling. Some studies also reported weather such as (Broache, 2012b; Fowler et al., 2017; Iwińska et al., 2018; Swiers, Pritchard, & Gee, 2017) as the main barrier towards cycling, which has also been emerged in our study, though its frequency has been found lesser as compared to other reported barriers.

Our results show that the majority of the biking trips are generated on a regular basis (56.8%) while the remaining biking trips are irregularly generated. The leading majority of the trips are generated daily (35.2%). Medium socioeconomic areas are 2.5 times more probable to generate the biking trips as compared to high income areas. People living in high income areas generally possess a high education level as compared to lower socioeconomic areas and our finding from binary logistic model reveals that as the education level rises, people perceive non availability of infrastructure as the main barrier towards biking. Also, our ordinal probit model reveals that people who perceive gender issues as the main barrier to cycling are 2.16 times more probable to bike as compared to people who reported no biking infrastructure as the main barrier. As there is not much difference in the available biking infrastructure across various socioeconomic areas in Pakistani urban places, the difference in education levels across different socioeconomic areas can explain the higher trip generation from medium socioeconomic areas. Another important finding is that the non-commuters are more probable to generate biking trips. More than two thirds of all cycling trips are non-work based. This finding is in similarity with the figures reported in Germany. GIM (GIM, 2008) reported that for all the work based trips, only 16% commuting to work trips are made by bicycles in Germany even though about half of all Germans (49%) use a cycle in their everyday life. Overall, the biking trip frequency is also decreasing in some parts of the developed world as in the UK, cycling trips accounted for only 1% of all trips in 2002, which accounted for 37% of all trips made in 1949 (Horton, 2016). However, there are differences in literature findings as well for other high income countries. Australian Bureau of Statistics (Statistics, 2007) reported the strongest growth of work based biking trips in the Australian capital cities during a period 2001-06, which experienced an increase of 28.9% work based biking trips during the period. It has also been depicted that travel time of 15 minutes by using cycle is significantly positively associated with the generation of biking trips. It means longer travel time (and distance) will be a barrier towards cycling trip generation. This is in accordance with the German case, where GIM (2018) reported top most barriers towards cycling as very long travel distance (44%) and very long travel time (43%). Damant and other researchers (Damant-Sirois & El-Geneidy, 2015; Estabrooks et al., 2003) reported safety, cost, convenience, and flexibility as the main predictors of cycling frequency in Montreal, Canada whereas our model displays location, travel attitude, gender and travel time as the main predictors of the biking trip generation which shows the differences based on contextual variations.

A few very important insights have been emerged in our study. For example, this study, being quantitative in nature, didn't offer much room to investigate about safety aspect in detail. More qualitative studies in future can be done to dig up deeper this aspect of urban travel behavior. Also, the results of this study are specific to a mega city of Pakistan (population more than 11 million) which might not be the same for intermediate and smaller cities of Pakistan. The results, though important for the urban and transportation planners, and policy makers alike, are not generalizable for other urban parts of the country.

6. Conclusion

The previous research on biking enlightened that there is no definite answer to date to understand how people can be encouraged to bike as it varies from regions, cultures, personal characteristics. Therefore, this research focused on the motives and barriers behind biking as the preferred mode in low-income countries, while studying Pakistani context using Logit and Probit models. This research based on primary data collected through direct questioning method and were conducted in three socioeconomic status. The outcome of research identified barriers of biking as cultural issue, gender problem and non-availability of biking

infrastructure and respondents weighted these almost uniformly. When, non availability of biking infrastructure was taken as reference in Binary Logistic model over cultural and gender issues, then it showed that there will be more biking trips with the provision of biking infrastructure (i.e. 13%). Whereas motives of biking labeled as reliability, affordability and accessibility while modeling the data these motives did not show any much variation in frequency and reliability ranked highest (35.6%) and accessibility lowest (31.0%). Nevertheless, further analysis showed that people even prefer biking over paratransit modes mainly due to accessibility concerns and the purpose of majority of biking trips has been found to work followed by health, fitness, wellbeing and recreation. The barriers of biking varied from education level to socioeconomic group. This research has discussed the motives and barriers using models in details and it provides substantiate material to guide policy makers to promote greener modes of transport i.e. biking in low income countries.

This study has included all types of cyclist for exploring the motives and barriers of biking. There is a need to conduct studies on a particular type of cyclist i.e. commuter, non-commuters, leisure based, event based, gender etc. Further, safety factor has not surfaced much in the present study, therefore, it is suggested that future research on this subject should explore this factor in details in relation to motives or barriers of biking in developing countries. Another feature of this research is that it is conducted in a mega city with a population of around 11 million. Thus, the results cannot be firmly extrapolated for medium and smaller cities. Consequently, in future such studies also need to be carried out in medium and smaller cities with similar research settings.

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