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Non-motorized commuting behavior of middle-income working adults in a developing country

Khatun E Zannat

Doctoral Researcher, Choice Modelling Centre, Institute for Transport Studies, University of Leeds, LS2 9JT, United Kingdom, Email: tskez@leeds.ac.uk

Assistant Professor, Department of Urban & Regional Planning, Chittagong University of Engineering and Technology (CUET), Chittagong - 4349, Bangladesh

K.M. Ashraful Islam

Lecturer, Department of Urban & Regional Planning, Chittagong University of Engineering and Technology (CUET), Chittagong - 4349, Bangladesh; Email: ashraful.cuet.bd@gmail.com

Dewan Salman Sunny

Graduate Planner, Department of Urban & Regional Planning, Chittagong University of Engineering and Technology (CUET), Chittagong - 4349, Bangladesh; Email: u1405006@student.cuet.ac.bd

Tabassum Moury

Graduate Planner, Department of Urban & Regional Planning, Chittagong University of Engineering and Technology (CUET), Chittagong - 4349, Bangladesh; Email: mourytabassum@gmail.com

Rajsree Das Tuli

Graduate Planner, Department of Urban & Regional Planning, Chittagong University of Engineering and Technology (CUET), Chittagong - 4349, Bangladesh; Email: rajsreetuli04@gmail.com

Ashraf Dewan, PhD

Senior Lecturer, Spatial Sciences Discipline, School of Earth and Planetary Sciences (EPS), Curtin University, Perth, Western Australia 6102, Australia; Email: A.Dewan@curtin.edu.au

Mohammed Sarfaraz Gani Adnan, PhD*

Researcher, Environmental Change Institute, School of Geography and the Environment, University of Oxford, South Parks Road, OX13QY Oxford, United Kingdom; Email: mohammed.adnan@oriel.ox.ac.uk

Assistant Professor, Department of Urban & Regional Planning, Chittagong University of Engineering and Technology (CUET), Chittagong - 4349,

**Corresponding author at: Mohammed Sarfaraz Gani Adnan; Environmental Change Institute, School of Geography and the Environment, University of Oxford, South Parks Road, OX13QY Oxford, United Kingdom; mohammed.adnan@oriel.ox.ac.uk*

Abstract

Although non-motorized transport (NMT) offers economic, environmental, and health benefits to individuals and communities, understanding non-motorized travel behavior is a challenging task due to complex interactions of a wide range of factors. Whilst behavioral models offer a conceptual framework to understand human behavior, their use in the study of travel behavior in developing countries is still in its infancy. This study uses three behavioral models — the theory of planned behavior, the theory of triadic influence, and the ecological model of health behavior— to identify potential factors influencing intentions and behavior toward the use of NMT by middle-income working adults, inhabiting Chittagong City Corporation (CCC) area of Bangladesh. A total of 720 middle-income working adults (aged between 18 and 65 years) was randomly selected and interviewed at major commercial and retail business areas of the CCC. Multiple linear and binary logistic models were developed to quantify the extent of the influence of different factors on non-motorized mode choice behavior. Results indicated that personal factors (proximal) such as attitude, subjective norm, and behavioral control influence respondents' intentions and motivation in choosing NMT. However, the current use of NMT was less controlled by intention, while factors associated with the social, cultural, and built environment had (distal) significant influence. The findings of this study could assist urban planners in adopting structural and non-structural measures to promote NMT use.

Key words: Non-motorized transport; travel behavior; behavioral model; commuting; developing countries.

1. Introduction

A large number of cities have become automobile-dependent, both in developed and developing countries, evidently threatening environmental well-being (Clarke and Mcip 2008; Hook and Replogle 1996; Kenworthy and Laube 1999). The transport sector reportedly contributes to 25% of total greenhouse gas emissions (a major contributor to global warming). Since the beginning of the 21st century, on average, the annual rate of carbon dioxide emission from the transport sector has been estimated to be 1.5% (Black 2010). This sector is an integral part of urban life, determining the economic growth of a city (Moore and

Pulidindi 2013). To ensure a balance between urban development and environmental sustainability, finding an alternative mode of transport is essential for city planners and transport engineers (Baltes 1996; Guo et al. 2007).

Non-motorized transport (NMT) is widely recognized as being an environment-friendly mode of transport that offers economic, environmental, and health benefits (Khan et al. 2014). Along with an improved public transport system, promotion of NMT could increase physical activities, leading to health benefits to urban dwellers (Ermagun and Levinson 2017), reduce car use, air pollution, and congestions (Bopp et al. 2015; Lachapelle et al. 2011; Pérez et al. 2017). The NMT system requires less road space, hence a lower level of investment, compared to motorized transport (MT) system (Ahsan and Sufian 2014). Despite NMT provides multiple benefits, this form of transport generates a small proportion of the total trips in different countries (e.g., 8.1% in the US cities, 15.8% in Australia/New Zealand cities, 10.4% in Canadian cities, 31.3% Western European cities, and 28.5% in high-income Asian cities) (Baltes 1996; Bopp et al. 2015; Droege 2008; Kaczynski et al. 2010) and is often marginalized compare to other transport modes (Gouda and Masoumi 2017). Various studies demonstrated that an increase in automobile-dependent short-distance trips could lead to a reduction in the use of NMT (Caspersen et al. 2000; Cohen et al. 2014; Davis 2010; Gordon-Larsen et al. 2005). In developing countries, NMT accommodates a greater number of passengers and goods than MT (Hossain 1996) and generally influences the informal labor market, supporting the livelihood of numerous marginalized people (Hasan and Dávila 2018). Nevertheless, transport planning policies in contemporary cities, particularly those in developing countries, are predominantly based on MT (Hasan and Dávila 2018). Understanding travel behavior is therefore important to promote NMT in different cities (Kerr et al. 2010).

Travel behaviors are usually studied using theories from psychology, social science, and urban studies (Cerin et al. 2006; Chaney et al. 2014; de Bruijn et al. 2005; Feuillet et al. 2015; Hess et al. 2017; Muñoz et al. 2016; Saelens et al. 2003). Among different theories or models, the theory of planned behavior (TPB) (Ajzen 1991), the theory of triadic influence (TTI) (Flay and Petraitis 1994), the ecological model of health behavior (McLeroy et al. 1988; Sallis et al. 1997), social ecology (Stokols 1992), and social cognitive (Bandura 1999) theories are widely used to understand travel behavior. The TPB is an extension of the reasoned action theory. According to the TPB, human behavior is driven by a combination of intention, occasion, situation, and forms of action. The theory further states that perceived behavioral control (e.g., confidence in one's ability) influences behaviors, which was termed as a concept of perceived self-efficacy. Perceived behavior control can directly explain behavioral achievements. However, the extent of the influence of intention or behavioral control on human behavior is contextual. The intention is dependent on three independent psychological or proximal determinants: attitude toward that behavior, subjective norm, and perceived behavioral control. The relative importance of each independent latent variable depends on the behavior and situation (Ajzen 1991). On the other hand, the TTI was developed to understand health behavior (e.g., smoking, snacking). Similar to the TPB, the TTI also considers personal behavioral intention (proximal factors) as an indicator of behavior. However, cultural origin, social situation, and inherited disposition influence individual attitude, social norms, and self-efficacy. Hence, the TTI additionally considers background or distal factors such as socio-cultural and environmental features to explain behavior (Flay and Petraitis 1994). According to the ecological model, intrapersonal (e.g., biological, psychological), interpersonal (e.g., social, cultural), communal and physical environmental factors, and planning decisions influence individual behavior (Sallis et al. 2008). The forerunner of the ecological model was Urie Bronfenbrenner (McLeroy et al. 1988). According to Bronfenbrenner's model, behavior is affected by multiple levels of influence. From socio-ecological perspectives, the well-being of people is more dependent on the social plus physical environment along with their attributes. Therefore, unlike behavioral models that focused primarily on individual and social factors, the ecological model reinforces the importance of understanding the complex nature of the environment encompassing the community and incorporates multiple levels of analysis to understand dynamic interrelations between people and the environment (Sallis et al. 2008). Several studies used explicit assumptions of these behavioral theories to explain non-motorized travel behavior, and provided insights on factors, influencing travel behavior (Cerin et al. 2006; Chaney et al. 2014; de Bruijn et al. 2005; Hess et al. 2017; Kerr et al. 2010; Saelens et al. 2003). However, most of the existing studies are focused on the contexts of developed countries such as those are in Europe and the USA. The use of behavioral models in understanding the travel behavior of commuters in developing countries is still in its infancy.

Individual travel behavior primarily depends on personal, psychological, social, and environmental factors. Generally, factors associated with the built environment have a greater influence on non-motorized travel behavior compared to different individual targeted interventions (e.g., capacity building program, social movement) (Baltes 1996; Craig et al. 2002; Feuillet et al. 2015; Frank et al. 2004; Zannat et al. 2020). Urban building density, population density, land use diversity, and design, destination accessibility, and access to transit are common indicators of the built environment, empirically proven as significant indicators of travel demand (Cervero and Kockelman 1997; Ewing and Cervero 2010). According to Baltes (1996), the use of NMT depends on personal preferences that are influenced by factors within and outside of personal control. For example, Bopp et al. (2011) reinforced that a combination of individual (eco-friendly attitude) and built environmental factors are associated with active travel (a form of NMT). Together, the social environment of the workplace (such as the relationship with colleagues) can also influence non-motorized mode choice behavior. Individuals' lifestyle, perception of safety and comfort of using NMT, awareness about the benefits of non-motorized travel, travel time and reliability, and individual capabilities to travel by NMT can also be related to non-motorized travel behavior (Muñoz et al. 2016). However, the degree of influence of different factors on non-motorized travel behavior is contextual. For instance, when people live in a place with adequate physical facilities, individual factors (e.g., self-efficacy, perceived benefits) influence travel behavior greatly than physical factors (e.g., accessibility to a destination, physical facilities) (De Geus et al. 2008). The purpose of travel determines the level of influence of physical and social environments on individual travel behavior. For example, an improved physical environment positively influences non-motorized travel for commuting purposes, while both physical and social environments influence non-motorized trips related to recreational purposes (Hess et al. 2017; Hoehner et al. 2005). Since a wide range of factors is associated with non-motorized travel behavior, a positive association of one factor in a context does not essentially indicate a similar relationship in other contexts. Therefore, it is necessary to understand the synergies among diversified factors to identify the optimum set of interventions to promote non-motorized travel in different contexts.

The purpose of this study is twofold. First, this study tested how well various behavioral models (Figure 2) explain NMT commuting travel behavior of people of a developing country. Second, this study identified potential factors influencing peoples' intentions and behavior toward the use of NMT. It focused on middle income working adults, inhabiting the Chittagong City Corporation (CCC) area of Bangladesh. Bangladesh is one of the developing countries, facing multiple challenges due to a lack of adequate and proper planning. Major cities of the country are characterized as 'low per capita Gross Domestic Product (GDP) NMT dominant cities' (Hook and Replogle 1996), facing rapid motorization to meet mobility demands of a rapidly growing population. Developing a guideline for promoting NMT in Bangladesh is a challenging task, due to a lack of empirical data and evidence-based study. The outcome of this study is expected to provide information to predict latent motorized/NMT demand, which could help to promote the use of NMT for commuting purposes.

2. Methodology

This study was conducted in four stages. First, a conceptual framework was developed based on the assumptions of three behavioral theories. They are the theory of planned behavior (TPB), the theory of triadic influence (TTI), and the ecological model of health behavior. Second, different factors influencing non-motorized travel behavior were consulted to prepare a questionnaire. Third, a semi-structured questionnaire survey was conducted to collect information on different aspects of the travel behavior of the target group. Finally, the conceptual framework was evaluated by developing statistical models that estimated the extent of the influence of different factors on non-motorized mode choice behavior.

2.1. The study area

Chittagong City Corporation (CCC) is located in the southeastern region of Bangladesh (Figure 1). It is the second-largest city and the commercial capital of the country. About 4 million people inhabit within 177 km^2 area of CCC. The administrative area of CCC is divided into 41 wards (smallest administrative unit) (Zannat et al. 2019). Like other major cities of the country, Chittagong city is growing at an alarming rate, fueled primarily by rural-urban migration. The city was ranked as the tenth fastest-growing city in the world in 2010 (Mia et al. 2015). In this city, NMT represents walking, cycling, rickshaw, rickshaw van, and pushcarts, where rickshaw and rickshaw van are propelled by manual pedaling. Transport policies adopted in CCC mainly focus on promoting motorized transport, especially private automobiles. For example, major policies in the 'Long-Term Development Strategy (LTDS) for Traffic and Transportation in Chittagong' include widening of existing roads, as well as constructing new roads, while rehabilitation or construction of pedestrian pathways was given less priority (Zannat et al. 2019). As a result, automobile dependency has been increasing, resulting in traffic congestion, environmental pollution, road crashes, and aesthetic degradation (Shamsher and Abdullah 2013). Despite different environmental and health benefits associated with the use of NMT, little attention has been given to promote this sector in CCC.

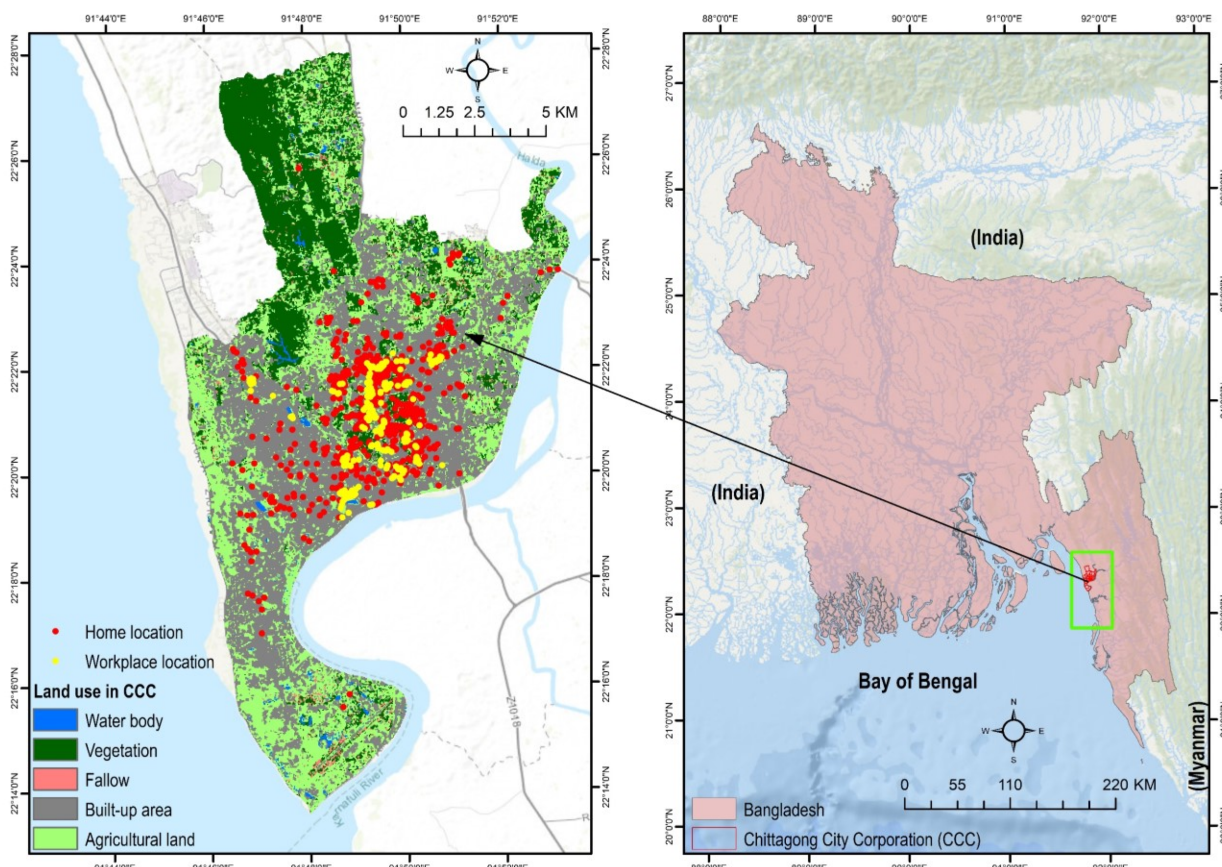

Figure 1. Location map of CCC in Bangladesh, showing the origin-destination of the respondents and land use categories of the study area. [Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community; land use data from Abdullah et al. 2019.].

In this study, middle income working adults were selected as the target group to understand the trade-off between motorized and NMT use. In Bangladesh, 50% of the total population are middle-income people (average monthly income approximately 25,000 Bangladeshi Taka, BDT), with 40% belong to the lower-income group (average monthly income ≤10,000 BDT) and the remaining 10% are the higher-income group (average monthly income approximately 150,000 BDT) (Rahman 2016). Unlike other income groups, middle-income working adults of Bangladesh shows heterogeneous mode choice behavior, as they use various combinations of MT and NMT. On the other hand, private cars are the primary mode of transport for the higher-income group, while the lower-income group is predominantly dependent on foot. Due to limited public transport service coverage, middle and lower-middle-income groups are dependent on different forms of NMT. The majority of people in CCC use a combination of public transport and NMT as their primary mode of travel (CDA 2009; Zannat et al. 2019). Therefore, understanding the impact of potential factors (except income) influencing NMT use of middle-income working adults may provide useful insights into the city planning.

2.2. Developing a conceptual framework

To understand the NMT commuting behavior of middle-income working adults, a conceptual framework was developed, based on the assumptions of three behavioral theories noted above, along with the concepts of microeconomics. It was assumed that (i) individual commuters tend to behave in a way that is rational and narrowly self-interested, that they aim to optimize the outcome; (ii) individuals' preference can be determined by behavioral indicators.

The TPB highlights the importance of psychological or proximal factors (e.g., attitude, subjective norm, perceived behavioral control) related to a certain behavior. Different studies used various proximal factors in explaining and predicting travel behavior (de Bruijn et al. 2005; Kerr et al. 2010). These proximal factors can be accurately assessed through direct questioning if the underlying beliefs are not the focus of a study (de Bruijn et al. 2005). With regard to this theory, this study hypothesized that the choice of commuting mode (NMT/MT) can be predicted by analyzing the users' intention which can be predicted from proximal determinants. Although the significance of psychological factors in understanding non-motorized travel behavior is highlighted in several studies, de Bruijn et al. (2005) found a relatively lower influence of psychological factors in understanding travel behavior compared to other health-related behavior (e.g., snacking behavior). The theory does not focus on external factors such as sociodemographic variables, social and cultural context, which may influence non-motorized mode choice behavior. According to the TTI, external or distal determinants of health behavior can be divided into three categories: cultural environment, social environment, and individual factors. This study assumed that distal determinates from triadic influence affect non-motorized travel behavior. The importance of individual factors is commonly examined in travel behavioral studies (Handy and Xing 2011; Ogilvie et al. 2008; Simons et al. 2017; Titze et al. 2007). This study considered the association between socio-demographic factors (e.g., age, gender, education, car ownership) and non-motorized mode choice behavior of commuters. Also, the importance of social environment and cultural environment (e.g. religion and ethnicity) was highlighted in similar studies (De Geus et al. 2008; Hess et al. 2017; Titze et al. 2007; Van Cauwenberg et al. 2012). Although de Bruijn et al. (2005) considered that the physical environment is part of the social environment, this study separated them to make the conceptual model more comprehensive and adaptable in the context of developing countries to predict travel behavior. This is because, unlike other human behaviors, the physical environment plays an important role in understating commuters' travel behavior.

The ecological models emphasize the importance of environmental context and consider that human behaviors are affected by multiple levels of associated factors. The multiple levels of factors signify the importance of factors related to the individual (e.g., socio-economic and attitudinal factors), physical environment (e.g., both natural and built environmental factors), and social environment. The social environment and individual factors are highlighted in the previous two models. The influence of built environment factors (e.g., land use, density, organization of destinations and accessibility, walkability) and their spatial organization (e.g., at the street, neighborhood, and city scales) were also examined in several studies to understand the use of NMT (Craig et al. 2002; Feuillet et al. 2015; Feuillet et al. 2016; Owen et al. 2004). However, the influence of different built environment factors is context-dependent, therefore, their influences could vary according to different socio-economic settings (De Geus et al. 2008; Handy and Xing 2011; Zhang et al. 2014). This study assumed that both social and built environment factors influence NMT use for commuting purposes.

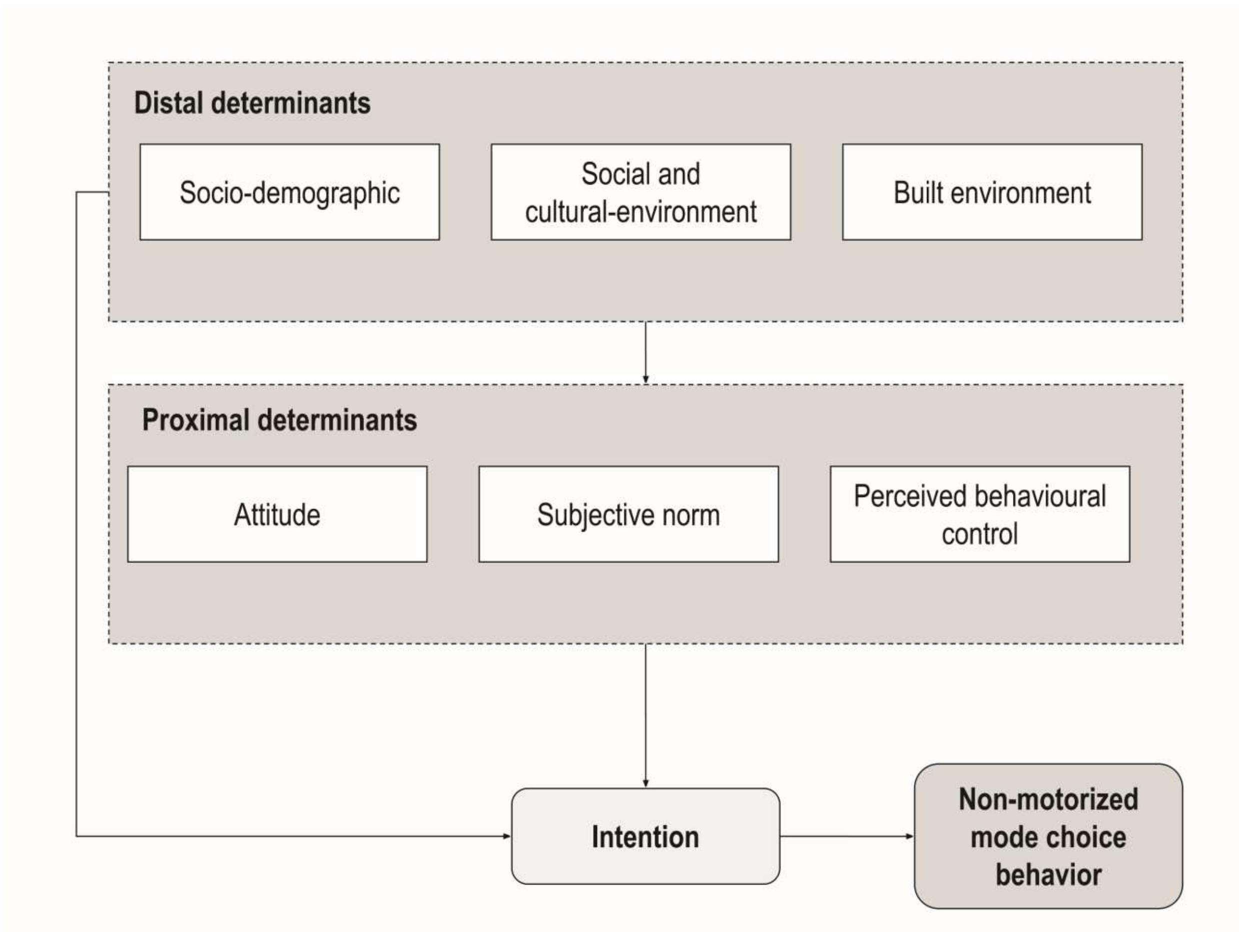

Figure 2. Conceptual framework. (Data from de Bruijn et al. 2005.)

2.3. Questionnaire design

A questionnaire was designed to collect information on middle-income commuters' travel patterns, their attitude towards NMT use, and their perception of existing en-route NMT facilities. Several studies were reviewed to develop the questionnaire (Table 1 and Table 2). Information on the type of modes (walking, cycling, rickshaw, bus, car, CNG autorickshaw (a form of autorickshaw powered by Compressed natural gas (CNG)), human hauler, and motorbike was collected that respondents had been frequently (at least 3 working days in a week) using for commuting purposes (Gondo 2010). Figure 4 (in Appendix) shows photographs of different transport modes available in the study area. The choice of modes was categorized into two classes: non-motorized (walking, cycling, rickshaw) and motorized (bus, CNG autorickshaw, motorbike) modes. The respondents were asked whether they intend to walk, cycle, and use rickshaws for work trips in the future. The responses were provided on a relative scale of 1 (never) to 5 (always).

Following the conceptual framework, we selected 25 independent variables, grouped under two categories: distal and proximal determinants. Distal determinants included information related to the social and cultural characteristics of the respondents, as well as, built environment characteristics of the en-route from home to workplace. As shown in Table 1, several questions were asked to explain each distal determinant. A single response can be unreliable as misleading a statement or placing a checkmark in the wrong place can result in incorrect responses. On the contrary, multiple items have a little systematic impact on the overall score of discrete indicators — greater reliability (Ajzen 2005). To evaluate how closely related the questions were as a group, a reliability check was performed using Cronbach's alpha score (Field 2013).

Proximal determinants included information related to attitude, subjective norm, and perceived behavioral control of the respondents. Information related to different variables under proximal determinants can be obtained by asking direct questions to the respondents (de Bruijn et al. 2005). Again, several questions were asked to quantify each of the proximal determinants (Table 2).

[*insert Table 1*]

[*insert Table 2*]

Table 1 Summary of questions related to major distal determinants used in this study

Category	Variables	Description	Response Category	Questions/checklist	Reference
Biological and psychological factors	Self-efficacy	People's belief about their ability to execute a certain course of action in a given situation. People with a strong sense of self-efficacy view challenging problem as a task to be mastered.	5-point Likert scale from 1 (not confident) to 5 (confident)	• Confidence of the respondents with their ability to use NMT within CCC; • Confidence of the respondents to use NMT as part of their regular commuting trips.	(Handy and Xing 2011; Simons et al. 2017)
	Self-esteem	Opinion of people about themselves. Healthy self-esteem motivates people to feel positive about their decision.	5-point Likert scale from 1 (very low) to 5 (very high)	• Respondents' satisfaction level with their action; • Respondents' level of competence compared to their colleagues; • Respondents' level of certainty in implementing decisions;	(de Bruijn et al. 2005)
	Perseverance	The ability to stick to a plan and keep doing something despite obstacles.	5-point Likert scale from 1 (very low) to 5 (very high)	• Likelihood of success in achieving a defined goal. • Level of hard-working.	(de Bruijn et al. 2005)
Social and cultural environmental factor	Relation	Connection among people who have recurring interactions.	5-point Likert scale from 1 (very bad) to 5 (very good)	• Respondents' relationship with their family; • Respondents' relationship with their colleagues.	(de Bruijn et al. 2005; Handy and Xing 2011)

Built environmental factors	Walking environment	Perception of the existing condition of en-route built environment to facilitate various NMT-based trips.	5-point Likert scale from 1 (very bad) to 5 (very good)	En-route from home to workplace, the existing condition of (if any) • Pedestrian sidewalk; • Street furniture such as sitting arrangement, benches, shed, bin etc.; • Street-side activity such as a retail shop, restaurant; • Green element along the street; • Crosswalks/foot-over bridges; • Center island/Median/Rest point; signals and signage; streetlight; existing en-route footpath surface condition.	(Zannat et al. 2019)
	Cycling environment		5-point Likert scale from 1 (very bad) to 5 (very good)	En-route from home to workplace, the condition of (if any): • Separate cycle lane; • Cycle parking facility; • Cycle maintenance facility; • Low-cost cycle maintenance shop	(Handy and Xing 2011)
	Rickshaw facilities		5-point Likert scale from 1 (very bad) to 5 (very good)	En-route from home to workplace, the condition of rickshaw stand/park and rickshaw lane (if any)	From the authors' observation in the study area
	Management of non-motorized facilities		5-point Likert scale from 1 (very bad) to 5 (very good)	• Priority of NMT at intersections; • Traffic calming initiative (speed reduction/volume reduction); • Education and training for promoting NMT;	(Mondschein et al. 2017)

				• Law enforcement to ensure justice for NMT users	
	Safety		5-point Likert scale from 1 (very bad) to 5 (very good)	Mark your experience regarding safety (e.g., crime and traffic).	(Handy and Xing 2011; Simons et al. 2017)

Table 2 Summary of questions regarding major proximal determinants used in this study

Variables	**Description**	**Response Category**	**Question**	**Reference**
Attitude	Subjective evaluation of behaviour which is often associated with experience and upbringing.	5-point Likert scale from 1 (very bad) to 5 (very good)	Feelings about frequent use of NMT.	(Handy and Xing 2011; Kerr et al. 2010)
Subjective norms	The belief that a person or a group of people will approve and disapprove a behaviour.	5-point Likert scale from 1 (very bad) to 5 (very good)	• Respondents colleagues' perception on frequent use of NMT; • Family members' perception on frequent use of NMT.	(Kerr et al. 2010)
Perceived behavioural control	People's perceptions of their ability to perform a given behaviour.	5-point Likert scale from 1 (very low) to 5 (very high)	• Level of confidence about frequent use of NMT for future trips; • Level of success in that situation.	(Kerr et al. 2010)

2.4. Survey design

A survey was conducted in August 2018 at major commercial centers and retail business areas in CCC. The sample size was calculated using equation 1 (Israel 1992). A minimum number of respondents required at a 95% confidence level with a normal distribution response of large population size were then determined.

$$n = z^2pq/e^2 \quad (1)$$

where *n* is the minimum sample size; *z* is the z-value of given confidence level (for 95% confidence level it is 1.96); p is the estimated proportion of an attribute that is present in the population, and q is the (1-*p*) and *e* is the tolerance level (assumed as 5%).

Around 4 million people live in CCC, of which 69.8% are working adults (BBS 2018). About 2 million people are middle income working adults (as 50% of the working population is middle-income people according to Rahman (2016)). Since the population size was large, and the variability in proportion (proportion of middle-income people use NMT) was not known, we assumed $p = 0.5$ (maximum variability), and thus, q would be 0.5. Hence, the estimated minimum size of the sample was 384. While conducting the survey, about 20% of people were unwilling to respond to clarify their income range. Also, some people avoided answering certain questions. As a result, some missing information could introduce systematic bias in our results. So, a total of 720 working adults (aged 18 to 65 years) were interviewed in 41 wards (smallest administrative unit) of CCC. The authors contacted randomly selected organizations (which were the workplace of our target group) via email, phone, or in-person to organize the survey. During the survey, questions were asked in Bengali and the survey team explained each question to the respondents in non-technical language.

2.5. Analytical approaches

The conceptual framework developed in section 2.2 was tested in two steps. First, two multiple linear regression models were developed to understand intention of the respondents in choosing NMT for their near future work trips. Second, two binary logistic regression models were established to understand the respondents' non-motorized mode choice behavior. These two forms of models were developed based on the premise that intention towards the future choice of NMT is associated with the choice of modes at present (de Bruijn et al. 2005).

2.5.1. Analyzing intention of the respondents towards NMT use

Stepwise multiple linear regression models were developed, incorporating distal and proximal determinants as independent variables and intention of the respondents toward the use of NMT as a dependent variable. Since intention was measured by averaging scores of three questions (respondents' intention to walk, cycle, and use rickshaw (see section 2.3)), the dependent variable was continuous. Therefore, this study used multiple linear regression models instead of ordered logit models. To check multicollinearity among independent variables, the variance inflation factor (VIF) of selected independent variables was estimated (Midi et al. 2010), using the package 'car' of R statistical package (Fox et al. 2018). The VIF determines the degree of variance if estimated coefficients were inflated by multicollinearity. The values exceeding 2.5 create a concern for the model, while a value greater than 10 indicates multicollinearity (Midi et al. 2010). Independent variables with a VIF value of <2 were selected for the final model. Since 'distance from home to the workplace' and 'average travel time required to reach workplace' variables were highly correlated, only the travel time variable was included in the model. Also, variables that had unacceptable α coefficients (i.e., values below 0.50) were excluded during model development (e.g., self-esteem and perseverance). The multiple linear regression model explains the relationship between two or more predictors and a dependent variable by fitting a linear equation to observed data. Each value of independent variable X is associated with a value of dependent variable y as in equation 2.

$$y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots \beta_n X_n + \varepsilon \tag{2}$$

where y is the mean value of intention to use NMT for a future work trip; X is different distal and proximal determinants; n is the number of independent variables (22); $\beta_1, \beta_2, \ldots\ldots, \beta_n$ are the regression coefficients; β_0 is the intercept; ε is the random error in prediction or residuals.

2.5.2. Analyzing non-motorized mode choice behavior

To identify factors influencing the current mode choice behavior of the respondents, binary logistic regression models were developed. Based on the assumption of the conceptual model, an iterative process was applied to select an optimum number of variables according to their order of importance. Instead of using stepwise methods (forward and backward), a manual procedure was deemed useful that highlighted the contribution of each predictor to the models. In addition, this procedure helped to avoid overfitting or underfitting the models (Field 2009).

The models incorporated the choice of binary modes (motorized and non-motorized) as a dependent variable and distal and proximal determinants as independent variables. Again, multicollinearity was diagnosed among 26 explanatory variables (including intention as an independent variable) by estimating the VIF. Variables with unacceptable α coefficients (e.g. self-esteem and perseverance) were excluded during model development. A total of 25 independent variables were incorporated into the models. To estimate the influence of distal determinants considered in the conceptual model, only distal determinants were incorporated in the first model. In the next step, three proximal determinants and the variable 'intention' were included along with distal determinants in the second model.

The regression coefficients and p-value of independent variables as well as the R^2 value of the model were then estimated. Derived regression coefficients were incorporated in the following equation:

$$p = 1/(1 + e^{-z}) \quad (3)$$

where probability (p) ranges from 0 to 1 on an S-shaped curve, explaining the likelihood of an individual to choose NMT for commuting purposes. The linear combination of independent variables z is estimated using the following equation:

$$z = b_0 + b_1x_1 + b_2x_2 + \cdots + b_nx_n \quad (4)$$

where b_0 is the model intercept, b_i (i = 1, 2, ..., n) indicates the regression coefficients of independent variables, and x_i (i = 1, 2, ..., n) represents the value of 25 variables. The logistic regression model also provides a log distribution which is also called logit. Logit is generally explained by the odds ratio which means the likelihood of an independent variable to be the member of a target group of dependent variables (Field 2013).

3. Results

3.1. Travel characteristics of the respondents

Most of the respondents used bus as their primary mode for commuting (Figure 3). About 22.7% of the total work trips were on foot. The proportion of cycle users was the least compared to other modes.

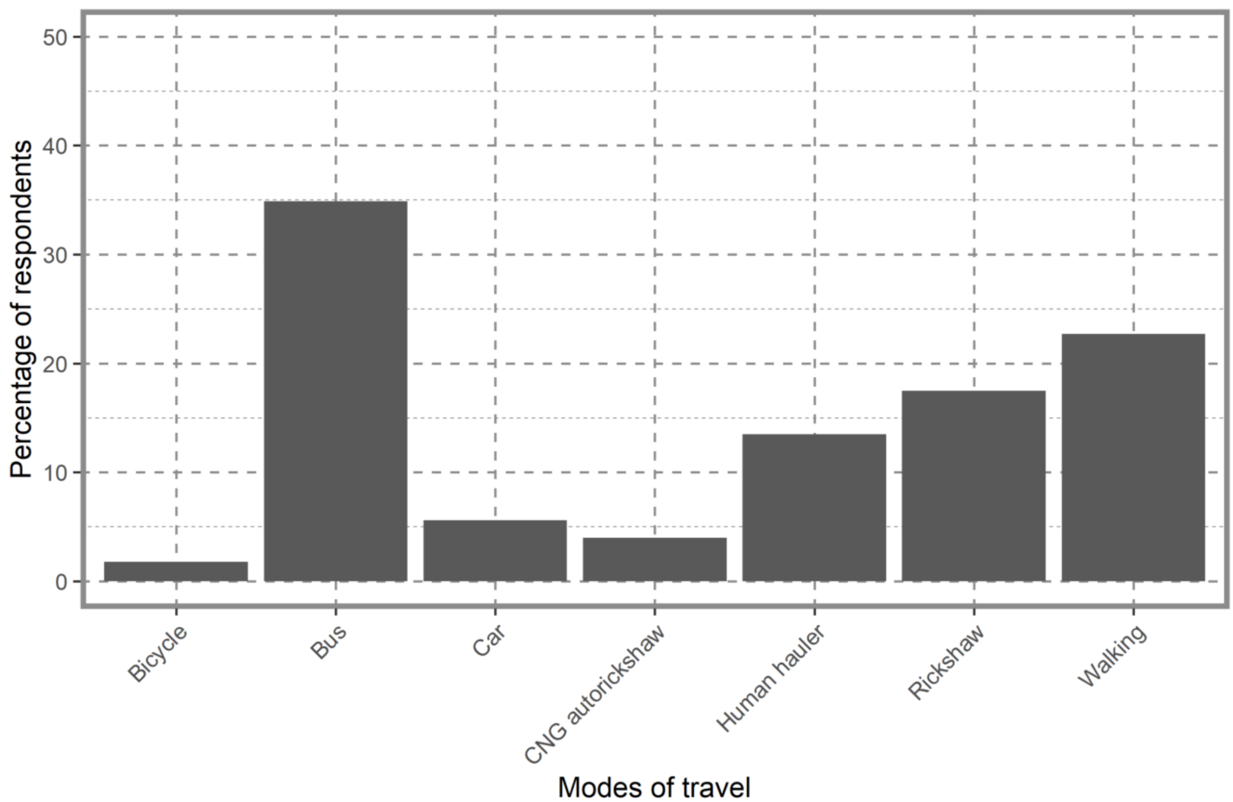

Figure 3. Mode choice characteristics of the respondents.

Table 3 summarizes the values of all independent variables and Cronbach's alpha. Notably, average scores of variables representing perceptions of the respondents of existing en-route NMT facilities from their home to workplace is low. Such a situation indicates that the respondents were unsatisfied with existing built environment facilities available for NMT users. However, relatively higher average scores (>3) were estimated for variables such as intention, attitude, subjective norm, and perceived behavioral control. This suggests a positive perception of the respondents toward the use of NMT.

Table 3 Summary of independent variables, Cronbach's alpha (α) and mean scores (SD)

Variables	%, Mean Score and SD	Cronbach's alpha (α)
Socio-demographic		
Age	37.50±10.94	
Gender		
Male (0)	90.8%	
Female (1)	9.2%	
Education		
Non-College Level (0)	28.5%	
College level (1)	71.5%	
Marital Status		
Single (0)	27.5%	
Married (1)	72.5%	
Dwelling type		
Rented (0)	78%	
Owner occupied (1)	22%	
Household size	4.78 ±2.07	
Biological & Psychological		
BMI	0.11±0.46	
Self-Efficacy (1-5)	3.90±0.60	0.75**
Self-Esteem (1-5)	3.25±1.14	0.49*
Perseverance (1-5)	3.98±0.63	0.27*
Social-cultural environmental		
Home District		
Chittagong (0)	70.8%	
Non-Chittagong (1)	29.2%	
Job type		
Private job (0)	63.3%	
Government job (1)	36.7%	
Relation	4.64±0.54	0.65**
Built environment		
Perception about home to workplace walking environment (1-5)	2.42±0.60	0.67**
Perception about home to workplace cycling environment (1-5)	1.63±0.62	0.64*
Perception about home to workplace rickshaw facilities (1-5)	2.29±0.54	0.62*
Perception about management of the en-route non-motorized facilities (1-5)	2.10±0.68	0.63*
Perception about safety (1-5)	2.59±1.10	0.68**
Transport related information		
Ownership of vehicle		
Yes	12.1%	
No	87.9%	
Average travel time (in minute)	20.62±14.30	
Frequency of work trips per week	7.21±4.38	
Distance between home and workplace (km)	2.40±2.50	
Personal (Proximal)		

Intention (1-5)	3.11±1.26	
Attitude (1-5)	3.02±1.16	0.62**
Subjective norms (1-5)	3.05±0.98	0.61**
Perceived behavioral control (1-5)	3.19±0.83	0.63**

*** α coefficient between 0.60 and 0.8 (acceptable)*

** α coefficient below 0.50 (unacceptable)*

3.2. Factors affecting intention to use NMT for future work trips

The results of statistically significant factors influencing intention of the respondents in choosing NMT for their future work trips are shown in Table 4. Model 1 only included distal determinants which resulted in a coefficient of determination (R^2) of 0.078, where education, marital status, age, self-efficacy, perception about existing en-route cycling facilities, and rickshaw facilities were statistically significant variables. However, when both distal and proximal determinants were included in the model, corresponding R^2 increased to 0.309. In that case, all the three selected proximal determinants were statistically significant, in addition to three distal determinants. This result indicates that the respondents, with a higher score for a positive attitude, perceived behavioral control, and subjective norm toward using NMT, are likely to use NMT for future work trips. In relation to the distal determinants, perceptions of cycling facilities, education, and marital status were significant as well. For all variables, positive coefficients (β) indicate a positive association of independent variables with the dependent variable. For instance, an estimated β of 0.171 for cycling facilities means, a unit increase in the perception of better cycling facilities leads to an increase in the likelihood by 0.171 times that the respondents would consider NMT for their future trips. Conversely, estimated negative β (-0.283) for marital status indicates that married people are more likely to use NMT for the future work trips. About 68% of the married respondents expressed a stronger intention (mean rating >3) toward NMT for future work trips.

Table 4 Results of multiple linear regression models

Variables	**Model 1**			**Model 2**			**VIF**
	β	**p-value**	R^2	β	**p-value**	R^2	
Perception about cycling facilities	.217	.007*	0.078	.171	.015*	.309	1.19
Perception about rickshaw facilities	.186	.038*		.088	.261		1.13

Perception about walking facilities	.133	.177	.064	.383	1.23
Perception about management for non-motorized user	.135	.055	-.032	.603	1.14
Perception about safety on road	.042	.327	-.023	.536	1.06
Education	-.368	.000*	-.326	.000*	1.05
Relation	.107	.256	-.068	.414	1.24
Self-efficacy	.202	.012*	.105	.133	1.11
Marital status	-.336	.008*	-.283	.010*	1.52
Age	-.012	.017*	-.005	.254	1.54
Attitude towards non-motorized transport use			.296	.000*	1.24
Subjective norm			.256	.000*	1.26
Perceived behavioral control			.327	.000*	1.32

3.3. Factors affecting the existing non-motorized mode choice behavior

This study analyzed the individual and compound influence of distal and proximal determinants on the existing choice of modes of the respondents. Table 5 summarizes the outcome of the logistic regression model, showing the relationship between the choice of non-motorized/motorized modes and distal determinants. The ratio of the respondents using non-motorized and motorized modes for their work trips was 42% and 58%, respectively. The estimated odds ratio of each independent variable explained the type and extent of influence on those variables on the choice of non-motorized mode. An odds ratio of a variable >1 indicates a positive impact, whereas, a value <1 suggests a negative relationship with the choice of non-motorized modes. The estimated *p*-value indicates that eight distal determinants significantly influence the mode choice behavior of middle-income people.

Among statistically significant variables, cycling facilities, safety, education, and self-efficacy exhibit odds ratio >1, implying that these variables positively influence the existing non-motorized mode choice of the respondents. Notably, the educational status shows a positive association with the existing choice of NMT, despite it has a negative influence on the intention to use NMT in the future (Table 4). The respondents, who have a higher level of education (e.g., university graduate) and use NMT at present, show little intention to use NMT for future work trips. About 82% of the respondents who owned private vehicles (12% of the total respondents) were university graduates. On the other hand, four variables were negatively associated with the existing choice of NMT for a work trip: walking facilities, management, travel time, and relation.

Table 5 Relationship between existing choice of modes (NMT/non-NMT) and selected distal determinants

Variables	**Odds ratio**	***p*-value**	**95% CI**	**R^2**
Perception about cycling facilities	1.648	.003*	1.188-2.287	0.356
Perception about rickshaw facilities	1.093	.446	.870-1.373	
Perception about walking facilities	.725	.037*	.536-.981	
Perception about management for non-motorized user	.713	.003*	.578-.894	
Perception about safety on road	1.280	.002*	1.098-1.493	
Travel time from home to work (in minute)	.904	.000*	.887-.922	
Education	1.848	.003*	1.230-2.776	
Relation	.644	.022*	.441-.939	
Self-efficacy	1.566	.006*	1.140-2.151	
Gender	.796	.453	.438-1.446	
Age	1.003	.685	.987-1.020	
BMI	1.156	.448	.795-1.682	
Home district	.990	.957	.673-1.454	

Table 6 exhibits the estimated compound influence of distal determinants, proximal determinants, and intention on the current choice of modes. The model included a total of 14 distal and 3 proximal determinants and intention which yielded an R^2 of 0.393. The inclusion of proximal determinants and intention with the distal determinants led to an increase in R^2 from 0.356 to 0.393. A total of 10 variables significantly influences the choice of modes of the respondents. Notably, the influence of the perception about management for the non-motorized user was insignificant in this compound model. The Respondents, who perceived a better safety condition for NMT users, along with the availability of cycling and rickshaw facilities, have a greater tendency to use non-motorized mode for their trips to workplace. For instance, the odds ratio of 1.561 for the variable 'perception about cycling facilities' indicates that a one-point increase on the scale of this variable leads to an increase of the odds over 56%, suggesting that the respondents would use NMT. Likewise, a one-unit increase in the perception scale about rickshaw facilities would increase the likelihood of NMT use by 54.4%. However, if the travel time of a respondent increases by one unit, the chance of using NMT might decrease by 10%.

Similarly, perception of the en-route walking facility is negatively associated with the use of non-motorized mode, as, with one unit increase in the scale of perception on existing walking facilities from home to workplace the probability to use NMT could reduce by 0.581. This is primarily because respondents, who were highly satisfied with the walking environment from their home (mean satisfaction level >3), had an average travel distance of 2.21 km. Therefore, they traveled relatively a longer distance from their home either by public transport (bus) or private or semi-private vehicles (car/CNG autorickshaw), although the perception of the walking environment was better.

In the case of psychological variables, respondents with a higher self-efficacy and poor relationship with their colleagues were more likely to use NMT. The estimated odds ratio of 1.441 for self-efficacy means one unit increase in the scale of self-efficacy may increase the likelihood of NMT use by 44.1%. Other psychological variables, such as the relationship with colleagues and family members, were negatively associated with the use of NMT. A better relationship with colleagues and family members tend to restrict the use of NMT due to perceived low socioeconomic status or poor safety of transport. In the case of proximal determinants, respondents' attitudes positively influenced the current use of NMT. However, an odds ratio of less than one for perceived behavioral control indicates a negative association with the existing use of NMT. The respondents who primarily used NMT for work trips were less confident in using this mode of transport continuously. More than 60% of the respondents, who have a higher confidence level in using NMT, traveled more than 1.5 km distance, on average, to reach their workplace. But, intention to use NMT for a future work trip was not significantly associated. This indicates that the use of NMT by the target group is less controlled by intention.

Table 6 The relationship between current choice of modes (NMT/non-NMT) and selected distal and proximal determinants

Variables	Odds ratio	*p*-value	95% CI	R^2	VIF
Perception about cycling facilities	1.561	.010**	1.112-2.193	0.393	1.26
Perception about rickshaw facilities	1.544	.017*	1.080-2.209		1.16
Perception about walking facilities	.581	.002**	.412-.821		1.24
Perception about management for non-motorized user	.831	.212	.622-1.111		1.16
Perception about safety on the road	1.360	.000**	1.150-1.609		1.11
Travel time from home to work (in minute)	.904	.000**	.886-.922		1.05
Education	.529	.003**	.346-.809		1.09
Relation	.672	.049*	.453-.998		1.24
Self-efficacy	1.441	.029*	1.037-2.003		1.15
Gender	1.209	.545	.653-2.239		1.05
Age	1.006	.451	.990-1.023		1.04

BMI	1.129	.543	.763-1.672	1.07
Home district	1.032	.875	.694-1.535	1.06
Attitude towards non-motorized transport use	1.458	.000**	1.212-1.754	1.36
Intention to use non-motorized transport for work trip	.993	.935	.837-1.178	1.44
Subjective norm	1.014	.900	.821-1.251	1.34
Perceived behavioral control	.793	.025*	.568-.962	1.39

4. Discussion

Predicting human behavior is a complex process, especially in transport studies. Existing studies considered different combinations of environmental, socio-cultural, and personal factors to explain people's travel behavior. Whilst there are different models to analyze human behavior, only a few studies have attempted to ensemble multiple models to understand human travel behavior comprehensively, targeting a developing country. This study endeavored to provide a comprehensive framework, combining three behavioral models to elucidate the complex nature of human travel behavior, residing in a developing country. A conceptual model was tested using both stated and revealed preference approaches to understand non-motorized mode choice behavior of middle-income people in CCC of Bangladesh. Primary data were collected from randomly selected middle-income working adults (aged 18 to 65 years), with a questionnaire survey at major commercial and retail business areas in 41 wards of CCC. A total of 720 respondents was surveyed. Various factors were selected from existing literature and categorized as distal and proximal determinants. The extent of influence of selected factors on current mode choice behavior and intention toward the use of NMT in the future was quantified by establishing an array of regression models.

The NMT in CCC primarily includes walking, cycling, rickshaws, and rickshaw van, which people use individually and/or collectively. Besides, motorized modes of transport include public transport (bus/minibus), car, CNG autorickshaw, human hauler, and motorbikes. Results from this study showed that different distal and proximal determents — which are the components of the conceptual model — significantly influence the non-motorized mode choice behavior of people. Regarding the stated preference of the respondents in choosing NMT for future work trips (i.e., intention), this study revealed that proximal determinants have a higher degree of influence than that of distal determinants. This supports the hypothesis derived from the TPB that intention can be predicted from proximal factors. On the other hand, in the case of the respondents' current mode choice, distal determinants have a greater influence on the use of NMT than proximal determinants, which supports the assumption derived from the TTI. Further, different types of proximal and distal determinants and their multi-level influence reinforces the hypothesis of the ecological models of health behavior that human behaviors are affected by multiple factors, acting at different levels.

In the case of distal determinants, perception of safety (e.g., crime and traffic collision), as well as, availability of facilities to support NMT (cycling and rickshaw) encouraged the respondents to use non-motorized modes. Ogilvie et al. (2008) suggested incorporating individuals' perceptions of the environment from origin to destination while estimating the probability to use NMT. Other studies also found a positive association between perceptions of safety and the use of active transport (Titze et al. 2007). In CCC area, the probability to use NMT increases when the respondents have a better perception of the safety and availability of en-route cycling and rickshaw facilities. The major transport policies and interventions adopted in Bangladesh least prioritize the use of rickshaws and rickshaw vans (Hasan and Dávila 2018). The existing condition of NMT facilities available in CCC area was not up to the average satisfaction level of the respondents (<3). Perception of better-walking facilities negatively associated with the current use of NMT in the study area, a result that contradicts existing studies (Craig et al. 2002; Simons et al. 2017; Van Cauwenberg et al. 2012). The travel time of the respondents significantly influences the choice of modes in CCC, as longer travel time discouraged the use of NMT for a work trip, which is in accord with other studies (Handy and Xing 2011; Ogilvie et al. 2008). The influence of travel time in determining the choice of NMT in CCC is greater than the perception of better pedestrian facilities.

Besides, the perception of built environment factors, personal, psychological, and social factors influence the choice of NMT for a work trip. Among different factors considered in this study, greater self-efficacy, low level of education, marital status, and poor relationship with colleagues and family had a significant role in choosing NMT. Several studies identified a positive influence of self-efficacy on individuals' choice of NMT (Bopp et al. 2011; De Geus et al. 2008; Merom et al. 2008; Simons et al. 2017). Notably, this study showed that higher-level educational status reduces the probability of using NMT, which contradicts the observation of Simons et al. (2017). The respondents of this study who held at least a college degree had a better work placement and higher social status. It encouraged them to use personalized vehicles (e.g. private car or motorcycle) for a work trip, depending on their income. Further, a good relationship with colleagues and family members was also inversely associated with the use of NMT. Several studies also found an association of the choice of modes with colleagues and family members' about NMT usage (Handy and Xing 2011; Muñoz et al. 2016). Hence, the social environment is an important factor that influences the use of NMT.

Among the proximal determinants, attitude toward the use of non-motorized mode and perceived behavioral control were estimated to be significant determinants in explaining current behavior. People who provided a higher rating, representing their positive attitude toward NMT, generated a greater proportion of non-motorized work trips — a result which was observed in the study by Handy and Xing (2011). A positive attitude toward the use of NMT is developed reasonably from the beliefs that people consider benefits (i.e. increase in utility) while choosing a mode of transport (Ajzen 1991). Therefore, most of the NMT users in the study area were aware of the benefits of this form of transport. However, perceived behavioral control was inversely related to the use of NMT, which is supported by the findings of Merom et al. (2008). Most of the NMT users in CCC were less confident about the frequent use of this mode of transport, due to difficulties (e.g., long travel time and distance, poor safety, topographical condition) that they experienced while using NMT.

5. Conclusion

Whilst cities in developing countries generate a higher share of NMT trips, there has been limited understanding of non-motorized travel behavior due to complex interactions among personal, psychological, social, and environmental factors. This study aimed at identifying different factors influencing existing and potential future non-motorized mode choice behavior in the context of a developing country. Despite the contribution made in this study, achieving a comprehensive understanding of the non-motorized mode choice behavior of people in developing countries is a challenging task. This study only focused on middle-income working adults. Besides, 'accessibility to destination' was considered as a built environment factor, while other factors such as residential/workplace density and land use were not included in the models. Furthermore, a limited number of distal determinants related to biological and social factors were considered. Though the model developed to analyze intention of the respondents toward the use of NMT was statistically reliable, a coefficient of determination (R^2) of 0.309 indicated that the independent variables explained just over 30% of the dependent variable (i.e., choice of NMT as a mode of transport). Therefore, further research is warranted to improve the robustness of the model(s).

Despite these limitations, this study is a novel attempt to address a major challenge of predicting non-motorized travel behavior, combining multiple behavioral models. Such an approach can assist urban planners in adopting (i) infrastructural interventions (e.g., provision of sidewalks or cycle lane, different types of barrier, divider, buffer or set back, street amenities, street furniture, and green elements) (Aziz et al. 2017; Forsyth and Krizek 2010), (ii) spatial planning measures (e.g., compact development, organization of destinations and accessibility, street-neighborhood-city scale design and management of built environment) (Kim et al. 2014; Tight et al. 2011), and (iii) non-structural measures (e.g., traffic and safety management, time and cost management, monitoring and evaluation of constructed project targeting NMT user, the green movement and social awareness for NMT use) (Faherty and Morrissey 2014; Ho et al. 2017) to promote the use of NMT. Evidence from this study underlined that improvements in the physical environment for different sociodemographic groups would encourage more commuters to shift from MT to NMT. Together, applications of spatial planning (e.g., mixed-use) approach and NMT dominant city concept are required to develop an NMT friendly city. This study emphasized the need to consider proximal and distal determinants to understand latent NMT/motorized travel demand for work trips. The proposed models can be applied to other sociodemographic groups, trip purposes, and cities of Bangladesh, as well as, in other developing countries which may assist in formulating guidelines to promote the use of NMT and achieve sustainable urban transport systems.

Appendix. Photographs of Different Transport Modes

Figure 4 shows images of different transport modes available in the study area.

Figure 4. Typical modes of transport in CCC: (a) bus; (b) private car; (c) CNG autorickshaw; (d) human hauler; (e) motorbike; (f) pedestrian; (g) bicycle; (h) rickshaw; and (i) rickshaw van. (Images by authors.)

Data Availability

Some or all data, models, or code that support the findings of this study are available from the corresponding author upon reasonable request.

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