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

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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

60　　Pulidindi 2013). To ensure a balance between urban development and environmental sustainability, finding

61　　an alternative mode of transport is essential for city planners and transport engineers (Baltes 1996; Guo et

62　　al. 2007).

63　　　　　Non-motorized transport (NMT) is widely recognized as being an environment-friendly mode of

64　　transport that offers economic, environmental, and health benefits (Khan et al. 2014). Along with an

65　　improved public transport system, promotion of NMT could increase physical activities, leading to health

66　　benefits to urban dwellers (Ermagun and Levinson 2017), reduce car use, air pollution, and congestions

67　　(Bopp et al. 2015; Lachapelle et al. 2011; Pérez et al. 2017). The NMT system requires less road space,

68　　hence a lower level of investment, compared to motorized transport (MT) system (Ahsan and Sufian 2014).

69　　Despite NMT provides multiple benefits, this form of transport generates a small proportion of the total

70　　trips in different countries (e.g., 8.1% in the US cities, 15.8% in Australia/New Zealand cities, 10.4% in

71　　Canadian cities, 31.3% Western European cities, and 28.5% in high-income Asian cities) (Baltes 1996;

72　　Bopp et al. 2015; Droege 2008; Kaczynski et al. 2010) and is often marginalized compare to other transport

73　　modes (Gouda and Masoumi 2017). Various studies demonstrated that an increase in automobile-dependent

74　　short-distance trips could lead to a reduction in the use of NMT (Caspersen et al. 2000; Cohen et al. 2014;

75　　Davis 2010; Gordon-Larsen et al. 2005). In developing countries, NMT accommodates a greater number

76　　of passengers and goods than MT (Hossain 1996) and generally influences the informal labor market,

77　　supporting the livelihood of numerous marginalized people (Hasan and Dávila 2018). Nevertheless,

78　　transport planning policies in contemporary cities, particularly those in developing countries, are

79　　predominantly based on MT (Hasan and Dávila 2018). Understanding travel behavior is therefore important

80　　to promote NMT in different cities (Kerr et al. 2010).

81　　　　　Travel behaviors are usually studied using theories from psychology, social science, and urban

82　　studies (Cerin et al. 2006; Chaney et al. 2014; de Bruijn et al. 2005; Feuillet et al. 2015; Hess et al. 2017;

83　　Muñoz et al. 2016; Saelens et al. 2003). Among different theories or models, the theory of planned behavior

84　　(TPB) (Ajzen 1991), the theory of triadic influence (TTI) (Flay and Petraitis 1994), the ecological model

85　　of health behavior (McLeroy et al. 1988; Sallis et al. 1997), social ecology (Stokols 1992), and social

86   cognitive (Bandura 1999) theories are widely used to understand travel behavior. The TPB is an extension

87   of the reasoned action theory. According to the TPB, human behavior is driven by a combination of

88   intention, occasion, situation, and forms of action. The theory further states that perceived behavioral

89   control (e.g., confidence in one's ability) influences behaviors, which was termed as a concept of perceived

90   self-efficacy. Perceived behavior control can directly explain behavioral achievements. However, the extent

91   of the influence of intention or behavioral control on human behavior is contextual. The intention is

92   dependent on three independent psychological or proximal determinants: attitude toward that behavior,

93   subjective norm, and perceived behavioral control. The relative importance of each independent latent

94   variable depends on the behavior and situation (Ajzen 1991). On the other hand, the TTI was developed to

95   understand health behavior (e.g., smoking, snacking). Similar to the TPB, the TTI also considers personal

96   behavioral intention (proximal factors) as an indicator of behavior. However, cultural origin, social

97   situation, and inherited disposition influence individual attitude, social norms, and self-efficacy. Hence, the

98   TTI additionally considers background or distal factors such as socio-cultural and environmental features

99   to explain behavior (Flay and Petraitis 1994). According to the ecological model, intrapersonal (e.g.,

100 biological, psychological), interpersonal (e.g., social, cultural), communal and physical environmental

101 factors, and planning decisions influence individual behavior (Sallis et al. 2008). The forerunner of the

102 ecological model was Urie Bronfenbrenner (McLeroy et al. 1988). According to Bronfenbrenner's model,

103 behavior is affected by multiple levels of influence. From socio-ecological perspectives, the well-being of

104 people is more dependent on the social plus physical environment along with their attributes. Therefore,

105 unlike behavioral models that focused primarily on individual and social factors, the ecological model

106 reinforces the importance of understanding the complex nature of the environment encompassing the

107 community and incorporates multiple levels of analysis to understand dynamic interrelations between

108 people and the environment (Sallis et al. 2008). Several studies used explicit assumptions of these

109 behavioral theories to explain non-motorized travel behavior, and provided insights on factors, influencing

110 travel behavior (Cerin et al. 2006; Chaney et al. 2014; de Bruijn et al. 2005; Hess et al. 2017; Kerr et al.

111 2010; Saelens et al. 2003). However, most of the existing studies are focused on the contexts of developed

4

112 countries such as those are in Europe and the USA. The use of behavioral models in understanding the

113 travel behavior of commuters in developing countries is still in its infancy.

114   Individual travel behavior primarily depends on personal, psychological, social, and environmental

115 factors. Generally, factors associated with the built environment have a greater influence on non-motorized

116 travel behavior compared to different individual targeted interventions (e.g., capacity building program,

117 social movement) (Baltes 1996; Craig et al. 2002; Feuillet et al. 2015; Frank et al. 2004; Zannat et al. 2020).

118 Urban building density, population density, land use diversity, and design, destination accessibility, and

119 access to transit are common indicators of the built environment, empirically proven as significant

120 indicators of travel demand (Cervero and Kockelman 1997; Ewing and Cervero 2010). According to Baltes

121 (1996), the use of NMT depends on personal preferences that are influenced by factors within and outside

122 of personal control. For example, Bopp et al. (2011) reinforced that a combination of individual (eco-

123 friendly attitude) and built environmental factors are associated with active travel (a form of NMT).

124 Together, the social environment of the workplace (such as the relationship with colleagues) can also

125 influence non-motorized mode choice behavior. Individuals' lifestyle, perception of safety and comfort of

126 using NMT, awareness about the benefits of non-motorized travel, travel time and reliability, and individual

127 capabilities to travel by NMT can also be related to non-motorized travel behavior (Muñoz et al. 2016).

128 However, the degree of influence of different factors on non-motorized travel behavior is contextual. For

129 instance, when people live in a place with adequate physical facilities, individual factors (e.g., self-efficacy,

130 perceived benefits) influence travel behavior greatly than physical factors (e.g., accessibility to a

131 destination, physical facilities) (De Geus et al. 2008). The purpose of travel determines the level of influence

132 of physical and social environments on individual travel behavior. For example, an improved physical

133 environment positively influences non-motorized travel for commuting purposes, while both physical and

134 social environments influence non-motorized trips related to recreational purposes (Hess et al. 2017;

135 Hoehner et al. 2005). Since a wide range of factors is associated with non-motorized travel behavior, a

136 positive association of one factor in a context does not essentially indicate a similar relationship in other

137 contexts. Therefore, it is necessary to understand the synergies among diversified factors to identify the

138 optimum set of interventions to promote non-motorized travel in different contexts.

139   The purpose of this study is twofold. First, this study tested how well various behavioral models

140 (Figure 2) explain NMT commuting travel behavior of people of a developing country. Second, this study

141 identified potential factors influencing peoples' intentions and behavior toward the use of NMT. It focused

142 on middle income working adults, inhabiting the Chittagong City Corporation (CCC) area of Bangladesh.

143 Bangladesh is one of the developing countries, facing multiple challenges due to a lack of adequate and

144 proper planning. Major cities of the country are characterized as 'low per capita Gross Domestic Product

145 (GDP) NMT dominant cities' (Hook and Replogle 1996), facing rapid motorization to meet mobility

146 demands of a rapidly growing population. Developing a guideline for promoting NMT in Bangladesh is a

147 challenging task, due to a lack of empirical data and evidence-based study. The outcome of this study is

148 expected to provide information to predict latent motorized/NMT demand, which could help to promote

149 the use of NMT for commuting purposes.

150   **2. Methodology**

151   This study was conducted in four stages. First, a conceptual framework was developed based on

152 the assumptions of three behavioral theories. They are the theory of planned behavior (TPB), the theory of

153 triadic influence (TTI), and the ecological model of health behavior. Second, different factors influencing

154 non-motorized travel behavior were consulted to prepare a questionnaire. Third, a semi-structured

155 questionnaire survey was conducted to collect information on different aspects of the travel behavior of the

156 target group. Finally, the conceptual framework was evaluated by developing statistical models that

157 estimated the extent of the influence of different factors on non-motorized mode choice behavior.

158   **2.1. The study area**

159   Chittagong City Corporation (CCC) is located in the southeastern region of Bangladesh (Figure 1).

160 It is the second-largest city and the commercial capital of the country. About 4 million people inhabit within

161 177 km^2 area of CCC. The administrative area of CCC is divided into 41 wards (smallest administrative

162 unit) (Zannat et al. 2019). Like other major cities of the country, Chittagong city is growing at an alarming

163 rate, fueled primarily by rural-urban migration. The city was ranked as the tenth fastest-growing city in the

164 world in 2010 (Mia et al. 2015). In this city, NMT represents walking, cycling, rickshaw, rickshaw van,

165 and pushcarts, where rickshaw and rickshaw van are propelled by manual pedaling. Transport policies

166 adopted in CCC mainly focus on promoting motorized transport, especially private automobiles. For

167 example, major policies in the 'Long-Term Development Strategy (LTDS) for Traffic and Transportation

168 in Chittagong' include widening of existing roads, as well as constructing new roads, while rehabilitation

169 or construction of pedestrian pathways was given less priority (Zannat et al. 2019). As a result, automobile

170 dependency has been increasing, resulting in traffic congestion, environmental pollution, road crashes, and

171 aesthetic degradation (Shamsher and Abdullah 2013). Despite different environmental and health benefits

172 associated with the use of NMT, little attention has been given to promote this sector in CCC.
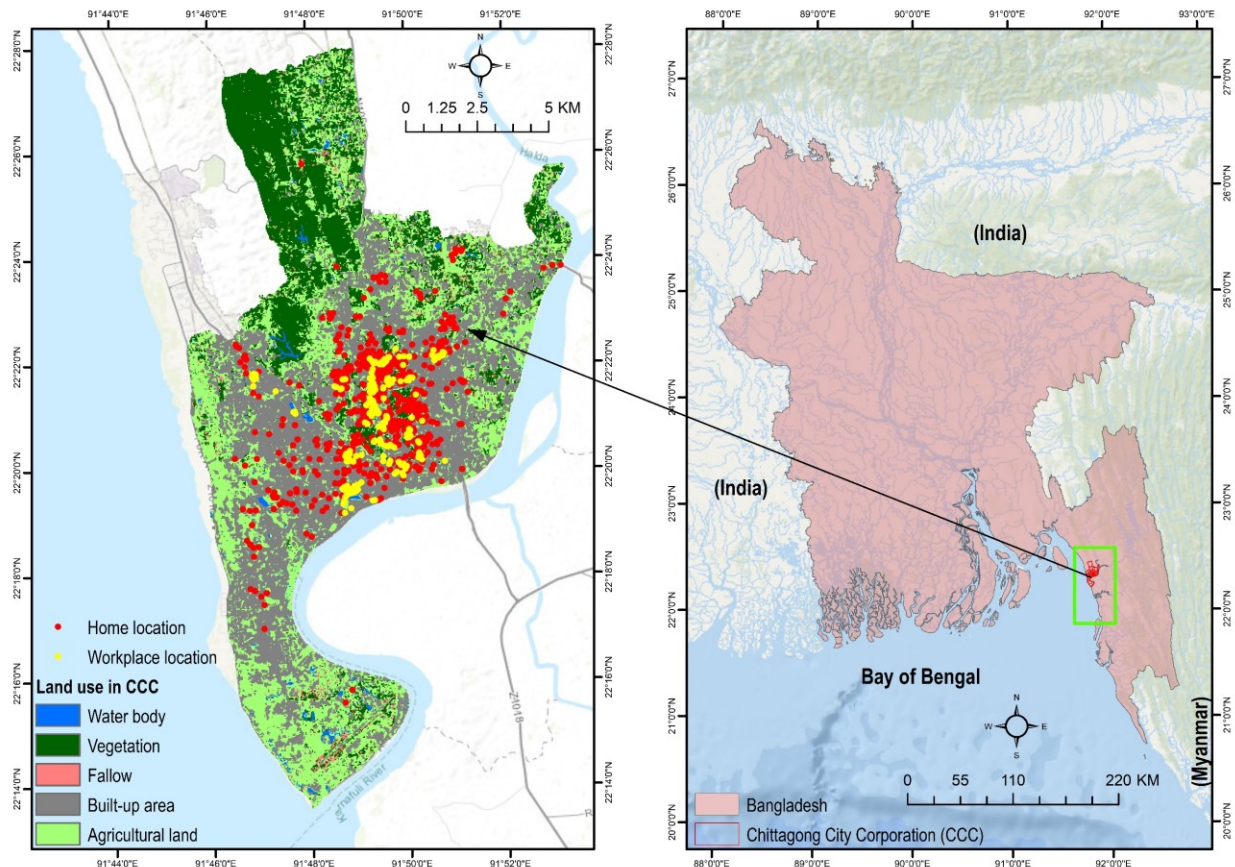
173

174   Figure 1. Location map of CCC in Bangladesh, showing the origin-destination of the respondents and

175   land use categories of the study area. [Sources: Esri, HERE, Garmin, Intermap, increment P Corp.,

176   GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan,

177   METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community; land use

178   data from Abdullah et al. 2019.].

179   In this study, middle income working adults were selected as the target group to understand the trade-off

180   between motorized and NMT use. In Bangladesh, 50% of the total population are middle-income people

181   (average monthly income approximately 25,000 Bangladeshi Taka, BDT), with 40% belong to the lower-

182   income group (average monthly income ≤10,000 BDT) and the remaining 10% are the higher-income group

183   (average monthly income approximately 150,000 BDT) (Rahman 2016). Unlike other income groups,

184   middle-income working adults of Bangladesh shows heterogeneous mode choice behavior, as they use

185   various combinations of MT and NMT. On the other hand, private cars are the primary mode of transport

186   for the higher-income group, while the lower-income group is predominantly dependent on foot. Due to

187   limited public transport service coverage, middle and lower-middle-income groups are dependent on

188   different forms of NMT. The majority of people in CCC use a combination of public transport and NMT

189   as their primary mode of travel (CDA 2009; Zannat et al. 2019). Therefore, understanding the impact of

190   potential factors (except income) influencing NMT use of middle-income working adults may provide

191   useful insights into the city planning.

192   **2.2. Developing a conceptual framework**

193   To understand the NMT commuting behavior of middle-income working adults, a conceptual

194   framework was developed, based on the assumptions of three behavioral theories noted above, along with

195   the concepts of microeconomics. It was assumed that (i) individual commuters tend to behave in a way that

196   is rational and narrowly self-interested, that they aim to optimize the outcome; (ii) individuals' preference

197   can be determined by behavioral indicators.

198   The TPB highlights the importance of psychological or proximal factors (e.g., attitude, subjective

199   norm, perceived behavioral control) related to a certain behavior. Different studies used various proximal

200   factors in explaining and predicting travel behavior (de Bruijn et al. 2005; Kerr et al. 2010). These proximal

201   factors can be accurately assessed through direct questioning if the underlying beliefs are not the focus of

202   a study (de Bruijn et al. 2005). With regard to this theory, this study hypothesized that the choice of

203   commuting mode (NMT/MT) can be predicted by analyzing the users' intention which can be predicted

204   from proximal determinants. Although the significance of psychological factors in understanding non-

205   motorized travel behavior is highlighted in several studies, de Bruijn et al. (2005) found a relatively lower

206   influence of psychological factors in understanding travel behavior compared to other health-related

207   behavior (e.g., snacking behavior). The theory does not focus on external factors such as sociodemographic

208   variables, social and cultural context, which may influence non-motorized mode choice behavior.

209   According to the TTI, external or distal determinants of health behavior can be divided into three categories:

210   cultural environment, social environment, and individual factors. This study assumed that distal

211   determinates from triadic influence affect non-motorized travel behavior. The importance of individual

212   factors is commonly examined in travel behavioral studies (Handy and Xing 2011; Ogilvie et al. 2008;

213   Simons et al. 2017; Titze et al. 2007). This study considered the association between socio-demographic

214   factors (e.g., age, gender, education, car ownership) and non-motorized mode choice behavior of

215   commuters. Also, the importance of social environment and cultural environment (e.g. religion and

216   ethnicity) was highlighted in similar studies (De Geus et al. 2008; Hess et al. 2017; Titze et al. 2007; Van

217   Cauwenberg et al. 2012). Although de Bruijn et al. (2005) considered that the physical environment is part

218   of the social environment, this study separated them to make the conceptual model more comprehensive

219   and adaptable in the context of developing countries to predict travel behavior. This is because, unlike other

220   human behaviors, the physical environment plays an important role in understating commuters' travel

221   behavior.

222   The ecological models emphasize the importance of environmental context and consider that

223   human behaviors are affected by multiple levels of associated factors. The multiple levels of factors signify

224   the importance of factors related to the individual (e.g., socio-economic and attitudinal factors), physical

225   environment (e.g., both natural and built environmental factors), and social environment. The social

226 environment and individual factors are highlighted in the previous two models. The influence of built

227 environment factors (e.g., land use, density, organization of destinations and accessibility, walkability) and

228 their spatial organization (e.g., at the street, neighborhood, and city scales) were also examined in several

229 studies to understand the use of NMT (Craig et al. 2002; Feuillet et al. 2015; Feuillet et al. 2016; Owen et

230 al. 2004). However, the influence of different built environment factors is context-dependent, therefore,

231 their influences could vary according to different socio-economic settings (De Geus et al. 2008; Handy and

232 Xing 2011; Zhang et al. 2014). This study assumed that both social and built environment factors influence

233 NMT use for commuting purposes.
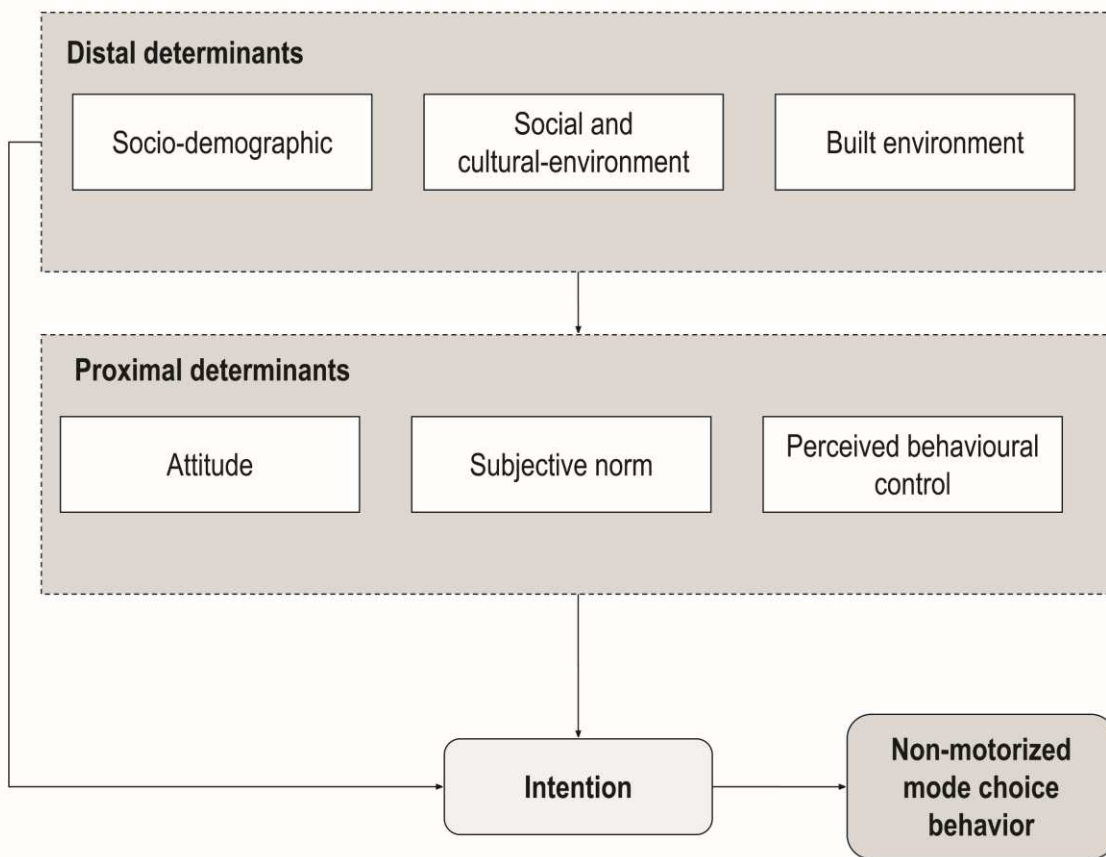
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235 Figure 2. Conceptual framework. (Data from de Bruijn et al. 2005.)

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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*]

11

264   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)

265

266

267 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)

268

269   **2.4. Survey design**

270   A survey was conducted in August 2018 at major commercial centers and retail business areas in

271   CCC. The sample size was calculated using equation 1 (Israel 1992). A minimum number of respondents

272   required at a 95% confidence level with a normal distribution response of large population size were then

273   determined.

$$n = z^2 pq/e^2 \tag{1}$$

274   where n is the minimum sample size; z is the z-value of given confidence level (for 95% confidence

275   level it is 1.96); p is the estimated proportion of an attribute that is present in the population, and q is the

276   (1-p) and e is the tolerance level (assumed as 5%).

277   Around 4 million people live in CCC, of which 69.8% are working adults (BBS 2018). About 2

278   million people are middle income working adults (as 50% of the working population is middle-income

279   people according to Rahman (2016)). Since the population size was large, and the variability in proportion

280   (proportion of middle-income people use NMT) was not known, we assumed p = 0.5 (maximum

281   variability), and thus, q would be 0.5. Hence, the estimated minimum size of the sample was 384. While

282   conducting the survey, about 20% of people were unwilling to respond to clarify their income range. Also,

283   some people avoided answering certain questions. As a result, some missing information could introduce

284   systematic bias in our results. So, a total of 720 working adults (aged 18 to 65 years) were interviewed in

285   41 wards (smallest administrative unit) of CCC. The authors contacted randomly selected organizations

286   (which were the workplace of our target group) via email, phone, or in-person to organize the survey.

287   During the survey, questions were asked in Bengali and the survey team explained each question to the

288   respondents in non-technical language.

289   **2.5. Analytical approaches**

290   The conceptual framework developed in section 2.2 was tested in two steps. First, two multiple

291   linear regression models were developed to understand intention of the respondents in choosing NMT for

292   their near future work trips. Second, two binary logistic regression models were established to understand

293   the respondents' non-motorized mode choice behavior. These two forms of models were developed based

294   on the premise that intention towards the future choice of NMT is associated with the choice of modes at

295   present (de Bruijn et al. 2005).

2.5.1. Analyzing intention of the respondents towards NMT use

297   Stepwise multiple linear regression models were developed, incorporating distal and proximal

298   determinants as independent variables and intention of the respondents toward the use of NMT as a

299   dependent variable. Since intention was measured by averaging scores of three questions (respondents'

300   intention to walk, cycle, and use rickshaw (see section 2.3)), the dependent variable was continuous.

301   Therefore, this study used multiple linear regression models instead of ordered logit models. To check

302   multicollinearity among independent variables, the variance inflation factor (VIF) of selected independent

303   variables was estimated (Midi et al. 2010), using the package 'car' of R statistical package (Fox et al. 2018).

304   The VIF determines the degree of variance if estimated coefficients were inflated by multicollinearity. The

305   values exceeding 2.5 create a concern for the model, while a value greater than 10 indicates multicollinearity

306   (Midi et al. 2010). Independent variables with a VIF value of <2 were selected for the final model. Since

307   'distance from home to the workplace' and 'average travel time required to reach workplace' variables were

308   highly correlated, only the travel time variable was included in the model. Also, variables that had

309   unacceptable α coefficients (i.e., values below 0.50) were excluded during model development (e.g., self-

310   esteem and perseverance). The multiple linear regression model explains the relationship between two or

311   more predictors and a dependent variable by fitting a linear equation to observed data. Each value of

312   independent variable X is associated with a value of dependent variable y as in equation 2.

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

313   where y is the mean value of intention to use NMT for a future work trip; X is different distal and

314   proximal determinants; n is the number of independent variables (22); $\beta_1,\ \beta_2,\ ......,\ \beta_n$ are the regression

315   coefficients; β_0 is the intercept; ε is the random error in prediction or residuals.

316

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:

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

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:

$$z = b_0 + b_1 x_1 + b_2 x_2 + \cdots + b_n x_n \tag{4}$$

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

340   means the likelihood of an independent variable to be the member of a target group of dependent variables

341   (Field 2013).

3. Results

3.1. Travel characteristics of the respondents

344   Most of the respondents used bus as their primary mode for commuting (Figure 3). About 22.7%

345   of the total work trips were on foot. The proportion of cycle users was the least compared to other modes.
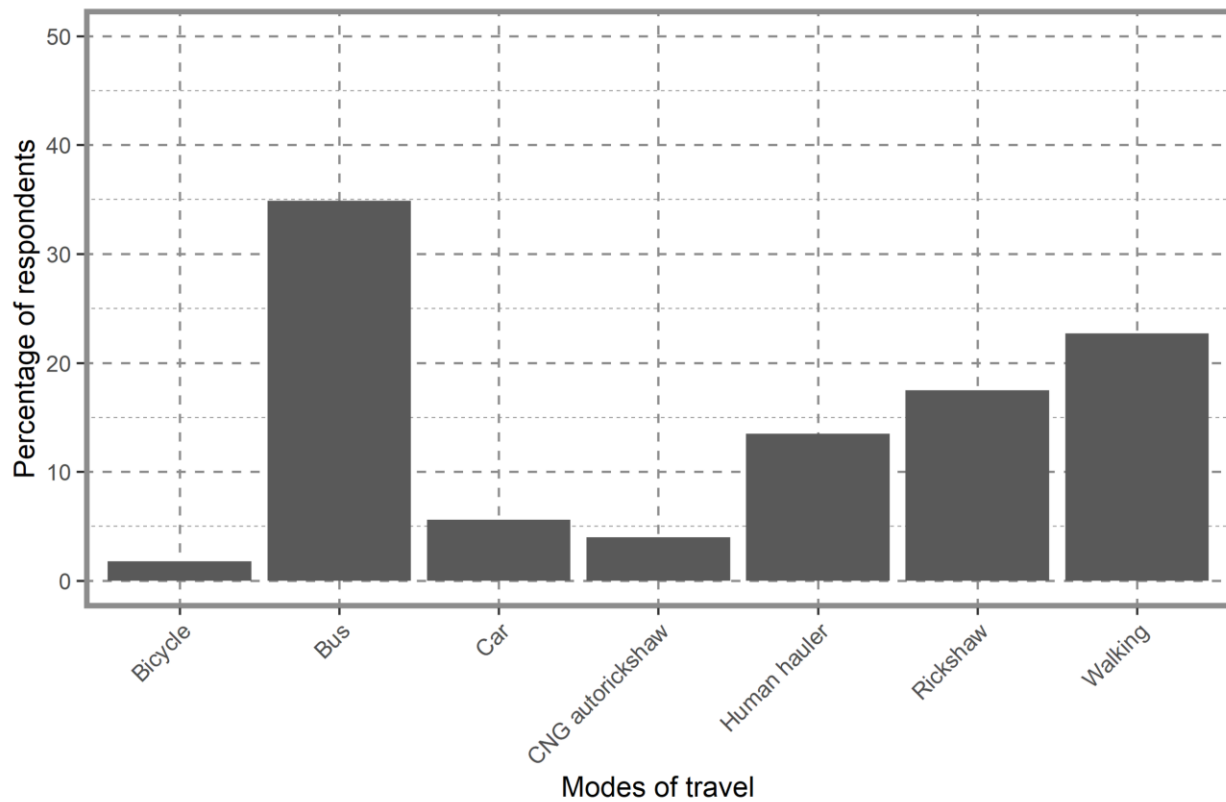
346

347   Figure 3. Mode choice characteristics of the respondents.

348   Table 3 summarizes the values of all independent variables and Cronbach's alpha. Notably, average

349   scores of variables representing perceptions of the respondents of existing en-route NMT facilities from

350   their home to workplace is low. Such a situation indicates that the respondents were unsatisfied with

351   existing built environment facilities available for NMT users. However, relatively higher average scores

352   (>3) were estimated for variables such as intention, attitude, subjective norm, and perceived behavioral

353   control. This suggests a positive perception of the respondents toward the use of NMT.

18

354 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**			

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

356 * *α coefficient below 0.50 (unacceptable)*

357

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

359   The results of statistically significant factors influencing intention of the respondents in choosing

360 NMT for their future work trips are shown in Table 4. Model 1 only included distal determinants which

361 resulted in a coefficient of determination (R^2) of 0.078, where education, marital status, age, self-efficacy,

362 perception about existing en-route cycling facilities, and rickshaw facilities were statistically significant

363 variables. However, when both distal and proximal determinants were included in the model, corresponding

364 R^2 increased to 0.309. In that case, all the three selected proximal determinants were statistically significant,

365 in addition to three distal determinants. This result indicates that the respondents, with a higher score for a

366 positive attitude, perceived behavioral control, and subjective norm toward using NMT, are likely to use

367 NMT for future work trips. In relation to the distal determinants, perceptions of cycling facilities, education,

368 and marital status were significant as well. For all variables, positive coefficients ($β$) indicate a positive

369 association of independent variables with the dependent variable. For instance, an estimated $β$ of 0.171 for

370 cycling facilities means, a unit increase in the perception of better cycling facilities leads to an increase in

371 the likelihood by 0.171 times that the respondents would consider NMT for their future trips. Conversely,

372 estimated negative $β$ (-0.283) for marital status indicates that married people are more likely to use NMT

373 for the future work trips. About 68% of the married respondents expressed a stronger intention (mean rating

374 >3) toward NMT for future work trips.

375   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

376

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

378   This study analyzed the individual and compound influence of distal and proximal determinants on

379 the existing choice of modes of the respondents. Table 5 summarizes the outcome of the logistic regression

380 model, showing the relationship between the choice of non-motorized/motorized modes and distal

381 determinants. The ratio of the respondents using non-motorized and motorized modes for their work trips

382 was 42% and 58%, respectively. The estimated odds ratio of each independent variable explained the type

383 and extent of influence on those variables on the choice of non-motorized mode. An odds ratio of a variable

384 >1 indicates a positive impact, whereas, a value <1 suggests a negative relationship with the choice of non-

385 motorized modes. The estimated p-value indicates that eight distal determinants significantly influence the

386 mode choice behavior of middle-income people.

387   Among statistically significant variables, cycling facilities, safety, education, and self-efficacy

388 exhibit odds ratio >1, implying that these variables positively influence the existing non-motorized mode

389 choice of the respondents. Notably, the educational status shows a positive association with the existing

390 choice of NMT, despite it has a negative influence on the intention to use NMT in the future (Table 4). The

391 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	

399   Table 6 exhibits the estimated compound influence of distal determinants, proximal determinants,

400   and intention on the current choice of modes. The model included a total of 14 distal and 3 proximal

401   determinants and intention which yielded an R^2 of 0.393. The inclusion of proximal determinants and

402   intention with the distal determinants led to an increase in R^2 from 0.356 to 0.393. A total of 10 variables

403   significantly influences the choice of modes of the respondents. Notably, the influence of the perception

404   about management for the non-motorized user was insignificant in this compound model. The Respondents,

405   who perceived a better safety condition for NMT users, along with the availability of cycling and rickshaw

406   facilities, have a greater tendency to use non-motorized mode for their trips to workplace. For instance, the

407   odds ratio of 1.561 for the variable 'perception about cycling facilities' indicates that a one-point increase

408   on the scale of this variable leads to an increase of the odds over 56%, suggesting that the respondents

409   would use NMT. Likewise, a one-unit increase in the perception scale about rickshaw facilities would

410   increase the likelihood of NMT use by 54.4%. However, if the travel time of a respondent increases by one

411   unit, the chance of using NMT might decrease by 10%.

412   Similarly, perception of the en-route walking facility is negatively associated with the use of non-

413   motorized mode, as, with one unit increase in the scale of perception on existing walking facilities from

414   home to workplace the probability to use NMT could reduce by 0.581. This is primarily because

415   respondents, who were highly satisfied with the walking environment from their home (mean satisfaction

416   level >3), had an average travel distance of 2.21 km. Therefore, they traveled relatively a longer distance

417   from their home either by public transport (bus) or private or semi-private vehicles (car/CNG

418   autorickshaw), although the perception of the walking environment was better.

419   In the case of psychological variables, respondents with a higher self-efficacy and poor relationship

420   with their colleagues were more likely to use NMT. The estimated odds ratio of 1.441 for self-efficacy

421   means one unit increase in the scale of self-efficacy may increase the likelihood of NMT use by 44.1%.

422   Other psychological variables, such as the relationship with colleagues and family members, were

423   negatively associated with the use of NMT. A better relationship with colleagues and family members tend

424   to restrict the use of NMT due to perceived low socioeconomic status or poor safety of transport. In the

23

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

434

4. Discussion

436   Predicting human behavior is a complex process, especially in transport studies. Existing studies

437   considered different combinations of environmental, socio-cultural, and personal factors to explain people's

438   travel behavior. Whilst there are different models to analyze human behavior, only a few studies have

439   attempted to ensemble multiple models to understand human travel behavior comprehensively, targeting a

440   developing country. This study endeavored to provide a comprehensive framework, combining three

441   behavioral models to elucidate the complex nature of human travel behavior, residing in a developing

442   country. A conceptual model was tested using both stated and revealed preference approaches to understand

443   non-motorized mode choice behavior of middle-income people in CCC of Bangladesh. Primary data were

444   collected from randomly selected middle-income working adults (aged 18 to 65 years), with a questionnaire

445   survey at major commercial and retail business areas in 41 wards of CCC. A total of 720 respondents was

446   surveyed. Various factors were selected from existing literature and categorized as distal and proximal

447   determinants. The extent of influence of selected factors on current mode choice behavior and intention

448   toward the use of NMT in the future was quantified by establishing an array of regression models.

449   The NMT in CCC primarily includes walking, cycling, rickshaws, and rickshaw van, which people

450   use individually and/or collectively. Besides, motorized modes of transport include public transport

451 (bus/minibus), car, CNG autorickshaw, human hauler, and motorbikes. Results from this study showed that

452 different distal and proximal determents — which are the components of the conceptual model —

453 significantly influence the non-motorized mode choice behavior of people. Regarding the stated preference

454 of the respondents in choosing NMT for future work trips (i.e., intention), this study revealed that proximal

455 determinants have a higher degree of influence than that of distal determinants. This supports the hypothesis

456 derived from the TPB that intention can be predicted from proximal factors. On the other hand, in the case

457 of the respondents' current mode choice, distal determinants have a greater influence on the use of NMT

458 than proximal determinants, which supports the assumption derived from the TTI. Further, different types

459 of proximal and distal determinants and their multi-level influence reinforces the hypothesis of the

460 ecological models of health behavior that human behaviors are affected by multiple factors, acting at

461 different levels.

462   In the case of distal determinants, perception of safety (e.g., crime and traffic collision), as well as,

463 availability of facilities to support NMT (cycling and rickshaw) encouraged the respondents to use non-

464 motorized modes. Ogilvie et al. (2008) suggested incorporating individuals' perceptions of the environment

465 from origin to destination while estimating the probability to use NMT. Other studies also found a positive

466 association between perceptions of safety and the use of active transport (Titze et al. 2007). In CCC area,

467 the probability to use NMT increases when the respondents have a better perception of the safety and

468 availability of en-route cycling and rickshaw facilities. The major transport policies and interventions

469 adopted in Bangladesh least prioritize the use of rickshaws and rickshaw vans (Hasan and Dávila 2018).

470 The existing condition of NMT facilities available in CCC area was not up to the average satisfaction level

471 of the respondents (<3). Perception of better-walking facilities negatively associated with the current use

472 of NMT in the study area, a result that contradicts existing studies (Craig et al. 2002; Simons et al. 2017;

473 Van Cauwenberg et al. 2012). The travel time of the respondents significantly influences the choice of

474 modes in CCC, as longer travel time discouraged the use of NMT for a work trip, which is in accord with

475 other studies (Handy and Xing 2011; Ogilvie et al. 2008). The influence of travel time in determining the

476 choice of NMT in CCC is greater than the perception of better pedestrian facilities.

477   Besides, the perception of built environment factors, personal, psychological, and social factors

478   influence the choice of NMT for a work trip. Among different factors considered in this study, greater self-

479   efficacy, low level of education, marital status, and poor relationship with colleagues and family had a

480   significant role in choosing NMT. Several studies identified a positive influence of self-efficacy on

481   individuals' choice of NMT (Bopp et al. 2011; De Geus et al. 2008; Merom et al. 2008; Simons et al. 2017).

482   Notably, this study showed that higher-level educational status reduces the probability of using NMT,

483   which contradicts the observation of Simons et al. (2017). The respondents of this study who held at least

484   a college degree had a better work placement and higher social status. It encouraged them to use

485   personalized vehicles (e.g. private car or motorcycle) for a work trip, depending on their income. Further,

486   a good relationship with colleagues and family members was also inversely associated with the use of NMT.

487   Several studies also found an association of the choice of modes with colleagues and family members'

488   about NMT usage (Handy and Xing 2011; Muñoz et al. 2016). Hence, the social environment is an

489   important factor that influences the use of NMT.

490   Among the proximal determinants, attitude toward the use of non-motorized mode and perceived

491   behavioral control were estimated to be significant determinants in explaining current behavior. People who

492   provided a higher rating, representing their positive attitude toward NMT, generated a greater proportion

493   of non-motorized work trips — a result which was observed in the study by Handy and Xing (2011). A

494   positive attitude toward the use of NMT is developed reasonably from the beliefs that people consider

495   benefits (i.e. increase in utility) while choosing a mode of transport (Ajzen 1991). Therefore, most of the

496   NMT users in the study area were aware of the benefits of this form of transport. However, perceived

497   behavioral control was inversely related to the use of NMT, which is supported by the findings of Merom

498   et al. (2008). Most of the NMT users in CCC were less confident about the frequent use of this mode of

499   transport, due to difficulties (e.g., long travel time and distance, poor safety, topographical condition) that

500   they experienced while using NMT.

501   **5. Conclusion**

502   Whilst cities in developing countries generate a higher share of NMT trips, there has been limited

503   understanding of non-motorized travel behavior due to complex interactions among personal,

504   psychological, social, and environmental factors. This study aimed at identifying different factors

505   influencing existing and potential future non-motorized mode choice behavior in the context of a

506   developing country. Despite the contribution made in this study, achieving a comprehensive understanding

507   of the non-motorized mode choice behavior of people in developing countries is a challenging task. This

508   study only focused on middle-income working adults. Besides, 'accessibility to destination' was considered

509   as a built environment factor, while other factors such as residential/workplace density and land use were

510   not included in the models. Furthermore, a limited number of distal determinants related to biological and

511   social factors were considered. Though the model developed to analyze intention of the respondents toward

512   the use of NMT was statistically reliable, a coefficient of determination (R^2) of 0.309 indicated that the

513   independent variables explained just over 30% of the dependent variable (i.e., choice of NMT as a mode of

514   transport). Therefore, further research is warranted to improve the robustness of the model(s).

515   Despite these limitations, this study is a novel attempt to address a major challenge of predicting

516   non-motorized travel behavior, combining multiple behavioral models. Such an approach can assist urban

517   planners in adopting (i) infrastructural interventions (e.g., provision of sidewalks or cycle lane, different

518   types of barrier, divider, buffer or set back, street amenities, street furniture, and green elements) (Aziz et

519   al. 2017; Forsyth and Krizek 2010), (ii) spatial planning measures (e.g., compact development, organization

520   of destinations and accessibility, street-neighborhood-city scale design and management of built

521   environment) (Kim et al. 2014; Tight et al. 2011), and (iii) non-structural measures (e.g., traffic and safety

522   management, time and cost management, monitoring and evaluation of constructed project targeting NMT

523   user, the green movement and social awareness for NMT use) (Faherty and Morrissey 2014; Ho et al. 2017)

524   to promote the use of NMT. Evidence from this study underlined that improvements in the physical

525   environment for different sociodemographic groups would encourage more commuters to shift from MT to

526   NMT. Together, applications of spatial planning (e.g., mixed-use) approach and NMT dominant city

527   concept are required to develop an NMT friendly city. This study emphasized the need to consider proximal

528 and distal determinants to understand latent NMT/motorized travel demand for work trips. The proposed

529 models can be applied to other sociodemographic groups, trip purposes, and cities of Bangladesh, as well

530 as, in other developing countries which may assist in formulating guidelines to promote the use of NMT

531 and achieve sustainable urban transport systems.

Appendix. Photographs of Different Transport Modes

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

534

535 Figure 4. Typical modes of transport in CCC: (a) bus; (b) private car; (c) CNG autorickshaw; (d) human

536 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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