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Impact of COVID-19 on Public Transportation Mode Choice and Travel Decisions by Ghanaians

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Abstract

The global outbreak of the Coronavirus (COVID-19) which was declared a pandemic by the World Health Organization (WHO) has affected several sectors including the transportation industry. The COVID-19 pandemic has led to a decrease in outdoor trips and hence patronage of public transportation. Therefore, this study attempted to investigate the influence of the spread of the COVID-19 pandemic on the choice of public transportation modes and travel decisions by Ghanaians. A Google form questionnaire was administered to 2030 participants across all the 16 regions in Ghana. The study indicated that Ghanaians were aware of the COVID-19 disease, how it was spread and various preventive protocols. In addition, a significant change was observed in the choice of public transportation modes where there was a shift to private cars and hired private taxi usage during the outbreak of COVID-19 compared to the pre-COVID-19 era. The ordered logit model predicted that the COVID-19 pandemic had a 17.7 % minor impact on the transportation mode choice of Ghanaians. Furthermore, the COVID-19 pandemic was likely to have a higher impact on social activities of youths in the age group of 30-39 years than on adults from 60 years and above and hence travel decisions. Finally, the model predicted that the demographic characteristics were 16.7% and 20.7% more likely to influence the choice of public transportation and private car usage respectively of Ghanaians during the COVID-19 pandemic. Thus, the eruption of the COVID-19 pandemic impacted on social activities, affected travel decisions and hence influenced the choice of public transportation modes of Ghanaians although these unexpected changes may not last. It is anticipated that life activities will be normal if the COVID-19 pandemic is declared over.

Keywords: Keywords: *COVID-19; Transportation Modes; Travel Decisions; Ghana*

1. Introduction

The world has witnessed the spread of a novel Coronavirus disease (COVID-19) starting in December 2019 which was declared a pandemic by the World Health Organization (WHO) in January 2020 (Gkiotsalitis & Cats, 2021; Tirachini & Cats, 2020). The COVID-19 outbreak has seriously affected many industries and fields such as health care systems, tourism, export and import, and transportation among others. The spread of COVID-19 globally became very rapid and continuous resulting in preventive and control measures proposed by WHO which were adopted by various countries worldwide. Among the proposed measures were restriction of social and physical distancing between people (including limitation of handshaking), regular washing of hands under running tap water and use of sanitizers to rub hands, wearing of face masks

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and limiting of large gatherings among people (Bonful et al., 2020; Gkiotsalitis & Cats, 2021; Organization, 2020). Furthermore, during the peak of the pandemic, governments of nations laid embargo on both local and foreign travels, shutdown of sectors as well as restriction of individuals travelling to minimize the risk of person-to-person infection. The shutdowns and restrictions on travels had a significant impact on the three categories of transportation modes namely land, water and air.

Ghana recorded the first two COVID-19 cases through importation of travellers from confirmed COVID-19 countries five months after the first incidence occurred in Wuhan, China (Dzisi & Dei, 2020). The Ministry of Health and the Ghana Health Service jointly advised the Government of Ghana to shutdown various educational institutions (i.e. from basic to tertiary level), hotels, nightclubs and pubs etc. However, restaurants and eating joints were allowed to serve take-away food packages and offer delivery services. Furthermore, there was a ban on public gatherings including political rallies, conferences, workshops, church services, mosque services etc. whiles attendance to funerals was limited to only 20 family members. Contact tracing for new COVID-19 cases was introduced which led to the identification of a number of infected persons. During the peak period of the spread of the COVID-19 virus, the Government of Ghana tightened the COVID-19 protocols by introducing stringent measures such as closure of all borders (including air, land and sea) in addition to a partial lockdown in two major cities (i.e. Accra and Kumasi) and their adjoining communities to contain the spread of the COVID-19 virus (Dzansi, 2020). These major cities were identified as the epicenters for the spread of the disease and thus lockdown measures were strictly enforced by the city authorities (i.e. the police, the military, and other security personnel) allowing only essential workers such as health workers, media personalities etc. to move to and from their various workplaces. These measures restricted people to stay in their homes and drastically reduced the number of travels within the country especially in cities where the lockdown was in force.

Transportation plays a major role in the socio-economic development of every nation by enabling easy movement and trade between nations and people (Nwaeze, 2020). Globally, land transportation is the most common mode patronized by many people. Among the various land transportation modes, public transportation is the primary form often used by the general populace and sometimes the only travel mode for several people. Due to the confined space and sitting arrangement in vehicles being used as public transport, it was perceived to be conducive for the transmission of COVID-19 disease. Furthermore, the perception was strong because of the close contact of people which was unavoidable at public vehicle stations (Shen et al., 2020; Tirachini & Cats, 2020). The public transportation sector in Ghana was one of the most highly hit industries by the COVID-19. The partial lockdown of the country and the stringent enforcement of COVID-19 protocols significantly reduced ridership (Bird et al., 2020). This was because during the partial lockdown period and the peak of the spread of the COVID-19 disease, public transport vehicles were directed to reduce the number of passengers in their vehicles (i.e. observation of physical and contact distance), placed hand sanitizers and running taps at vantage points at the boarding stations and ensuring that all passengers wore face masks during travels. Studies indicated that travel restrictions and reduction in public vehicle occupancy had a potential of minimizing the risk of spread and contracting the COVID-19 disease (Bonful et al., 2020; Cui et al., 2020; Tirachini & Cats, 2020; Vingilis et al., 2020).

The public transport sector in Ghana includes vehicles and taxis based in stations, chartered taxis, motorcycle taxis and bus transit services (Acheampong et al., 2020; Dzisi & Dei, 2020; Junior Dzisi et al., 2021). Therefore, a passenger has the choice of selecting any of these public transportation modes to facilitate travel to a desired destination. The onset of COVID-19 influenced the perception of people that public transportation is a riskier mode of transmission than private or personal means of transport. Based on mobility and life style changes brought about by the COVID-19 outbreak, commuters often may consider some critical factors before embarking on a trip. These factors may determine the choice of the transportation modes by the commuter. In addition, it has been over two years since the outbreak of the COVID-19 pandemic with a majority of Ghanaians not really adhering to the protocols and preventive measures with the Ghana government relaxing the stringent measures deployed during the peak of the pandemic. Therefore, it is very imperative to conduct a study to assess the pre COVID-19 and COVID-19 impacts on transport modes. In addition, to ascertain the perception of commuters after the relaxation the COVID-19 stringent measures. This study attempts to investigate the influence of the spread of COVID-19 pandemic on the choice of public transportation modes by Ghanaians, choice factors considered and the impact on their travel decisions.

2. Methodology

2.1 Questionnaire Design

The data for the study was collected using a structured questionnaire. The questionnaire had three (3) sections. The first section comprised of questions on participants' bio-data such as gender, age, educational level, employment status and personal income level. The questions in section two were asked to solicit information from participants on their opinions on factors that influence their choices of transportation modes and travel decisions during the two years of COVID-19 disease outbreak. In addition, the participants were asked to assess the level of COVID-19 impact on travel decision and livelihood activities. The last section focused on whether or not participants prioritize their health in the choice of transportation modes and its associated challenges. The questions concerned both local and inter-city trips of respondents.

2.2 Data Collection

Data was collected from participants across all the 16 regions of Ghana partly through face-to- face interviews and online survey. The questionnaire used for the current study was adopted from the work of (Abdullah et al., 2021) and modified into a google form for the online survey which was distributed through emails as well as various social media platforms (i.e. WhatsApp, Facebook and Twitter). The simple random sampling technique was used to administer the questionnaires face-to-face to various participants at different locations such as workplaces, shops, schools etc. In all, 2030 participants were involved in the study using both the face-to-face interviews and online survey. Prior to the main survey, pre-testing of the questionnaire was carried out to determine any ambiguity and unclear statements. The questionnaire was revised based on suggestions

and feedback from the pilot study. After, the initial screening of the questionnaires, no errors were detected and hence all the 2030 questionnaires were analysed.

3.0 Data Analysis

The data collected was edited, coded and entered into Statistical Package for Social Scientists (SPSS) version 22 software for descriptive statistical analysis. The impact of COVID-19 on social activities and transportation modes choice was estimated using the ordered logit model with STATA data analysis software.

3.1 Ordered logit model

The analysis in this study was in two folds. First it estimates impact of COVID-19 on social activities and secondly, how the pandemic influenced the transportation mode choice decisions of the general public in Ghana. The study therefore adopted an opinion survey of "minor impact, no impact and major impact" responses of participants to questions on how the pandemic impacted on their social activities. Again, responses on mode choice of 'public transport', 'private transport' and 'walking' and how the pandemic impacted on transportation mode choice.

Some previous studies have examined transportation decisions of the general public (Luan et al., 2021; Parker et al., 2021) but failed to consider the probability in terms of impacts of the pandemic on influencing their travel or transportation decisions. In such cases, a number of models have been applied in the literature. Some of them include logistic and probit regression models. Though they are easy to estimate and interpret, they are binary in nature and can be used to for categorical dependent variables with two (binary) alternative probabilities or outcomes (Mize, 2019; Tarasi et al., 2021). Hence, they are not appropriate for estimating the impact of transportation decisions as a result of the pandemic with three (3) options as outcomes (1. No impact, 2. Minor impact, 3. Impact). In other cases, various regression approaches could be used, for instance, the Poisson and the Ordered Logistic Models. However, the Poisson regression is time dependent, (such that no two events can occur at the same time) and it does not consider ranking complexity of the outcomes of the events. Contrarily, the Ordered Logistic Model is not time dependent and is appropriate for the ranking of categorical variables in terms of complexities (Mishra et al., 2019; Williams & Quiroz, 2020), for instance from a low level of "no impact" to highest level of "major impact" as implied in this study. As a result, the opinion of the respondents was considered as the dependent variables using a linear ordered logit model to estimate influence of the independent variables on the level impacts exerted by the pandemic. This means that the categorical dependent variable (K) was ranked from no impact to a major impact as follows: 1. No impact 2. Minor impact and 3. Major impact as outcomes and it increased in complexity. As a result, the difference between the first and second outcomes might be the same as the difference between the second and third one. Hence, an index model for a single latent variable K* can be expressed as:

$$K_i^* = X_i'\beta + \epsilon_i \qquad \text{(Equation 1)}$$

$$K_i = j \; if \;\; \propto_{j-1} < Y_i^* \leq \propto_j \qquad \text{(Equation 2)}$$

Where X_i denotes a set of independent variables. The independent variables used in the model included age and sex. Other independent variables were level of education, personal income, type of employment and choice of transport type, as categorical

variables. Further, β is the coefficient and ϵ_i is the error terms of the model. Also, *j =1, 2* and *3* denotes categories of the dependent variable (1. No impact 2. Minor impact and 3. Major impact as outcomes) with *i= 1, 2, 3…*, denoting the individual respondents. The probability or the chance that observation *i* , ($\propto$) could select an alternative impact of *j* for the i^{th} individual respondent is given by

$$p_{ij} = p(K_i = j) = p(\propto_{j-1} < K_i^* \leq \propto_j) = K(\beta_j - X_i'\alpha) - G(\propto_{j-1} - X_i'\beta) \quad \text{(Equation 3)}$$

With respect to interpretation of estimated coefficients of the model the sign of parameters shows whether the latent variable *Y** increases or otherwise with the independent variables. Meanwhile, the ordered logit model with *j* alternatives has *j* corresponding sets of marginal effects. The marginal effect of an increase in the dependent variables *Xi* on the probability of selecting alternative *j* of the opinions of impacts on the pandemic on transportation decisions and social activities respectively (i.e. Minor impact, No impact and Major impact) is expressed as

$$\frac{\partial p_{ij}}{\partial X_{ri}} = \{K'(\propto_{j-1} - X_i'\beta) - G(\alpha_j - X_i'\beta)\beta_r\} \quad \text{(Equation 4)}$$

The marginal effects with respect to the independent variables means that a unit increase in the any of the significant independent variables could lead to an increase or decrease in the probability of selecting alternative *j* by the marginal effect expressed as a percent. The independent variables used in the models included age, sex, level of education, personal income, type of employment and choice of transport type, as categorical variables.

4 Results and discussion

4.1 Bio-Data Characteristics of Participants

Table 1 shows the bio-data and socio-economic characteristics of participants sampled. The study was dominated by males (70.9%) and youths (i.e. 30 – 49 years). Most of them were educated. Non-essential workers in the public sector of Ghana constituted majority of the research participants (46.8%) with some proportions being essential workers (25.1%). The result further indicated that 53.7% of the participants had their personal income levels above GH¢ 2000 (equivalent to US Dollars 310) as at 16th February, 2022. This suggests that most of the participants were average income earners (i.e. salary income range of GH¢499 (77 US dollars) - GH¢2200 (341 US dollars) in Ghana (Bukari et al., 2021). The awareness and perception of Ghanaians regarding the COVID-19 pandemic is influenced by how participants thought about the COVID-19 disease, individual's knowledge and understanding levels. Furthermore, it is also dependent on people's perspective, feelings and imaginations about the COVID-19 disease (Tan & Ma, 2021). The result shows that all the study participants (100%) were aware and had a certain level of perception about the COVID-19 pandemic. The participants' awareness and perception levels included the acceptance of the outbreak of the disease, fear of the disease, the uneasiness the disease caused among people, threat of the disease killing people, easy self-infection and the probability of being infected during usage of public transportation (i.e. commercial vehicles, private, taxis, bike and on foot).

Table 1: Demographic Characteristics of Participants

Demographic characteristics	*Category*	*Frequency*	*Percentage*
Gender	Male	1440	70.9
	Female	590	29.1
Age (Years)	20-29	510	25.1
	30-39	630	31.0
	40-49	630	31.0
	50-59	200	9.9
	60 and above	60	3.0
Educational Qualification	Basic level	80	3.9
	Secondary/Vocational/Technical	170	8.4
	HND/Diploma	330	16.3
	Bachelor/Degree	590	29.1
	Post Graduate Degree	860	42.4
Employment / Occupational status	Essential Workers (Nurse, Security service, Doctors, Food joints etc.)	510	25.1
	Non-Essential Worker (Public sector)	950	46.8
	Non-Essential Worker (Private sector)	200	9.9
	Self Employed/Business Owners	90	4.4
	Not Employed	280	13.8
Personal income per month (Ghana cedis)	<500	260	12.8
	500-1000	260	12.8
	1000-2000	420	20.7
	Above 2000	1090	53.7

NB: 1US dollars = 6.454 Ghana cedis (Accessed on 16/2/2022)

4.2 Factors influencing Choice of Transportation Modes and Travel Decisions

In Ghana, the public transport industry is mostly operated by the informal sector. Different forms of public transportation modes exist in Ghana among which commuters consider for paratransit services and intercity travels. These include station-based vehicles, taxis, hiring cars, tricycles, motorcycles, on foot etc. The result indicated that 88.7% of the participants had travelled within and outside their regions of residence during the peak period of the COVID-19 outbreak (i.e., June – December, 2020). Table 2 shows that most participants (67.6%) commute usually using the public transportation mode involving the use of mini buses (i.e., "trotro"), taxis etc. in Ghana. This finding was in line with other studies which indicated that mini buses, taxis etc. were the commonest means by which Ghanaians commute inter and intra city (Bonful et al., 2020; Dzisi & Dei, 2020; Nutsugbodo et al., 2018). However, 39.4% of the participants stated that their choice of transportation modes had changed since the outbreak of the COVID-19 disease. This result is in line with similar studies conducted in various countries showing a significant drop in travel times, modal shift in transportation means for both short and long distances and change behaviour of transportation type choice (Aaditya & Rahul, 2021; Abdullah et al., 2021; Borkowski et al., 2021; Echaniz et al., 2021). But majority of the participants (60.6%) still commute using public transportation types.

According to 84.2% of the participants, the outbreak of the COVID-19 disease had influenced the cost of commuting intra and inter cities in Ghana.

Table 2: The Usual Choices of Transportation Modes

Transportation Modes	*Frequency*	*Percentage*
Public Transportation	1373	67.6
Private Car	602	29.7
Private Car (Hiring, Uber)	2.0	0.1
Motorcycle	31	1.5
Cycling	1.0	0.0
Walking	21	1.0
Total	2030	100.0

The Relative Importance Index (RII) was employed to determine the relative importance of safety factors considered by participants in the choice of transportation modes during the outbreak of the COVID-19 disease. This index computed was used to rank the factors. The higher the RII, the more critical or important that factor was for impact (Kassem et al., 2020). According to Table 3, facemask usage during transportation was ranked as the first important factor commuters considered before their choice of transport. This implied that commuters considered usage of facemasks during transportation as the key safety measure to prevent or minimize the risk of contracting the COVID-19 disease. This is one of the recommended safety protocols by WHO for the prevention of the spread of the disease because it is known to be an upper respiratory disease (Bonful et al., 2020). The arguments from various studies that commuters can be infected with COVID-19 during public transportation has received mixed and inconclusive results. This is because there is no empirical study to confirm this perception. However, a search through literature indicated that public transportation is a potential source for transmission of the COVID-19 disease because of the nature of sitting arrangements in vehicles (Borkowski et al., 2021). Various factors have been considered in making public transportation stations and vehicle environments high risk for the COVID-19 infection. These factors included the confinement of people in the limited space as passenger occupancy in vehicles and stations and the existence of multiple surfaces in vehicles such as seats, handrails, doors etc. that easily transfer germs (des Transport Publics, 2020).

Table 3: Ranking of Factors that Influenced the Choice of Transportation Modes by the Relative Importance Index (RII) Method

Factors	*RII*	*Rank*
Fear of contracting the disease	0.873	3
Observing social distance during transportation	0.172	5
Use of facemask during transportation	0.906	1
Use of hand sanitizers during transportation	0.885	2
Adequate on-board ventilation	0.858	4

The study shows that 81.8% of the participants mentioned that the outbreak of the COVID-19 disease impacted on their travel decisions since the peak period of the disease (i.e. June-December 2020) and lingers on to date. The travel decisions that were impacted

on by the COVID-19 pandemic were shown in Table 4. The result indicated that most participants mentioned that they did not travel frequently as they did during the pre-COVID-19 period. This implied that they only travel on very important occasions (34%) and hence the outbreak of COVID-19 had impacted their usual travel decisions. According to the current study, a significant proportion of the participants (13.7%) had the perception that they could contract the COVID-19 disease during transportation.

Table 4: Impact of COVID-19 on Travel Decision of Participants

Travel Decision	*Frequency*	*Percentage*
No socialization So I travel only when it is very important	91	4.5
Always using hired taxis which is expensive	120	5.9
Conference calls and zoom	34	1.7
Infrequent travelling (Only on very important occasions)	690	34.0
Family travelling mode has changed from public transport to private	60	3.0
Fear of disease contraction during transportation	278	13.7
Difficulty in mingling with large number of people	10	0.5
High cost of transportation	30	1.5
Uncomfortable and unsafe due to poor social distances	60	3.0
Commute with vehicles with reduced number of passengers	89	4.4
Only official travel using official vehicles	176	8.7
Inability to travel to places which have restrictions	134	6.6
Use of motorcycle for daily transport	160	7.9
Minimize group travels	98	4.8
Total	2030	100

According to the current study, the key activity COVID-19 had impact on was attendance to funerals by Ghanaians (Table 5). This was because funeral ceremonies form a part of the Ghanaian culture where families and friends gather to mourn departed persons and perform burial rites. During the pre-COVID-19 era, a lot of people travelled for funeral ceremonies. However, the restriction by the government of Ghana allowing only 25 family members to gather for funeral ceremonies during the peak of COVID-19 period impacted on people's travel decisions to attend funerals 2 years after the outbreak of the COVID-19 disease. This implied that Ghanaians did not travel for funeral ceremonies as they did during the pre-COVID-19 era due to the fear of contracting the COVID-19 disease, size of funeral gatherings and being confined at the venue for the funeral. Other travel decisions ranked by participants to be impacted on by the COVID-19 pandemic was travelling to visit friends and family members as well as attending parties.

Table 5: Ranking of COVID-19 Impact on Travel Decision and Livelihood Activities using the Relative Importance Index (RII) Method

S/N	*COVID-19 Impacts on choice of transportation modes*	*RII*	*Ranking*
1	For livelihood activities	0.685	7th
2	On economic activities of people	0.749	5th
3	On travel decision of social activities of visiting friends	0.783	2nd
4	On travel decision of social activities of attending parties	0.776	3rd
5	On travel decision of social activities of funerals	0.785	1st
6	On travel decision of social activities of night clubbing	0.7103	6th
7	On religious activities (i.e. going to church, going to the mosque, Easter or Ramadan).	0.752	4th

4.3 Prioritization of Participants' Health and Choice of Transportation Modes

The results of the current study shows that 72.4% of the participants mentioned that they did not travel often since the outbreak of the COVID-19 pandemic whilst 27.6% said they often travel. This was because of the fear of contracting the COVID-19 disease which was easily spread through contact with infected person or surfaces. Therefore, their health was of utmost importance to them than the purpose for travelling. It can be observed from Table 6 that there was a significant decrease in the usage of public transportation modes such as "trotro", shared taxis etc. during the peak period of COVID-19 whiles the use of private transportation modes increased significantly. The decrease in the use of public transportation modes could be attributed to non-adherence to the safety COVID-19 protocols, especially social distancing. Although the government had directed that there should be a reduction in the number of vehicle occupants and physical distancing in vehicles (Dzisi & Dei, 2020), some drivers were not adhering to this directive. The increase in private vehicle transportation mode choice was attributed to the limited number of passengers or commuters on board, strict observation of the safety and preventive protocols, especially the use of hand sanitizers, and face masks. In addition, during the peak of the COVID-19 pandemic, traveling in public transport with unknown people has been rated as a high potential risk infection factor which might account for the shift to private car usage (Borkowski et al., 2021). Another study conducted in India also indicated that the outbreak of the COVID-19 pandemic had shifted the choice of transportation of young millennials from public transportation during the pre-COVID era to other different transportation modes during early COVID-19 days which agreed with the findings of the current study (Bhaduri et al., 2020; Verma et al., 2016).

Table 6: Choices of Transportation Modes During Pre- and COVID-19 Eras

Transportation Modes	*Pre-COVID-19 Era*	*During COVID-19 Era*
	Frequency (%)	*Frequency (%)*
Public transportation	1373 (67.6)	910 (44.8)
Private car	602 (29.7)	760 (37.4)
Hiring private car (i.e.Uber, Taxis)	2.0 (0.1)	270 (13.3)
Motorcycle	31 (1.5)	80 (4.0)
Cycling	1.0 (0.0)	0.0
Walking	21 (1.0)	10 (0.5)
Total	2030 (100)	2030 (100)

Figures in bracket are percentages

4.4 Impact of COVID-19 on Social Activities

The analytical results of the COVID-19 pandemic impact (i.e. "Minor impact", "No impact" and "Major impact") on social activities in relation to the demographic features of the participants is presented in Table 7. In this study, the result of the proportional odds assumption was (p=0.098) an indication that the COVID-19 impacts across the levels were assumed to be the same regardless of the impact category. The log-likelihood ratio (LR) value determined was 209.37 which was statistically significant at 1% suggesting that the model was reliably fitted. The results of the ordered logit model in Table 7, shows that the log odds of COVID-19 impact on the social activities was 0.330 points higher on average for persons within the age group of 30-39 as compared to 20-29 years. This suggested that Ghanaians within the age group of 30-39 years were more likely to have a higher impact of COVID-19 on their social lives than people less than 30 years. This was not surprising because most of the Ghanaian youths were within this age category and always participating in various social activities such as parties, night clubbing, etc. However, the result further indicated that the log odds of COVID-19 impact on the social activities was -0.537 points less on average for persons within the age group of 60 years and above as compared to 20-29 years. This means that the people aged 60 years and above were less likely to have their social lives impacted on by the COVID-19 pandemic than people below 30 years of age. This was because most of the people in this age category would not be attending social activities hence less impact of the COVID-19 on their social lives. The results again revealed that individuals with postgraduate education were more likely (B=0.620) to face major impacts of the COVID-19 than people with primary education. The results also indicated that the people who were self-employed (B=0.998) and non-essential workers (both private and public) were more likely to experience major impact of COVID-19 on their social lives than essential workers. This could be attributed to the lockdown and restriction of citizenry during the peak of the COVID-19 which affected the activities of small and medium businesses. In addition, due to the low patronage of self-employed businesses, a significant proportion of some workers were laid off from their businesses. Similarly, individuals earning incomes above 2,000 Ghana Cedis (310 US dollars) recorded higher chance of experiencing a major impact of COVID-19 on their social lives (B=0.709) than those earning less than 500 Cedis. Contrarily, people who considered the existence of COVID-19 before making their travel decisions were less likely to experience impacts of the disease on their social lives than those who do not consider the consequences of contracting the COVID-19 disease before making their travel decisions. Such people would, by choice, participate more in various social activities.

In terms of marginal effects of the variables on the level of COVID-19 impact on social lives of the Ghanaian populace, the results show that people in the age bracket of 30-39 years were 4.9 % and 2.0 % less likely to experience minor and no impact respectively on their social lives compared to the age group of 20-29 years.

At the same time, the participants in the 30-39 years age category had 6.9 % chance of experiencing a major impact on their social lives.

Also, the participants in the age group of 60 years and above were 9.8 % and 2.3 % more likely to experience minor and no impact respectively of COVID-19 on their social lives compared to the age group of 20-29 years.

Table 7: Estimation of COVID-19 Impact on Social Activities

Ordered logit model			*Marginal effects*					
Demographic Characteristics	*Coefficient*	*Std. Err.*	*SI=1*	*Std. Err.*	*SI=2*	*Std. Err.*	*SI=3*	*Std. Err.*
Gender: Male with female as reference group	0.118	0.109	-0.018	0.017	-0.007	0.006	0.025	0.023
Age (years) with 20-29 years as a reference group								
30-39	0.330***	0.145	-0.049**	0.022	-0.020**	0.009	0.069**	0.031
40-49	0.042	0.147	-0.007	0.024	-0.002	0.008	0.009	0.032
50-59	0.047	0.191	-0.008	0.030	-0.003	0.011	0.010	0.041
60 & above	-0.537*	0.282	0.098*	0.055	0.023**	0.009	-0.120*	0.063
Educational attainment, with primary education as a reference point								
Secondary	-0.113	0.248	0.019	0.042	0.007	0.015	-0.026	0.057
Diploma	-0.235	0.228	0.041	0.039	0.014	0.014	-0.055	0.053
First Degree	-0.300	0.216	0.053	0.036	0.017	0.013	-0.070	0.050
Postgraduate	0.620***	0.231	-0.085**	0.036	-0.045***	0.016	0.130**	0.051
Employment, with essential workers the reference group								
Non-essential (public)	0.277**	0.120	-0.045**	0.020	-0.015***	0.007	0.060**	0.026
Non-essential (Private)	0.330*	0.174	-0.053*	0.027	-0.018*	0.010	0.071*	0.037
Self-employed	0.998***	0.288	-0.134***	0.032	-0.063***	0.019	0.197***	0.049
Not employed	0.282	0.324	-0.046	0.050	-0.015	0.018	0.061	0.068
Personal income, with incomes less than 500 as the reference group								
500 -1000	-0.021	0.318	0.004	0.059	0.001	0.015	-0.005	0.075
1001-2000	-0.004	0.317	0.001	0.059	0.000	0.015	-0.001	0.074
Above 2000	0.709**	0.333	-0.110*	0.058	-0.046**	0.019	0.156**	0.076
Travel Decisions	-0.536***	0.106	0.082***	0.016	0.031***	0.006	-0.114***	0.022
/cut1	-1.318	0.448						
/cut2	-0.424	0.447						
LR chi2 (17)	209.370							
Prob > chi2	0.000							
Pseudo R2	0.056							

*** Significant at 1%; ** significant at 5%; * significant at 10%; Social live (SI); SI=1=No impact; SI=2=Minor impact; SI=3=Major impact

However, they had a 12 % increase in the chances of experiencing a major social impact of the COVID-19 pandemic than the age group of 20-29 years. The study also indicated that participants holding postgraduate degrees were 8.5 % and 4.5 % less likely to experience minor and no impacts respectively of COVID-19 on their social activities, but was 13 % more likely to experience a major impact of the COVID-19 pandemic compared to those with primary education. This could be due to the number of social activities postgraduates are engaged in which might expose them to contracting the COVID-19 disease. The result further shows that participants earning incomes above 2000 Ghana Cedis (i.e. 310 US Dollars) had less chances of 11 % and 4.6 % of experiencing minor and no impact respectively of COVID-19 on their social activities than income earners less than 500 Ghana Cedis. But such category (i.e. income earners above 2000 Ghana Cedis) also had 15.6 % more chance of experiencing a major impact of the COVID-19 pandemic. This might be ascribed to the fact that some of the sources of gaining incomes might be significantly impacted on by the COVID-19 pandemic. The study shows that the emerging of the COVID-19 disease had an 11 % chance of having a major impact on travel decisions and social activities of participants with 8.2 % and 3.1% chances of a minor and no impact respectively.

4.5 Impact of COVID-19 on Transportation Mode Choice Decisions

Table 8 shows the result of the COVID-19 impact on the transportation mode choice decisions made by the participants. The log-likelihood ratio (LR) value was 206.41, an indication of a statistically significant fitted model at 1 %. The analysis of the ordered logit model in Table 8, shows the log odds of COVID-19 impact on the transportation mode choice was -0.238 points less on average for males as compared to females. This explains that the males are less likely to have their transportation mode choice decisions impacted by COVID-19 pandemic than their female counterparts. Also, people holding diploma certificates were less likely (B= -0.554) to have their transportation mode choice decisions impacted on by the COVID-19 pandemic than people who had completed primary school education. However, postgraduate degree holders were more likely to experience a high impact of COVID-19 on their transportation mode choice decisions than people with primary education. Furthermore, the result indicated that the non-essential workers (both private and public) were more likely to experience a high impact of the COVID-19 on their transportation mode choice decisions than the essential workers. This finding is in concord with the fact that essential workers were allowed by the government to fully perform their jobs at their various workplaces during the COVID-19 pandemic and the partial lockdown imposed in some cities in Ghana. Thus, essential workers may use any available means of transportation mode to commute to their various destinations and hence would not experience the impact of the COVID-19 on their transportation mode choice decisions.

The result of the marginal effects of the variables shows that the males were 3.4 % and 1.5 % more likely to experience minor and no impact respectively on their transportation mode choice decisions compared to females. Also, the study shows that participants in the age group of 60 years and above was 2.7 % more likely to experience a minor impact of COVID-19 on their transportation choice decisions as well as those less than 20 years. These age brackets of people do not travel much again in Ghana especially those who were 60 years and above because of ill-health and hence are not liable to make transportation mode choice decisions (Borkowski et al., 2021).

The analysis in Table 8 also shows that the non-essential workers in the public sector had 9.2 % and 3.2 % less chance of experiencing minor and no impact respectively of COVID-19 on their transportation mode choice decisions compared with the essential workers. However, there was a 6 % chance of non-essential workers experiencing a major impact of the COVID-19 pandemic on their transportation mode choice decisions. Additionally, participants without any employment had 13 % and 5.2 % less chance of COVID-19 having minor and no impact respectively on their transportation mode choice decisions relative to essential workers. But participants without any employment had about 18 % more chance of experiencing a major impact of the COVID-19 pandemic on their transportation mode choice decisions.

The study also shows that income earners within the range of 500 and 1000 Ghana Cedis had a higher chance of 8.6 % of experiencing minor impact of COVID-19 on their transportation mode choice decisions, whilst personal income earners in a range of 1001-2000 Ghana Cedis had 11.5 % more chance of experiencing a major impact on their transportation mode choice decisions.

Table 8: Estimation of impact of COVID-19 on Transportation Mode Choice Decision

Ordered logit model			*Marginal effects*					
Demographic characteristics	*Coefficient*	*Std. Err.*	*TC=1*	*Std. Err.*	*TC=2*	*Std. Err*	*TC=3*	*Std. Err.*
Gender: Male with female as reference group	-0.238**	0.108	0.034**	0.016	0.015**	0.007	-0.049**	0.022
Age (years) with 20-29 years as a reference group								
30-39	-0.138	0.158	0.020	0.022	0.009	0.010	-0.028	0.032
40-49	-0.100	0.163	0.014	0.023	0.006	0.010	-0.020	0.033
50-59	-0.107	0.197	0.015	0.028	0.007	0.013	-0.022	0.040
60 & above	-0.467	0.296	0.072	0.049	0.027*	0.015	-0.099	0.064
Educational attainment, with primary education as a reference point								
Secondary	0.401	0.282	-0.059	0.043	-0.025	0.017	0.084	0.060
Diploma	-0.554**	0.252	0.102**	0.044	0.023*	0.012	-0.124**	0.055
First Degree	0.048	0.232	-0.008	0.038	-0.003	0.013	0.010	0.051
Postgraduate	0.627**	0.242	-0.087**	0.038	0.041***	0.014	0.128**	0.052
Employment, with essential workers the reference group								
Non-essential (public)	0.574***	0.119	-0.092***	0.020	-0.032***	0.007	0.124***	0.026
Non-essential (Private)	0.766***	0.190	-0.116***	0.027	-0.045***	0.012	0.162***	0.038
Self-employed	0.404	0.258	-0.067*	0.040	-0.022	0.015	0.089	0.055
Not employed	0.878***	0.310	-0.130***	0.040	-0.053***	0.020	0.183***	0.059
Personal income, with incomes less than 500 as the reference group								
500 -1000	-0.521	0.302	0.086*	0.047	0.029	0.019	-0.115*	0.065
1001-2000	-0.329	0.296	0.052	0.044	0.020	0.019	-0.072	0.063
Above 2000	0.222	0.316	-0.030	0.045	-0.015	0.021	0.045	0.065
Impact on Travel Decision	-1.229***	0.119	0.177***	0.017	0.077***	0.007	-0.254***	0.022
/cut1	-3.255	0.451						
/cut2	-2.344	0.448						
LR chi2(17)		206.410						
Prob > chi2		0.000						
Pseudo R2		0.0568						

*** Significant at 1%; ** significant at 5%; * significant at 10%; Transportation choice (TC); TC=1=No impact; TC=2=Minor impact; TC=3=Major impact

The results suggested that the outbreak of COVID-19 pandemic had 17.7 % and 7.7 % greater chance of participants experiencing minor and no impacts respectively on their transportation mode choice decisions but 25 % less likely to experience a major impact. The major change predicted by the model was observed in a similar study carried out in Pakistan which showed that a significant number of commuters shifted from motorbike to non-motorized modes of travel less than 5 km likewise shifting from public transport to private car for longer distance (Abdullah et al., 2021). The outbreak of the COVID-19 pandemic has had an adverse effect on the transportation industry and affected the choices of public transportation modes in Ghana. Furthermore, it has had an influence on the travel decisions and travel patterns of Ghanaians.

4.6 Impact of COVID-19 on Transportation Mode Choices

Table 9 shows the result of the COVID-19 impact on the transportation mode choices made by the participants. The log-likelihood ratio (LR) value was 208.620 showing that the fitted model was statistically significant at 1 %. It can be observed from Table 9 that the log odds of COVID-19 impact on transportation mode choice was -0.265 points less for males with reference to females. This suggests that the transportation mode choices

by males were less likely to be impacted by the COVID-19 pandemic relative to females. The result further shows that participants in the age brackets of 30-39 and 40-49 years (i.e. B=0.147 and 0.110 respectively) were more likely to have COVID-19 impacting their transportation mode choices. The study also shows that people with income above 2000 Ghana Cedis (B=0.422) were more likely to have COVID-19 impacting their transportation mode choices relative to people who earned less than 500 Ghana Cedis. This could be attributed to the fact that they could afford any choice of transportation mode and hence might not be too choosy. Generally, the demographic characteristics of participants had significant impact on the transportation mode choices (B=1.248) of Ghanaians during the COVID-19 pandemic.

Table 9: Estimates of Demographic Characteristics on Transportation Mode Choices

Ordered logit model		*Marginal effects*				
Demographic characteristics	*Coefficient*	*TMC=1*	*TMC=2*	*TMC=3*	*TMC=4*	*TMC=5*
Gender: Male with female as reference group	-0.265**	0.044**	0.054**	0.015**	0.005*	-0.049
Age (years) with 20-29 years as a reference group						
30-39	0.147**	0.020	0.022	0.019**	0.011	-0.030
40-49	0.110**	0.018	0.023	0.026**	0.020	-0.021
50-59	-0.107	0.016	0.028	0.007	0.011	-0.028
60 & above	-0.467	0.074	0.069*	0.027	0.018	-0.029
Educational attainment, with primary education as a reference point						
Secondary	0.401	-0.059	0.043	-0.025	0.027	0.084
Diploma	0.655	0.102	0.044	0.023*	0.016	0.124
First Degree	0.048	-0.008	0.038	-0.006	0.015	0.010
Postgraduate	0.737**	0.067	0.098**	0.071	0.064	0.128
Employment, with essential workers the reference group						
Non-essential (public)	0.676***	0.092***	0.040**	0.069*	0.007*	0.005
Non-essential (Private)	0.743***	0.116**	0.067**	0.045	0.012	0.162
Self-employed	0.404	0.077*	0.060**	0.032	0.025	0.089
Not employed	0.878	0.130**	0.040	0.053	0.020	0.183
Personal income, with incomes less than 500 as the reference group						
500 -1000	0.621	0.086*	0.047	0.029	0.019	-0.115
1001-2000	0.219	0.052	0.044	0.020	0.019	-0.072
Above 2000	0.422***	0.030	0.145**	0.019	0.041	0.045
Transport choice mode	1.248***	0.167**	0.207**	0.07	0.007	-0.292
/cut1	-3.355	0.561				
/cut2	-2.444	0.548				
LR chi2 (17)		208.620				
Prob > chi2		0.000				
Pseudo R2		0.0513				

*** Significant at 1%; ** significant at 5%; * significant at 10%; Transportation Mode choice (TMC); TMC=1= Public Transportation; TMC=2= Private Car; TMC=3= Private car taxis (i.e. Hiring, Uber etc.); TMC=4= Motorcycle; TMC=5= Unmootrized system (Bicycling, walking)

The result of the marginal effects shows that the males were 4.4 % and 5.5 % more likely to choose public transportation and private cars respectively compared to females. Similarly, participants in the age categories of 30-39 and 40-49 years were more likely to have a 1.9% and 2.6% impact respectively on the choice of private car taxis (i.e. Hiring ones, Uber, etc.) than the 20-29 years reference group. However, participants aged above 60 years were 6.9% more likely to choose private car usage during the COVID-19 period. This might be due to the fact that they are the high-risk infection age category as stated by the WHO and also suffering from any underlying health factors which might influence

their early death. The result further shows that participants with postgraduate education were 9.8% more likely to use private cars than the people with primary school certificates. This could be explained by the fact that this category of people have their own private cars they normally commute with hence less possibility of them joining other public transport. The non-essential workers (both public and private) were more likely to choose from the various transportation modes. However, participants who were not employed had a 1.3% more likelihood to choose the public transportation mode. This is because public transportation is the only available option for them to commute since they do not own their private cars. The result further shows that participants with income above 2000 Ghana Cedis were 14.5% more likely to choose the private car mode compared with income earners in the less than 500 Ghana Cedis reference group. Most participants belonging to this class of income earners have their own private cars they commute with and thus may not opt for other transportation modes. In all, the demographic characteristics of participants were 16.7% and 20.7% more likely to influence the choice of public transportation and private car usage respectively by Ghanaians during the peak of COVID-19 era.

5. Conclusion

Globally, the outbreak of the COVID-19 pandemic has posed challenges in the transportation sector in Ghana. This study attempted to investigate if the outbreak of COVID-19 pandemic had influenced on the choice of public transportation modes and travel decisions as well as the impact on social activities of Ghanaians. Almost all Ghanaians are aware of the COVID-19 disease, how it was spread and associated preventive protocols. Over 60% of Ghanaians stated that the commonest transmission mode of the COVID-19 is through physical contact with an infected person and likelihood of infection during transportation was very high. Thus, their choice of transportation modes has changed since the outbreak of the COVID-19. Wearing of facemasks during transportation was ranked as the first safety factor that determined participants' choice of transportation modes. Furthermore, the COVID-19 pandemic impacted on the travel decisions and social activities of Ghanaians especially during the peak period and lingers on to date. It hindered their frequent travelling to social activities especially funerals and changed significantly their choice of common public transportation modes during pre-COVID-19 days to private cars and hired private taxis in the COVID-19 era. The modeling analysis estimated that the COVID-19 pandemic was likely to have a higher impact on the social lives of youths in the age group of 30-39 years and less on adults from 60 years and above. Ghanaians with postgraduate education were more likely to have a major impact of the COVID-19 on their social activities likewise self-employed and non-essential workers (both private and public). In all, the study showed that the outbreak of the COVID-19 pandemic had an 11 % chance of having a major impact on social activities and hence travel decisions of Ghanaians. It was further estimated from the ordered logit model that males, postgraduate degree holders and non-essential workers (both private and public) were more likely to have a higher impact of the COVID-19 pandemic on their transportation mode choice decisions. The model predicted that Ghanaians had a 17.7 % of minor impact of the COVID-19 pandemic on transportation mode choice decisions. Finally, the model predicted that demographic characteristics of participants had a significant impact on the transportation mode choices (B=1.248) with

16.7% and 20.7% more likely to influence the choice of public transportation and private car usage respectively of Ghanaians during the COVID-19 pandemic.

Reference

Aaditya, B., & Rahul, T. (2021). Psychological impacts of COVID-19 pandemic on the mode choice behaviour: A hybrid choice modelling approach. *Transport policy*, 108, 47-58.

Abdullah, M., Ali, N., Hussain, S. A., Aslam, A. B., & Javid, M. A. (2021). Measuring changes in travel behavior pattern due to COVID-19 in a developing country: A case study of Pakistan. *Transport policy*, 108, 21-33.

Acheampong, R. A., Siiba, A., Okyere, D. K., & Tuffour, J. P. (2020). Mobility-on-demand: An empirical study of internet-based ride-hailing adoption factors, travel characteristics and mode substitution effects. *Transportation Research Part C: Emerging Technologies*, 115, 102638.

Bhaduri, E., Manoj, B., Wadud, Z., Goswami, A. K., & Choudhury, C. F. (2020). Modelling the effects of COVID-19 on travel mode choice behaviour in India. *Transportation Research Interdisciplinary Perspectives*, 8, 100273.

Bird, J., Kriticos, S., & Tsivanidis, N. (2020). Impact of COVID-19 on public transport. IGC Blog Post, https://www. theigc. org/blog/impact-of-covid-19-on-public-transport.

Bonful, H. A., Addo-Lartey, A., Aheto, J. M., Ganle, J. K., Sarfo, B., & Aryeetey, R. (2020). Limiting spread of COVID-19 in Ghana: compliance audit of selected transportation stations in the Greater Accra region of Ghana. PloS one, 15(9), 0238971.

Borkowski, P., Jażdżewska-Gutta, M., & Szmelter-Jarosz, A. (2021). Lockdowned: Everyday mobility changes in response to COVID-19. *Journal of Transport Geography*, 90, 102906.

Bukari, C., Peprah, J. A., Ayifah, R. N. Y., & Annim, S. K. (2021). Effects of credit 'plus' on poverty reduction in Ghana. *The Journal of Development Studies*, 57(2), 343-360.

Cui, Z., Zhu, M., Wang, S., Wang, P., Zhou, Y., Cao, Q., Kopca, C., & Wang, Y. (2020). Traffic performance score for measuring the impact of COVID-19 on urban mobility. arXiv preprint arXiv:2007.00648.

Des Transport Publics, U. I. (2020). Management of COVID-19 Guidelines for Public Transport Operators. Retrieved July, 10, 2020.

Dzansi, J. (2020). Ghana lifts the lockdown: Has the government reneged on its commitment to contain COVID-19 at all costs? International Growth Centre blog.

Dzisi, E. K. J., & Dei, O. A. (2020). Adherence to social distancing and wearing of masks within public transportation during the COVID 19 pandemic. *Transportation Research Interdisciplinary Perspectives*, 7, 100191.

Dzisi, J. E. K., Obeng-Atuah, D., Ackaah, W., Tuffour, A. Y., & Aidoo, N. E. (2021). Uptake in on-demand ride-hailing for intracity long distance trip making during COVID-19. *Urban, Planning and Transport Research*, 9(1), 120-131.

Echaniz, E., Rodríguez, A., Cordera, R., Benavente, J., Alonso, B., & Sañudo, R. (2021). Behavioural changes in transport and future repercussions of the COVID-19 outbreak in Spain. *Transport policy*, 111, 38-52.

Gkiotsalitis, K., & Cats, O. (2021). Public transport planning adaption under the COVID-19 pandemic crisis: literature review of research needs and directions. *Transport Reviews*, 41(3), 374-392.

Kassem, M. A., Khoiry, M., & Hamzah, N. (2020). Using Relative Importance Index Method for Developing Risk Map in Oil and Gas Construction Projects. Jurnal Kejuruteraan, 32(3), 85-97.

Luan, S., Yang, Q., Jiang, Z., & Wang, W. (2021). Exploring the impact of COVID-19 on individual's travel mode choice in China. *Transport policy*, 106, 271-280.

Mishra, P., Pandey, C. M., Singh, U., Keshri, A., & Sabaretnam, M. (2019). Selection of appropriate statistical methods for data analysis. *Annals of Cardiac Anaesthesia*, 22(3), 297.

Mize, T. D. (2019). Best practices for estimating, interpreting, and presenting nonlinear interaction effects. *Sociological Science*, 6, 81-117.

Nutsugbodo, R. Y., Amenumey, E. K., & Mensah, C. A. (2018). Public transport mode preferences of international tourists in Ghana: Implications for transport planning. *Travel Behaviour and Society*, 11, 1-8.

Nwaeze, G. (2020). COVID-19 Outbreak and the Transportation Industry: Effects, Prospects and Challenges. Prospects and Challenges (June 5, 2020).

Parker, M. E., Li, M., Bouzaghrane, M. A., Obeid, H., Hayes, D., Frick, K. T., Rodríguez, D. A., Sengupta, R., Walker, J., & Chatman, D. G. (2021). Public transit use in the United States in the era of COVID-19: Transit riders' travel behavior in the COVID-19 impact and recovery period. *Transport policy*, 111, 53-62.

Shen, J., Duan, H., Zhang, B., Wang, J., Ji, J. S., Wang, J., Pan, L., Wang, X., Zhao, K., & Ying, B. (2020). Prevention and control of COVID-19 in public transportation: Experience from China. *Environmental Pollution*, 115291.

Tan, L., & Ma, C. (2021). Choice behavior of commuters' rail transit mode during the COVID-19 pandemic based on logistic model. *Journal of Traffic and Transportation Engineering* (English Edition), 8(2), 186-195.

Tarasi, D., Daras, T., Tournaki, S., & Tsoutsos, T. (2021). Transportation in the Mediterranean during the COVID-19 pandemic era. *Global Transitions*, 3, 55-71.

Tirachini, A., & Cats, O. (2020). COVID-19 and public transportation: Current assessment, prospects, and research needs. *Journal of Public Transportation*, 22(1), 1.

Verma, M., Manoj, M., & Verma, A. (2016). Analysis of the influences of attitudinal factors on car ownership decisions among urban young adults in a developing country like India. *Transportation research part F: Traffic Psychology and Behaviour*, 42, 90-103.

Vingilis, E., Beirness, D., Boase, P., Byrne, P., Johnson, J., Jonah, B., Mann, R. E., Rapoport, M. J., Seeley, J., & Wickens, C. M. (2020). Coronavirus disease 2019: What could be the effects on Road safety? *Accident Analysis & Prevention*, 144, 105687.

Williams, R. A., & Quiroz, C. (2020). Ordinal regression models. SAGE Publications Limited.

World Health Organization (WHO) (2020). Infection prevention and control during health care when COVID-19 is suspected: interim guidance, 19 March 2020.

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