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How commuting choices affect physical and mental health: A case study of Bangkok, Thailand

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Abstract

Bangkok and its peripheral areas in Thailand have experienced increased traffic congestion, and the choice of commuting mode affects Thai commuters' health. This study examines the effects of commuting choices on the mental and physical health of the commuters in Bangkok and its peripheral areas. Cross-sectional data on 13,122 individuals are used in the study. The commuters' physical and mental health were addressed on a self-assessment questionnaire. The effects of the commuting modes on health are estimated by using an ordered logistic regression. The results show that commuters choosing public transportation are more likely to experience a significant reduction in physical and mental health compared to those commuting by car. In contrast, commuting by motorcycle and other active travel choices, including walking and biking, leads to better mental and physical health than does commuting by car. However, taking a sky train/subway does not have a significant effect on either physical or mental health. Our findings suggest specific impacts on people's health of different commuting modes.

Introduction

Gaining access to a transportation system is an important issue that affects people every day. This issue is especially important for people living in big cities, which are densely populated and where traffic is often congested. This traffic congestion can directly affect commuters' health by causing both physical and mental stress. Congestion can also damage people's health indirectly, by polluting the environment. Its associated problems of noise and air pollution have a diverse set of social impacts on health (Punpuing & Ross, 2001).

In metropolitan areas, there usually are various choices of travel mode. Since the modes of commuting have different service attributes, they affect commuters' physical and mental health differently. Undoubtedly, on-road commuting modes are affected by traffic. Commuters choosing these modes are likely to have health issues compared to those choosing active transportation. On the other hand, commuters taking open-air transportation, such as public buses, motorcycles, or active transportation, might be exposed to air pollution (e.g., Ramos et al., 2016), and noise pollution (e.g., Liu et al., 2019), causing further problems for their health.

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Bangkok, Thailand's capital city, and the surrounding areas provide various commuting modes. As in other Asian countries, however, cars and motorcycles are the dominant modes of commuting. In recent years, Bangkok has developed severe problems with congestion. In 2015, it was ranked the 12th most congested city in the world (Fernquest, 2017). Although Bangkok has continued to develop its public transportation network, it still ranked 15th in 2020 (Pishue, 2020).

Given the variety of commuting modes in Bangkok and its peripheral areas, this study aims to examine the impact of the choice of travel mode on a person's physical and mental health. To the best of our knowledge, there has been barely any such study in Thailand. The results could shed light on related transportation policies to improve the health of commuters. Moreover, the present study adds to the limited literature on the effects of commuting choice on health in Thailand, in particular, and more generally in developing countries in Asia with a similar commuting infrastructure and culture.

The rest of the paper is organized as follows. Section 2 discusses the related literature. Section 3 discusses our data and highlights several empirical facts. Sections 4 and 5 show the ordered logistic analysis and results, respectively. Section 6 discusses recommendations from the study. Section 7 concludes.

How Commuting Modes Might Affect Physical and Mental Health

Commuting is likely to affect people's well-being in various ways, given the range of specific commuting and personal characteristics (Liu et al., 2022). Since commuting is a daily activity, the availability of commuting options could shape the schedule for individual and household activities. Thus, changes to commuting options could sometimes determine activities, which potentially affects people's well-being.

The sense of well-being derived from travel is made up of affective (i.e., emotional) and cognitive (i.e., evaluative) components (Ettema et al., 2010). Affects are the immediate feelings that a person has in response to experiences during commuting. These experiences may include both instrumental and non-instrumental elements, such as the time to arrive or seat availability, for example. A cognitive assessment of commuting is an assessment of both the instrumental and non-instrumental aspects of commuting, based on prior commuting experiences. Cognitive and affective assessments of commuting determine commuter satisfaction and well-being (Liu et al., 2022).

Commuting can have an effect on people's well-being. Some trip-specific characteristics, such traffic congestion, could reduce the well-being of commuters. Longer commuting distance and time, for instance, decrease one's well-being. Discomfort from crowding, heat, and noise are also linked to commuter stress (Legrain et al., 2015). Such factors suggest that different commuting modes, given their specific characteristics, could affect commuters' emotion and evaluation affecting mental health differently.

In addition, different commuting modes promote different levels of physical activity. Commuting by passive modes as a primary mode, such as taking a car or public transportation, commonly involve less physical activity. Commuting by car in heavy traffic, for instance, involves being seated for long periods, increasing the risk of obesity, weight gain, and unhealthy lifestyle behaviors. By contrast, active commuting modes, such as walking and biking, could promote increased physical activity and thereby help improve people's health and well-being. The relationship between commuting mode and health can be shown in Figure 1.

In economics, according to Jacob et al. (2021), individuals' utility (or disutility) is a function of commuting mode choices and value in health. Direct utility could be either positive or negative, depending on how individuals feel toward their commute. Indirect utility is derived from a mode choice, through its impact on health. To select a commuting mode, individuals are assumed to maximize utility subject to constraints over income and time.

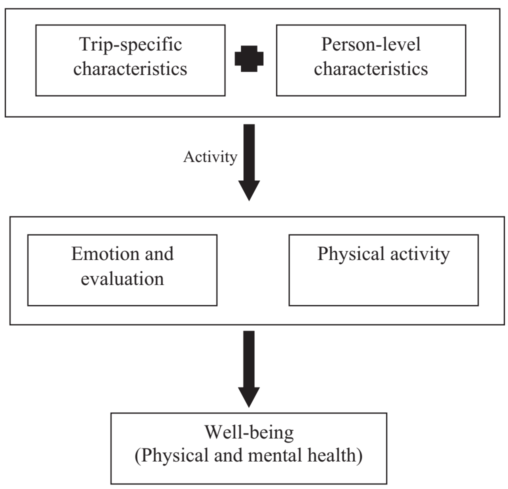

Figure 1 Relationship between commuting mode and physical and mental health

Health Measurements and Estimations of a Commuting Mode's Effects on Health

Health measurements

Personal health can be measured by either subjective or objective variables, or both. To estimate the impacts of commuting on health, studies often assess subjective well-being (SWB). This SWB is a broad concept of mental states, including the various positive and negative evaluations that people make of their lives, and the affective reactions people have to their experiences (Organisation for Economic Co-operation and Development [OECD], 2013).

Liu et al. (2022) systematically summarize studies relating to commuting, subjective well-being, and mental health. Life/job satisfaction, cognitive well-being, quality of life, and also overall well-being can be used to measure well-being. Evaluating mental health specifically includes perceived stress, emotions, and overall mental health. Questions used to ask respondents are generally broad and unrelated to any specific issues, such as how dissatisfied or satisfied with life overall. Typically, health survey questionnaires include such well-being measurements (e.g., SF-36 and SF-12). Questions for self-assessment can apply subjective ratings to measure well-being and mental health, as well as physical health. This subjective measurement, however, is arguably important, because only the person themself knows how they are feeling (Layard, 2005).

Subjective well-being can be specifically used to obtain the well-being from travel, referred to as travel or commuting well-being. Commuters respond regarding their satisfaction with the commute or feelings about commuting. Respondents are asked specific questions related to their commute, such as how happy they feel during their commute.

Besides subjective measurement, physical health can be measured using objective variables. As mentioned in the previous section, travel involves related physical activities, particularly active commuting. Commuting activities can affect overall physical health, such as obesity, diabetes, hypertension, and heart disease.

Estimations of a commuting mode's effects on health

An estimation of a commuting mode's effects on health depends on how health is measured. For a subjective rating scale, well-being or health is strictly an ordinal. Several studies, therefore, apply an ordered logistic regression (Gottholmseder et al., 2009; Legrain et al., 2015; Zhu & Fan, 2018). However, Ferrer-i-Carbonell and Frijters (2004) find that assuming ordinal or cardinal well-being measure generate insignificant differences in results. They compare the results from a linear fixed-effects (FE) model to those from FE ordered logistic specification. The results from both models are similar.

In some studies, however, multiple questions related to subjective well-being are used to obtain an average score (Humphreys et al., 2013; Smith, 2017). Multiple linear regressions are more appropriate for this health measurement.

In addition, some studies emphasize whether a respondent is likely to have some specific health issue, such as obesity or alcohol use (Liao et al., 2019). These studies group their main dependent variable as a dichotomous choice. Their dependent variable equals one if a respondent has those specific health issues, and otherwise equals zero. For this health measurement, they adopt a binary regression to estimate the effects of commuting modes on health.

Possible endogeneity issues

Estimating the effects of commuting modes on health using general subjective well-being and cross-sectional data may raise concerns about endogeneity from reverse causation between a selected commuting mode and subjective well-being.

Commuters' physical health may influence their decision to choose a primary commuting mode. A study by van Wee and Ettema (2016), for instance, indicates that less healthy people could be self-selected to less likely to start, or to continue commuting actively. Long-distance commuting could exacerbate this selection bias since commuters who experience any health problems may choose a primary mode that reduces their commuting time or change mode of commuting to minimize the impact of this strain.

Personal mental health issues may also impact commuters' commuting mode choices. Stressed people can engage in unhealthy behaviors, which leads them to commute by active modes less (Avila-Palencia, 2017) and more likely to commute by passive modes (Hansson et al., 2011). Changes in mood from day to day can also affect a commuting mode selection on that day (Lancée et al., 2017).

From those possible endogeneity problems, studies using general well-being may not conclude a causation of a commuting's mode effects on health issues. In the case of the panel data, however, changing in a primary commuting mode can be used to avoid endogeneity bias from estimating the commuting effects on health (Jacob et al., 2021). Reverse causation could also occur with other related-commuting variables, such as commuting time and distance, and health. Many studies use instrumental variables to avoid this endogeneity. For example, Tigre et al. (2016) use average distance as an instrument to predict actual commuting time that has an impact on youth's school performance. Kobus et al. (2015) use average commuting time to the nearest places as an instrument for actual commuting time. From our best knowledge, there is no study using instrumental variables for commuting modes.

In contrast, for studies that apply health measurements specifically obtained from commuting (i.e., known as travel/commuting well-being), there would be less of a possibility of endogeneity between commuting modes and health. Respondents chose their primary commuting mode, and then evaluated their emotions or mental and physical well-being based on their experiences in regards to the commuting mode choice (see Liu et al., 2022). Therefore, these studies claim a casual effect between commuting mode choice and commuter health.

Literature Review

Studies of a Commuting Mode's Effects on Health in Non-Asian Countries

Several studies in non-Asian countries have looked at the relationship between commuting mode and health. Evidence consistently indicates that commuting by car reduces overall physical and mental health (Jacob et al., 2020; Legrain et al., 2015). Specifically, they suggest that people who commute by car engage in less physical activity (Wener & Evans, 2007) and experience more negative moods and stress (Wener & Evans, 2011).

In general, studies reveal that active transportation is positively associated with mental and physical health. Since it is involved in active transportation, physical activity could lower the incidence of obesity, hypertension, and diabetes (Tajalli & Hajbabaie, 2017). This active mode, therefore, increases overall physical well-being (Humphreys et al., 2013). Moreover, active commuters report significantly greater life satisfaction (Chng et al., 2016) and are happier with their commutes, because they are relatively unaffected by traffic congestion, compared to commuters by bus or car (Smith, 2017).

The effects of public transportation on physical and mental health are mixed, based on commuting choice. For example, Tajalli and Hajbabaie (2017) show that taking the subway is related to a lower probability of obesity and diabetes, while riding the city bus is linked to a higher probability of obesity. Better public transportation connectivity can also lower mental distress (Chng et al., 2016).

In non-Asian countries, the motorcycle is not the main commuting mode, and therefore, few studies investigate its effects on health. In the United Kingdom, the effects on health from commuting by motorcycle are ambiguous. Roberts et al. (2011) find that commuting by motorcycle has an insignificant effect on mental health. In contrast, Gottholmseder et al. (2009) find that motorcyclists are more likely to be stressed from their commute.

Studies of a Commuting Mode's Effects on Health in Asian Countries

The relationship between commuting choice and health has been underexplored in Asian countries. Given the specific commuting environments and cultures involved, however, some studies find that the effects on health of commuting in Asian countries are different from those in non-Asian countries.

For example, Zhu and Fan (2018) find that commuters using public city buses report the least happiness during commuting. People who use the subway, public bikes, and electric bikes show no difference from car users in commuting happiness. Meanwhile, active transportation shows ambiguous effects on health in Asian countries. Zhu et al. (2019) unexpectedly find that the subjective well-being of Chinese residents who commute by walking or cycling is significantly lower than that of those who commute by other transportation modes.

Contrarily, in Japan, some studies show a positive association between active commuting, mental status, and the physical activity of commuters (Abe et al., 2018; Tsunoda et al., 2015). These findings are similar to those in non-Asian countries.

Even though motorcycles have become an important commuting mode in Asian countries, few studies investigate its effects on health. Taking an example closest to the present study, Liao et al. (2019) find that spending more time commuting by motorcycle can increase the level of active transportation. Zhu et al. (2019) report that commuting by motorcycle in urban areas of China causes the lowest subjective well-being, compared to other commuting modes.

Summary of the Literature and Contribution of This Study

Based on the previous studies, commuting choices in different countries affect commuters' physical and mental health differently. The motorcycle is not the main vehicle for commuting in non-Asian countries; therefore, its effects on health are still unclear. In the meantime, the motorcycle has become a more important commuting mode, while active transportation is not widely used in Asian countries. Additionally, the previous studies arrive at inconclusive results, unrelated to the choice of commuting mode and its health effects. This area of study is thus worth investigating, to fill in the gap in the literature about those commuting modes.

Data and Descriptive Analysis

This study uses individual data obtained from the National Statistical Organization (NSO). Unfortunately, the NSO only collected data about physical and mental health status by commuting mode in 2016. Therefore, we use cross-sectional data in this study. Since most primary transportation modes and traffic situations rarely change, the findings still provide useful information to Thai policymakers to improve transportation quality. The sample is limited to people living and working/studying in Bangkok and the peripheral provinces — Nonthaburi, Patumthani, Nakhonpratom, Samutprakarn, and Samutsakorn — at the time of the interview. The total sample covers 13,122 observations.

The commuting choices covered in this study are divided into five categories. First, the car mode includes both private car and pooling car/taxi. Several studies group private car and pooling car/taxi together as an automobile commuting mode (e.g., St-Louis, 2014). This is also appropriate in Bangkok, since private car and pooling car/taxi share similar characteristics, such as commuters being guaranteed to have seats, air conditioning in vehicles, and door-to-door commuting from the original location to the destination. The second mode is the bus, as public transportation. Third, the sky train and subway are also public transportation; however, we separate this mode from buses because of the different characteristics of on-road and speed railway public transportation, and also because transportation cost could be a constraint for commuters in choosing this mode. Details on fares charged by public transportation mode are in Appendix A1 of Appendix A. Fourth, motorcycle commuting may be private or taxi. Last, active commuting includes walking and biking.

To assess the physical and mental health issues related to commuting, the NSO conducted a self-assessment questionnaire. The respondents were asked which commuting mode they used most frequently as their primary mode. Then, they were asked whether or not this commute negatively affected their physical or mental health. They rated the impact levels on a scale from zero to three. Zero indicates no effect on physical or mental health from the commute. Impact levels from one to three, respectively, indicate low, medium, and high impacts. Health assessments, therefore, are obtained for each specific commuting mode.

There are data limitations related to commuting mode choices and commuters' health that future studies need to consider, as follows:

1. According to the NSO questionnaire, the respondents had to choose only one primary commuting mode (i.e., the mode used for the longest portion of the trip or used most frequently). Some commuters, however, use multiple commuting modes in each trip. Even though the impacts on health in this study should be mostly from the primary commuting mode, other modes used in the trip could possibly affect commuters' health, as well.

2. There may be concerns about the driver-passenger status between private car and pooling car/taxi, since being a passenger could reduce the negative commuting effect on a commuter's health (Roberts et al., 2011). Unfortunately, we do not have data about driver-passenger status.

3. According to the NSO's questions, our study can assess only the negative impacts of commuting modes on physical and mental health. Moreover, the health assessments are subjectively measured by rating scale. The trip-specific influences on physical and mental health may differ from day to day (Ettema et al., 2010). A response of self-assessment may be a specific evaluation of the day of the interview, and cannot be considered steady states.

The descriptive statistics are reported in Table 1. More than half of those in the sample commute by motorcycle and car. Only 14 percent of the sample commute by active transportation. The average commuting time and distance are almost an hour and 10 kilometers, respectively. According to congestion by time, commuting rush hour lasts from 7 AM to 9 AM and 5 PM to 7 PM (TomTom International BV, 2022). More than 80 percent of those in the sample commute during rush hour, in the morning, in the evening, or in both.

Almost half of the sample is female, and 53 percent are married. The sample covers children from preschool age to elderly, and the average age is approximately 34 years old. Only 35 percent of the sample has a college degree. The average family income is approximately 33,700 Thai baht (or $531.44) per month. The majority of the sample works as craft, plant, and machine operators, or as managers, professionals, and technicians.

Table 1 Descriptive statistics

	Description	Mean	*SD*	Max.	Min.
Health assessment					
Physical health	4-scale rating of negative physical health from commuting; no effect, low, medium, and high effect	0.509	0.742	0	3
Mental health	4-scale rating of negative mental health from commuting; no effect, low, medium, and high effect	0.602	0.817	0	3
Commuting mode					
Car	1: if the respondents commute by car/ 0: otherwise	0.316	0.465	1	0
Public bus	1: if the respondents commute by public transportation/ 0: otherwise	0.211	0.408	1	0
Sky train/subway	1: if the respondents commute by sky train/subway/ 0: otherwise	0.010	0.098	1	0
Motorcycle	1: if the respondents commute by motorcycle/ 0: otherwise	0.321	0.467	1	0
Active commuting	1: if the respondents commute by active commuting/ 0: otherwise	0.142	0.349	1	0
Control Variables					
Commuting-Related					
Total commuting time	One-way commuting time (unit: hours)	0.937	0.790	4	0.017
Total commuting distance	One-way commuting distance (unit: kilometers)	9.371	9.666	25	0.001
Commuting in rush hour	1: if the respondents commute in rush hour either in the morning or evening, or both/ 0: otherwise	0.830	0.376	1	0
Sociodemographic					
Female	1: if the respondents are female/ 0: otherwise	0.476	0.499	1	0
Married	1: if the respondents are married/ 0: otherwise	0.525	0.499	1	0
Age	Respondents age in years (unit: years)	33.807	15.371	94	6
Holding a college degree	1: if the respondents hold a college degree/ 0: otherwise	0.353	0.478	1	0
Family income	Family income from all sources (unit: thousands Thai baht)	33.703	117.148	2,999.997	2
Number of household members	Number of family members (unit: persons)	3.791	2.211	15	11
Occupation					
Manager, professional, and technician	1: if the respondents are either manager, professional, or technician/ 0: otherwise	0.267	3.791	1	0
Service worker	1: if the respondents are service worker/ 0: otherwise	0.155	0.362	1	0
Skilled agricultural worker	1: if the respondents are skilled agricultural worker/ 0: otherwise	0.023	0.151	1	0
Craft, plant, and machine operator	1: if the respondents are either craft, plant, or machine operator female/ 0: otherwise	0.307	0.461	1	0
Other	1: if the respondents working as other occupation/ 0: otherwise	0.248	0.432	1	0

Note: *SD* indicates standard deviation.

In Figure 2, approximately half of the sample commuting by car and public bus report that they experience no negative effect on their physical health from their commute. Approximately 30 percent of the people taking a public bus, and slightly less than 30 percent of the people commuting by car, indicate that commuting has little effect on their physical health. Almost 90 percent of the people who choose an active commuting mode report no negative effect on their physical health from the commute.

The lowest proportion of the commuters taking the sky train/subway indicate that their commute does not affect their physical health, while almost 40 percent of them perceive a low negative effect.

In Figure 3, more than half of the people commuting by motorcycle and other forms of transportation indicate that they experience no negative impact on their mental health from the commute. Commuting by sky train/subway has the highest proportion of low and medium negative effects. However, people driving cars and taking public buses have the highest proportion of reporting a strong negative effect on their mental health.

Figures 4 to 6 show the average commuting time spent and distance by commuting mode. Our data reveal that people commuting longer distances chose non-active transportation modes. Commuting by sky train/subway involves more time (1.78 hours) and distance (18.08 kilometers) than do other modes. However, its average distance per hour is slightly different from that of a car or motorcycle.

Interestingly, taking public transportation covers the least distance per hour. This could be explained by the traffic congestion in Bangkok and the peripheral areas. Since driving a car or riding a motorcycle could be speedier than riding a public bus, people taking a public bus would, as a result, spend much more time in traffic.

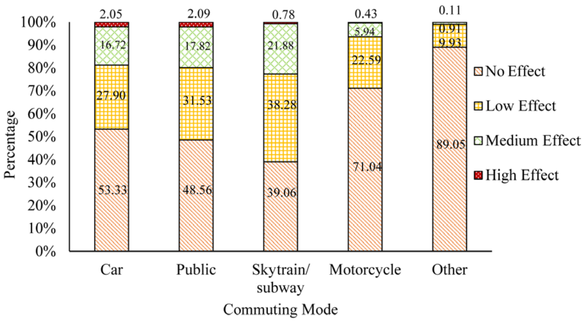

Figure 2 Negative effects on physical health by commuting mode

Note: Percentages are calculated based on the number of respondents for each commuting mode.

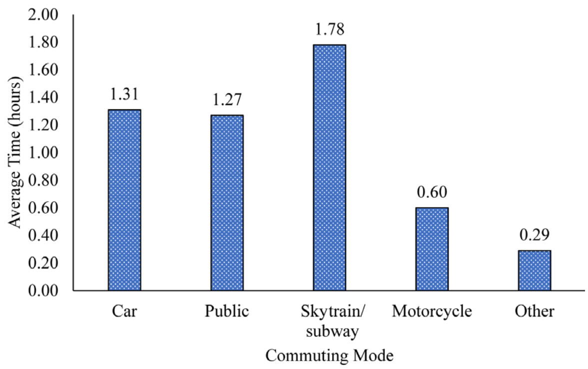

Figure 4 Average commuting time by commuting mode

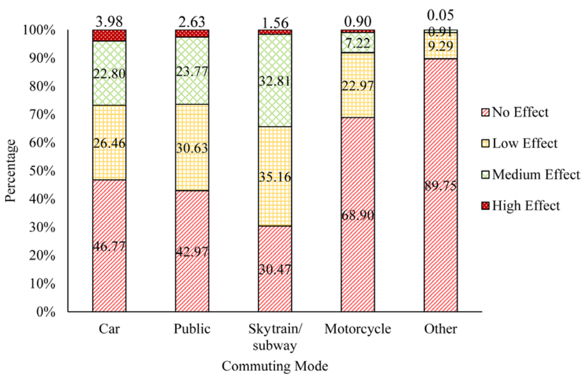

Figure 3 Negative effects on mental health by commuting mode

Note: Percentages are calculated based on the number of respondents for each commuting mode.

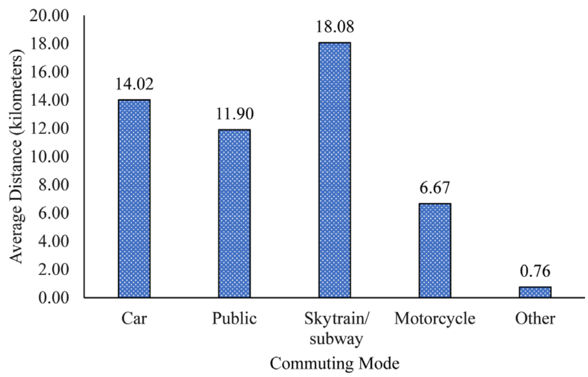

Figure 5 Average commuting distance by commuting mode

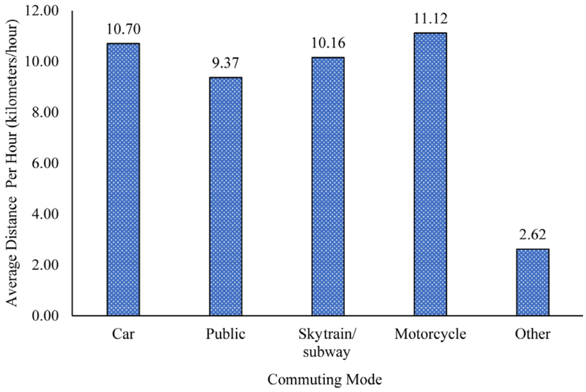

Figure 6 Average commuting distance per hour by commuting mode

Methodology

To take into account the discrete and ordered nature of our dependent variable, we estimate the ordered logistic model. Following Greene (2000), the empirical model is defined by the following equation:

$$Y_i^* = \beta * mode_i + \gamma * X_i' + \varepsilon_i, \quad (1)$$

where Y_i^* is the levels of commuting impact on the physical or mental health status of individual i. Both mental and physical health statuses have four ratings: no effect, low, medium, and high effect. $Mode_i$ is a set of commuting mode dummy variables; car as a reference group, public bus, sky train/subway, motorcycle, and active transportation.

Our dependent and main independent variables are similar to a study of Zhu and Fan (2018). As mentioned earlier in the data section, the impacts on physical and mental health in this study are specifically derived from the commuting mode. Consequently, in our study, there is less possibility of endogeneity bias between the selected commuting mode and commuter health.

X_i' represents the vector of the control variables of individual i, including sociodemographic and commuting-related variables as shown in Table 1. β and γ denote the corresponding coefficients.

Results

Linear Probability Model

Before presenting the results from our main estimations using the ordered logistic regressions, we also estimate the commuting mode's effects on physical and mental health by using linear probability models. Physical or mental health status is grouped as a binary variable. In this estimation, therefore, physical or mental health status is equal to one if a respondent stated that their commuting had an impact on physical or mental health, and equal to zero otherwise.

The results reported in the first columns of Tables 2 and 3 show that commuters taking a public bus are 7.8 and 7 percent more likely, respectively, to have negative physical and mental health issues from their commuting than are those driving/taking a car. In contrast, taking a motorcycle or commuting by an active mode could significantly reduce the chance of having negative physical health issues, by 2.5 and 1.4 percent, respectively. The probabilities of experiencing mental health issues from those two commuting modes are also less than taking a car, by 5 and 17.9 percent, respectively.

Following the study of Ferrer-i-Carbonell and Frijters (2004), we also treat physical and mental health as a cardinal variable and apply linear fixed-effect regressions. Our additional results, reported in Appendix C1 of Appendix C, are similar to those using linear probability models and ordered logistic regressions.

Ordered Logistic Regression

The results of the ordered logistic regression are reported in Tables 2 and 3. The overall results are consistent with those using the linear probability models. Since the coefficients of the regression cannot be interpreted, the marginal effects are calculated. In Table 2, we find that commuting by public bus could have a 7 percent lower chance of having no negative effect on physical health. In contrast, this kind of commuting choice increases the probability of having low and medium negative effects by 3.5 percent and 3.1 percent, respectively.

In contrast, taking a motorcycle and active transportation could reduce the chance of physical health issues for commuters. Specifically, the probability that commuting will have no negative effect on physical health increases by approximately 20 percent.

Table 2 Effects of commuting choice on physical health

Commuting Mode	Linear Probability Model	Ordered Logit Regression				
		Coefficient	Marginal Effect			
			No effect	Low	Medium	High
Public bus	0.078***	0.358***	-0.070***	0.035***	0.031***	0.004***
	(0.013)	(0.054)	(0.010)	(0.005)	(0.005)	(0.001)
Motorcycle	-0.025**	-0.154***	0.030***	-0.015***	-0.013***	-0.002***
	(0.012)	(0.053)	(0.010)	(0.005)	(0.005)	(0.001)
Sky train/ subway	0.040	-0.003	0.001	0.000	0.000	0.000
	(0.045)	(0.175)	(0.034)	(0.017)	(0.015)	(0.002)
Active	-0.140***	-1.045***	0.204***	-0.101***	-0.090***	-0.013***
	(0.013)	(0.088)	(0.017)	(0.008)	(0.008)	(0.001)
		Thresholds				
		Y=1 (low effect)		1.146		
		Y=2 (medium effect)		2.785		
		Y=3 (high effect)		5.350		
n	13,122	13,122				
R^2	0.1610	0.1032				

Notes: The reference group is commuting by car. All regressions are controlled by individual characteristics. In the ordered logistic regression, the physical health rating ranges from zero to three, in which zero indicates no effect and three indicates a high negative effect. In the linear probability model, physical health equals 1 if a respondent stated that their commuting negatively affects physical health and otherwise equals zero. Robust standard errors are in parentheses. Full results of the ordered logistic regression are reported in Appendix B1 of Appendix B. *$p < .10$; **$p < .05$; ***$p < .01$.

Table 3 Effects of commuting choice on mental health

Commuting Mode	Linear Probability Model	Ordered Logit Regression				
		Coefficient	Marginal Effect			
			No effect	Low	Medium	High
Public bus	0.070***	0.271***	-0.052***	0.002***	0.027***	0.005***
	(0.012)	(0.053)	(0.010)	(0.004)	(0.005)	(0.001)
Motorcycle	-0.050***	-0.270***	0.052***	-0.020***	-0.027***	-0.005***
	(0.012)	(0.052)	(0.010)	(0.004)	(0.005)	(0.001)
Sky train/ subway	0.041	-0.015	0.003	-0.001	-0.001	0.000
	(0.044)	(0.161)	(0.031)	(0.012)	(0.016)	(0.003)
Active	-0.179***	-1.268***	0.242***	-0.092***	-0.125***	-0.026***
	(0.013)	(0.089)	(0.017)	(0.006)	(0.009)	(0.002)
		Thresholds				
		Y=1 (low effect)		0.790		
		Y=2 (medium effect)		2.305		
		Y=3 (high effect)		4.828		
n	13,122	13,122				
R^2	0.2039	0.1323				

Notes: The reference group is commuting by car. All regressions are controlled by individual characteristics. In the ordered logistic regression, the mental health rating ranges from zero to three, in which zero indicates no effect and three indicates a high negative effect. In the linear probability model, physical health equals 1 if a respondent stated that their commuting negatively affects physical health, and otherwise equals zero. Robust standard errors are in parentheses. Full results of the ordered logistic regression are reported in Appendix B2 of Appendix B. *$p < .10$; **$p < .05$; ***$p < .01$.

The findings for the negative impact on mental health are similar to those for physical health. The marginal effects in Table 3 show that commuters who take public transportation are approximately 5 percent less likely to have no negative impact on mental health from the commute than are those traveling by car. Taking public transportation could lead to a higher chance of having a low, medium, and high negative impact on their mental health than does taking a car. Our results are consistent with Zhu et al. (2019); Zhu and Fan (2018), who find that Chinese commuters taking public transportation report less happiness than those taking a car. Discomfort from crowding, heat, and noise from public transportation can negatively affect mental health (Legrain et al., 2015).

Contrarily, commuters taking a motorcycle have a 3 percent lower probability of mental health impairments. This result contradicts that of Zhu et al. (2019), who find that commuting by motorcycle causes the least subjective well-being in China. Different environments and regulations for commuting by motorcycle across countries could account for this contradiction. Commuters choosing active transportation also have an approximately 20 percent lower probability of mental health issues. Our result is similar to that of other studies mentioned in the literature section (Abe et al., 2018; Tsunoda et al., 2015).

Estimated physical health that is equal to zero indicates no effect. The thresholds show that estimated physical health ranges between more than zero and less than or equal to 1.146 ($0 < \widehat{Y_i} \leq 1.146$) indicate a low effect on physical health ($Y_i = 1$). Estimated physical health ranges between more than 1.146 and less than or equal to 2.785 ($1.146 < \widehat{Y_i} \leq 2.785$) indicate a medium effect on physical health ($Y_i = 2$). Estimated physical health ranges between more than 2.785 and less than or equal to 5.350 ($2.785 < \widehat{Y_i} \leq 5.350$) indicate a high effect on physical health ($Y_i = 3$).

Estimated mental health that is equal to zero indicates no effect. The thresholds show that estimated mental health ranges between more than zero and less than or equal to 0.790 ($0 < \widehat{Y_i} \leq 0.790$) indicate a low effect on mental health ($Y_i = 1$). Estimated mental health ranges between more than 0.790 and less than or equal to 2.305 ($0.790 < \widehat{Y_i} \leq 2.305$) indicate a medium effect on mental health ($Y_i = 2$). Estimated mental health ranges between more than 2.305 and less than or equal to 4.828 ($2.305 < \widehat{Y_i} \leq 4.828$) indicate a high effect on mental health ($Y_i = 3$).

Robustness Checks

A respondent's socio-economics, especially income, can be correlated with a commuting mode choice. Different income levels determine commuting mode choices (Li & Zhao, 2015; Shokoohi et al., 2012). We also do robustness checks by excluding control variables that may be endogenous. Our results, as reported in Table C2 of Appendix C, are mostly similar to the baseline results.

Columns 1 and 3 show the coefficients of the ordered logistic regressions without income level as a control variable. The significant negative effects of taking sky train/ subway on physical and mental health become significant. Compared to the results with full controls, the magnitude of all coefficients are greater than those without controlling income level. Altogether, they indicate that excluding an income variable from the models may generate an upward bias in the results.

The results in Columns 2 and 4, excluding all control variables, are similar to those without an income variable. The results of full controls are preferred, to avoid a bias from omitting variables.

Predicted Probabilities

To further ease interpretation, we predict the probability of having physical and mental health impacts from a particular commuting choice, based on the full models in Tables 2 and 3. Since a high proportion of our sample commutes by motorcycle, car, and public bus, we choose to predict the probability of these modes.

Based on the existing literature, commuting time could be another important factor affecting commuters' health, besides commuting mode (Künn-Nelen, 2016; Roberts et al., 2011; Zhu et al., 2019). In the meantime, commuting time is one of the commuting-related controls in our specification, and it is significant in all results. We therefore emphasize the effects on health of commuting mode by commuting time spent. We manipulate the values of the commuting mode and commuting time variables while holding the other controls at their mean values.

Commuting by motorcycle or car has a higher chance of having no effect on either physical or mental health than does taking a public bus (Figures 7 and 11). However, all modes decrease in probability, the more time one spends commuting.

When commuting for a short time (approximately 2–2.5 hours or less), commuters taking a public bus have a higher probability of experiencing a low effect on their health than do those commuting by motorcycle and car (Figures 8 and 12. In contrast, people commuting by motorcycle and car are more likely to have a higher chance of having a low effect on their mental and physical health than do those taking public transportation, when they travel for more than 2.5 hours. Explanations for this should be sought in future studies.

For a medium effect on mental health (Figures 9 and 13, the gap between all commuting modes becomes smaller, the longer one travels. In contrast, the gap for physical health is constant across commuting time. These results indicate that when commuting for a longer period of time, commuters using all commuting modes have an indifferent probability of experiencing a medium effect on their mental health. For their physical health, however, public bus commuters still have a higher chance of experiencing a medium effect than do car and motorcycle commuters.

Additionally, people taking public transportation are more likely to have a high level of physical and mental health issues from their longer commuting time, since the gap becomes wider (Figures 10 and 14).

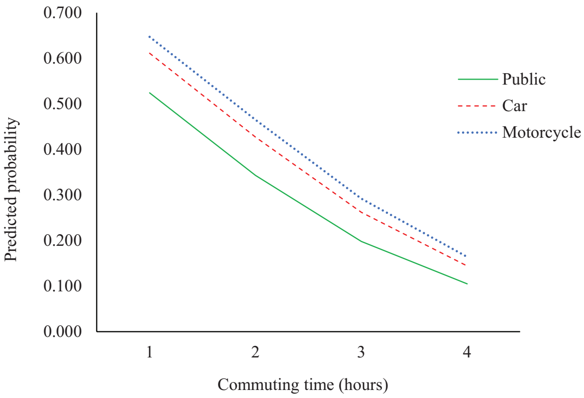

Figure 7 Predicted probability of no effect on physical health by commuting time

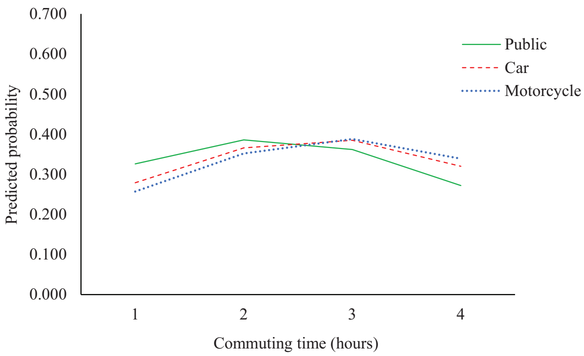

Figure 8 Predicted probability of low effect on physical health by commuting time

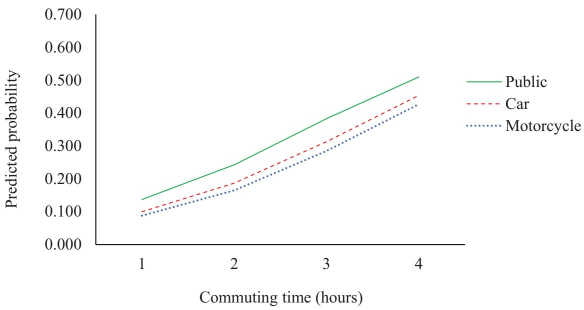

Figure 9 Predicted probability of medium effect on physical health by commuting time

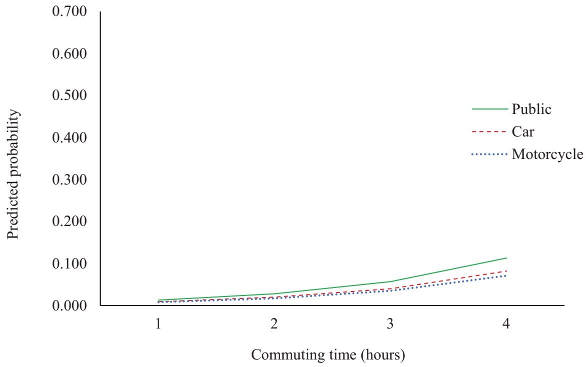

Figure 10 Predicted probability of high effect on physical health by commuting time

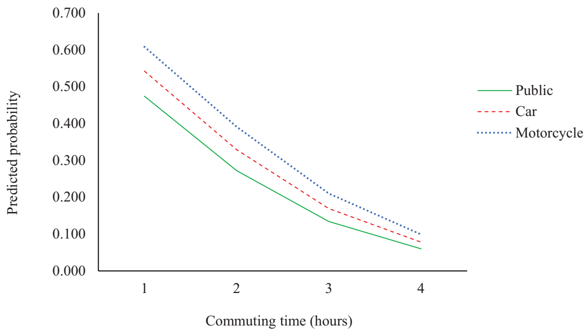

Figure 11 Predicted probability of no effect on mental health by commuting mode and time

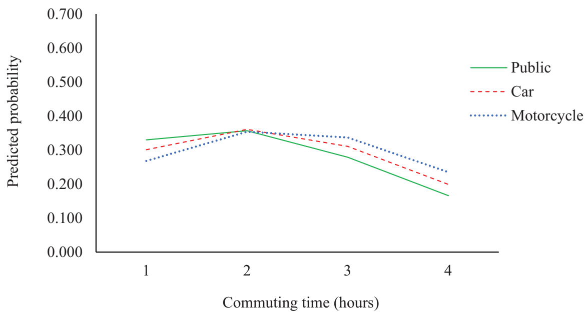

Figure 12 Predicted probability of low effect on mental health by commuting mode and time

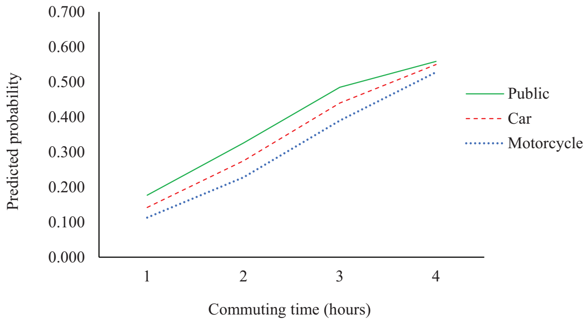

Figure 13 Predicted probability of medium effect on mental health by commuting mode and time

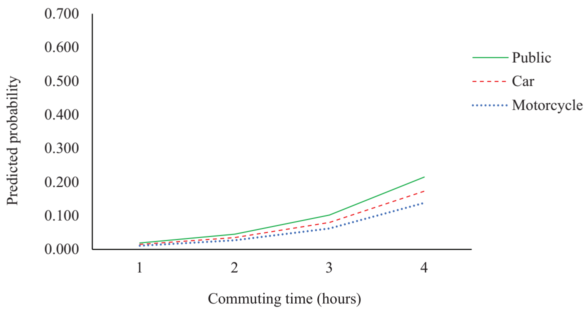

Figure 14 Predicted probability of high effect on mental health by commuting mode and time

In sum, the longer someone commutes on the road, the greater their chance of experiencing an impact on their health. Our predicted results are consistent with those of previous studies (Rüger et al., 2017; Sha et al., 2019) in finding that a longer commuting time is negatively associated with life satisfaction. In the context of Thailand, however, the health of commuters taking a public bus can suffer a higher effect from the commute than does the health of those taking a car or motorcycle.

Discussion and Recommendations

Our results are different from those of the study by Gottholmseder et al. (2009), who find that commuting modes have an insignificant effect on health. They specifically explain that this is because they control for other commuting-related variables, such as commuting time and distance. Even though our specification is controlled for those commuting-related variables, we find significant results with regard to commuting mode. Our results therefore strongly indicate that the characteristics of each commuting mode can affect commuters' health. Specifically, different commuting modes provide different convenience levels. In Thailand, there are many issues related to the public bus, such as bus stop proximity, on-board space availability, and bus reliability, leading commuters to report low satisfaction (Chaisomboon et al., 2020; Ueasangkomsate, 2019). Moreover, given the weather in Thailand, commuting by public bus could cause heat stress, affecting commuters' health (Arifwidodo & Chandrasiri, 2020). Consequently, based on the predicted probabilities, the public bus is more likely to increase physical and mental health issues when commuters travel longer. Our results thus suggest the need to improve public bus facilities and infrastructure, to enhance the quality of public buses. Also, improving traffic congestion to reduce commuting time could alleviate physical and mental health issues for commuters taking public transportation.

These results overall are consistent with those of previous studies showing that active transportation could lead to better physical and mental health (Abe et al., 2018; Chng et al., 2016; Smith, 2017; Tajalli & Hajbabaie, 2017; Tsunoda et al., 2015). However, in Bangkok and the peripheral areas, active travel is often not a suitable choice because of the safety issue for pedestrians (Pongprasert & Kubota, 2017). Therefore, adequate infrastructure for pedestrians could encourage people to decide to choose the active mode.

Even though commuters taking a motorcycle are more likely to have better physical and mental health, the issues related to motorcycle accidents require further consideration. According to Pongprasert and Kubota (2017), the number of pedestrian accidents in 2015 increased by approximately 20 percent from 2014, due to an increase in the number of motorcycle taxis in Bangkok. This could reduce the motivation for commuters to choose active transportation.

Sky train/subway commuting shows statistically insignificant results, which implies that the effects on the physical and mental health of commuters taking the sky train/subway are insignificantly different from those of commuters taking a car.

Another possible way to improve commuters' health is by encouraging commuters to switch from taking a public bus to taking a sky train/subway. Currently, the government has extended sky train/subway lines to cover the areas of Bangkok and its peripheries. Doing so could increase accessibility for commuters to choose this mode. As mentioned earlier, however, the sky train/subway fare is more expensive than that of other forms of public transportation. This cost could be a barrier for commuters. The government should consider this issue, to help motivate people to take the sky train/subway.

In the present study, there are data limitations with which future studies should be concerned. First, only a primary commuting mode is observed. Given that some commuters take multiple modes, other modes could also be affecting commuters' health. Second, we lack a driver-passenger status for commuters taking a private car/pooling car/taxi. This status could also affect commuters' health. Third, physical and mental health are collected in subjective questions, and measured only negative sides on health.

Conclusion

Given the different cultures of commuting in Asian countries, this study emphasizes the effects of different commuting modes on physical and mental health. Our findings from the ordered logistic regression indicate that commuters who travel by public transportation are more likely to have physical and mental health issues than are those commuting by other modes. This could be a result of specific characteristics of the public bus in Thailand. Commuters taking a motorcycle or choosing an active form of transportation are more likely to have better physical and mental health. The issues related to motorcycle accidents, however, should be taken into consideration. On the other hand, our results do not show significant differences in physical and mental health issues between commuters traveling by car and those taking a sky train/subway. Our study thus suggests related policies to improve public bus facilities and infrastructure, to alleviate the problems for physical and mental health.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Appendices

Appendix A *Additional Information on Fare Charge by Commuting Mode*

Appendix A1 Fare charges within Bangkok and peripheral areas by commuting mode

Commuting Mode and Fare	Fare Charge	Cost Per Round
Public buses without air conditioning	One price	8 THB (or approximately $0.23)
Public buses with air conditioning	By distance	From 12–26 THB (or approximately $0.35–$0.76)
Sky train/subway	By distance	From 16–59 THB (or approximately $0.47–$1.74)

Source: Collected by the authors.

Appendix B *Full Results of Ordered Logistic Regressions*

Appendix B1 Full results of ordered logistic regression of mental health

Variable	Coefficient	Marginal Effect			
		No effect	Low	Medium	High
Public bus	0.271***	-0.052***	0.002***	0.027***	0.005***
	(0.053)	(0.010)	(0.004)	(0.005)	(0.001)
Motorcycle	-0.270***	0.052***	-0.020***	-0.027***	-0.005***
	(0.052)	(0.010)	(0.004)	(0.005)	(0.001)
Sky train/subway	-0.015	0.003	-0.001	-0.001	0.000
	(0.161)	(0.031)	(0.012)	(0.016)	(0.003)
Active	-1.268***	0.242***	-0.092***	-0.125***	-0.026***
	(0.089)	(0.017)	(0.006)	(0.009)	(0.002)
Controls					
Commuting time	0.880***	-0.168***	0.064***	0.086***	0.018***
	(0.034)	(0.006)	(0.003)	(0.003)	(0.001)
Commuting distance	0.006**	-0.001***	0.000***	0.001***	0.000***
	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)
Rush hour	-0.011	0.002	-0.001	-0.001	0.000
	(0.052)	(0.010)	(0.004)	(0.005)	(0.001)
Female	-0.106***	0.020***	-0.008***	-0.010***	-0.002***
	(0.039)	(0.007)	(0.003)	(0.004)	(0.001)
Married	-0.200***	0.038***	-0.015***	-0.020***	-0.004***
	(0.050)	(0.010)	(0.004)	(0.005)	(0.001)
Age	0.006***	-0.001***	0.000***	0.001***	0.000***
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)
Having a college degree	0.042	-0.008	0.003	0.004	0.001
	(0.050)	(0.010)	(0.004)	(0.005)	(0.001)
Family income	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Household member	-0.004	0.001	0.000	0.000	0.000
	(0.009)	(0.002)	(0.001)	(0.001)	(0.000)
Service worker	-0.246***	0.047***	-0.018***	-0.024***	-0.005***
	(0.064)	(0.012)	(0.005)	(0.006)	(0.001)
Skilled agricultural worker	-1.421***	0.271***	-0.103***	-0.140***	-0.029***
	(0.215)	(0.041)	(0.016)	(0.021)	(0.005)
Craft, plant, and machine operator	-0.424***	0.081***	-0.031***	-0.042***	-0.009***
	(0.061)	(0.012)	(0.004)	(0.006)	(0.001)
Other occupation	-0.542***	0.103***	-0.039***	-0.053***	-0.011***
	(0.071)	(0.013)	(0.005)	(0.007)	(0.002)

Notes: Commuting by car, not during rush hour, male, single, not holding a college degree, and working as either manager, professional, or technician are a reference group. Robust standard errors are in parentheses.
$*p < .10$; $**p < .05$; $***p < .01$.

Appendix B2 Full results of ordered logistic regression of physical health

Variable	Coefficient	Marginal Effect			
		No effect	Low	Medium	High
Public bus	0.358***	-0.070***	0.035***	0.031***	0.004***
	(0.054)	(0.010)	(0.005)	(0.005)	(0.001)
Motorcycle	-0.154***	0.030***	-0.015***	-0.013***	-0.002***
	(0.053)	(0.010)	(0.005)	(0.005)	(0.001)
Sky train/subway	-0.003	0.001	0.000	0.000	0.000
	(0.175)	(0.034)	(0.017)	(0.015)	(0.002)
Active	-1.045***	0.204***	-0.101***	-0.090***	-0.013***
	(0.088)	(0.017)	(0.008)	(0.008)	(0.001)
Controls					
Commuting time	0.745***	-0.146***	0.072***	0.064***	0.009***
	(0.033)	(0.006)	(0.003)	(0.003)	(0.001)
Commuting distance	0.002	0.000	0.000	0.000	0.000
	(0.003)	(0.001)	(0.000)	(0.000)	(0.000)
Rush hour	-0.007	0.001	-0.001	-0.001	0.000
	(0.052)	(0.010)	(0.005)	(0.004)	(0.001)

Appendix B2 Continued

Variable	Coefficient	Marginal Effect			
		No effect	Low	Medium	High
Female	-0.092**	0.018**	-0.009**	-0.008**	-0.001**
	(0.039)	(0.008)	(0.004)	(0.003)	(0.000)
Married	-0.205***	0.040***	-0.020***	-0.018***	-0.003***
	(0.051)	(0.010)	(0.005)	(0.004)	(0.001)
Age	0.009***	-0.002***	0.001***	0.001***	0.000***
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)
Having a college degree	0.085*	-0.017*	0.008*	0.007*	0.001
	(0.051)	(0.010)	(0.005)	(0.004)	(0.001)
Family income	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Household member	-0.001	0.000	0.000	0.000	0.000
	(0.009)	(0.002)	(0.001)	(0.001)	(0.000)
Service worker	-0.133**	0.026**	-0.013**	-0.011**	-0.002**
	(0.064)	(0.013)	(0.006)	(0.006)	(0.001)
Skilled agricultural worker	-1.503***	0.294***	-0.145***	-0.130***	-0.019***
	(0.239)	(0.047)	(0.023)	(0.021)	(0.003)
Craft, plant, and machine operator	-0.297***	0.058***	-0.029***	-0.026***	-0.004***
	(0.062)	(0.012)	(0.006)	(0.005)	(0.001)
Other occupation	-0.397***	0.078***	-0.038***	-0.034***	-0.005***
	(0.072)	(0.014)	(0.007)	(0.006)	(0.001)

Notes: Commuting by car, not during the rush hours, male, single, not holding a college degree, and working as either a manager, professional, or technician are a reference group. Robust standard errors are in parentheses.
$*p < .10$; $**p < .05$; $***p < .01$.

Appendix C *Additional Results of Robustness Checks*

Appendix C1 Additional Results of Linear Fixed-Effect Regressions

Commuting Mode	Physical Health	Mental Health
Public bus	0.121***	0.096***
	(0.020)	(0.021)
Motorcycle	-0.046***	-0.095***
	(0.017)	(0.018)
Sky train/subway	-0.004	-0.026
	(0.074)	(0.075)
Active	-0.159***	-0.226***
	(0.019)	(0.020)
n	13,122	13,122
R^2	0.1832	0.2438

Notes: The reference group is commuting by car. All regressions are controlled by individual characteristics. Robust standard errors are in parentheses.
$*p < .10$; $**p < .05$; $***p < .01$.

Appendix C2 Additional results of different controls

Commuting Mode	Mental Health		Physical Health	
	(1)	(2)	(3)	(4)
Public bus	0.091*	0.086*	0.165***	0.161***
	(0.047)	(0.047)	(0.048)	(0.048)
Motorcycle	-1.002***	-1.009***	-0.810***	-0.815***
	(0.044)	(0.044)	(0.045)	(0.045)
Sky train/subway	0.449***	0.451***	0.428***	0.430***
	(0.155)	(0.154)	(0.164)	(0.164)
Active	-2.362***	-2.371***	-1.997***	-2.005***
	(0.081)	(0.081)	(0.079)	(0.079)
Controls				
Income	YES	NO	YES	NO
Others	NO	NO	NO	NO
n	13,122	13,122	13,122	13,122
R^2	0.0671	0.0669	0.0527	0.0525

Notes: Results in Table C2 report only the coefficients from the ordered logistic regression. Robust standard errors are in parentheses.
$*p < .10$; $**p < .05$; $***p < .01$.