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COVID-19 stimulated travel behavior policy framework with evidence from travel change in southwestern Nigeria

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ABSTRACT: The COVID-19 pandemic unprecedentedly redefined urban mobility as some spread containment protocols, such as lockdown, travel restrictions, and physical distancing, directly impinged mobility: these policies or personal health concerns altered travel behavior during the first and the second waves of the pandemic. Transportation users' reactions to the spread of COVID-19 vis-à-vis the government-imposed containment strategies hinged on the theory of interpersonal behavior and social practice theory, informing that the travel behavior cultured during the waves may become a practice as we advance. This paper investigated the extent of preferential modal shift and travel change during the waves of COVID-19 toward developing a travel behavior framework for a more holistic transportation policy for pre-, during, and post-pandemic periods. This COVID-induced urban mobility assessment sourced primary data from transportation users during Phase 2 of the COVID-19 intervention in southwestern Nigeria. The findings show that COVID-19 has a weak but positive relationship with transportation means change. A private vehicle use mode preference was evident, and daily travel patterns skewed towards the weekends. Most participants felt the state border restrictions every day of the week, and most of the transportation users who commuted were essential workers. At the same time, a medium-range positive association for COVID outings due to travel purpose and employment type informed that the unemployed dominated sports and leisure trip purposes, evidence of exigent travel. Dips in routine travel purposes, geographical extent, and modal choice imply unsustainable economic decisions and must be forestalled post-COVID. The paper recommends an evidence-based COVID-19 travel behavior policy framework for systemic, sustainable transportation policy formulations effective pre-, during, and post-pandemics.

KEYWORDS: Pandemic, travel restrictions, travel patterns, travel purpose, public transportation, private vehicle use

1. INTRODUCTION

The new coronavirus disease (COVID-19) pandemic redefined urban mobility between early 2020 and recently when the virus was seemingly controlled by deploying several measures that include vaccination (Tartof *et al.,* 2021; Feikin *et al.,* 2022) and transportation policies. Thus, relative to the health concerns of COVID-19, from the imposed lockdown policy by most governments to travel restrictions, social distancing, and restrictive vehicle-passenger capacity protocols, transportation, and indeed, the travel industry, including the hospitality and the tourism industry (Kaushal and Srivastava, 2021; Gursoy and Chi, 2020; Mohamed *et al*., 2020), have felt the impact of the pandemic in no small measure (Babalik, 2020; De Vos, 2020; Carrington, 2020; Mogaji, 2020; Abdullah *et al*., 2020; Gaskin *et al.,* 2020; Dong *et al*., 2021; Hensher *et al.,* 2021; Faiyetole, 2022). Travel behavior in trip purpose, directed or motion needs, daily travel patterns, and modal types witnessed unprecedented changes during COVID (Abdullah *et al.,* 2020; De Vos, 2020; Gaskin *et al*., 2020; Gutiérrez et al., 2020; Hensher *et al*., 2021; Hook *et al.,* 2021; Dong *et al*., 2021).

To this end, the objectives of this present study are to examine the extent of modal shift and travel change influenced by the COVID-19 spread-mitigative protocols in southwestern Nigeria to develop an evidence-based sustainable travel behaviour policy framework effective pre-, during, and post-pandemic.

The paper is organized as follows: related works to this study were documented in section two, including pre-COVID and COVID period reviews. The data source, instrument's validity, and reliability, and statistical techniques adopted to elicit information are documented in section three. Section four of this paper contains the results. After that, the discussion and conclusions.

2. LITERATURE REVIEW

2.1. Pre-COVID travel period

The pre-COVID travel period predated the detection of the SARS-CoV-2 strain on the last day of December 2019; thus, transportation normalcy still existed in 2019.

2.1.1. The constancy of commute times hypothesis

During pre-COVID, the Italian physicist Cesare Marchetti's (1994) hypothesis that human beings universally have commute times of about 66 minutes was supported by Kung *et al*. (2014). And both directed and undirected trips, motion need, or travel for travel itself, are universally defined. Despite the constancy in travel time commuting in urban centers, the US Bureau of Labour Statistics (BLS, 2014; Herriges, 2017) showed that commuting time is altered with a dip during recessions. They showed a differing travel pattern during weekdays, for directed travels, such as commuting, and at weekends when they generally have more relaxing activities. The COVID-19 pandemic, similar to a recession in some ways, would expectedly significantly impact travel patterns. Especially since travel restrictions protocols and other policies (Bhaduri et al., 2020; Tirachini and Cats, 2020; Dzisi and Dei, 2020; De Vos, 2020) have a direct or indirect impact on travel behavior.

2.1.2. The principle of modal shift

The pre-COVID era's transportation modal shift was somewhat affected by the other comparative merits or disadvantages of cost, convenience, speed, timeliness, reliability, congestion, and carbon emissions (Rodrigue, 2020; Choi *et al*., 2019). Therefore, preferences reflect society, which could be due to forced or willing behavioral change (Faiyetole, 2019). The availability of alternatives primarily informs modal choic-

es and a possible shift by passengers to other options based on the advantages a particular mode of transportation has over the other. In low-income countries, associated costs, such as the purchase of vehicles or energy costs, in short, affordability, are determinants for making a modal shift. According to Rodrigue (2020), increased purchasing power usually leads to a modal change from a public to a private mode of transportation. It is much more sustainable to consider human and the environment's health when considering a modal shift, especially from public to private transportation mode (Anwar and Yang, 2017; Abuhamoud, 2010; Anwar, 2009; Nurdden *et al.,* 2007; Kii *et al.*, 2005).

The principles and theories of modal shift (see Figure 1), according to Rodrigue *et al.* (2006), are encapsulated in the inertia, the modal shift, and the maturity phases of the modal share. There is a high demand for transportation means during the inertial phase based on their competitive advantages. The modal share is less than expected during this phase due to the disparity in investment and assets on the existing infrastructure, such as terminals or other road assets. While the actual transition from one mode of transportation to another occurs in the modal shift phase, it slowly changes from a stage of underperformance to over-performance. The maturity phase shows the stabilization of the new modal share balance with the actual comparative advantage realized and enjoyed (Choi *et al.*, 2019).

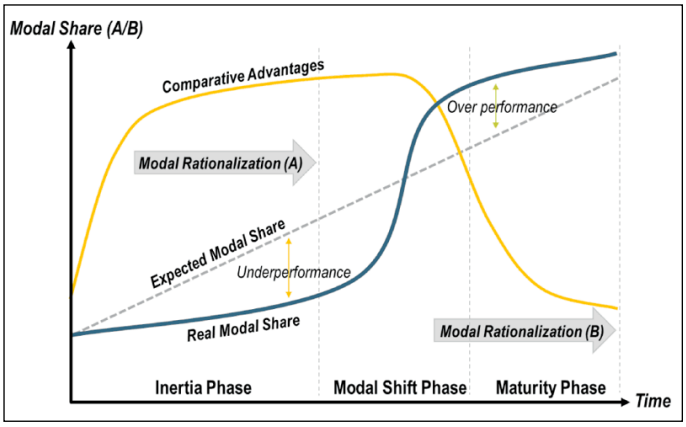

Figure 1: Principles of modal shift; source Rodrigue *et al.* (2006).

2.1.3. Theories on behavior and practice

The theory of interpersonal behavior (TIB) and the social practice theory (SPT) were equally found appropriate for explaining travel behavior during the pre-COVID period (Daramy-Williams *et al.*, 2019; Bauer, 2017). Triandis' (1977) TIB, on the one hand, recognized roles played by social factors, emotion, and attitude in his integrated interpersonal behavior model for forming intentions. He stressed the importance of past behavior on the present, an immediate consequence of choices. Triandis (1977) posited that intention and past behavior could moderate facilitating conditions, such as contextual factors, with implications. Faiyetole (2019) opined that preferences lead to changed behavior and social practices; the dynamic of change, whether behavioral or otherwise, can be experienced in any sector owing to changing government policies. The SPT, on the other hand, as projected by Reckwitz (2002) and as advanced by authors that include Shove *et al.* (2012), considered three interdependent elements, materials, meaning, and competencies, as being necessary for any practice to exist (Bauer, 2017; Spotswood *et al.*, 2015). Materials are things, hardware, encompassing objects, and the body itself (Shove *et al.*, 2012). According to Spurling *et al.* (2013), competencies are required to modify, sustain, or develop different practices by inventing, innovating, or modifying materials. Peattie and Peattie (2009) opined that for any transformation of existing approaches to occur or be expected, ensuring a more sustainable option accessible to the people will be expedient. The meaning was described as the knowledge state of mind of the people, whether as mental, emotional, or motivational knowledge (Reckwitz, 2002) or an unconscious form of knowledge or experience (Shove *et al.*, 2012).

2.2. COVID-19 impacts and transport modes, trip purpose, and motion needs

The COVID-19 index case in Nigeria, like other countries, was an international traveler, reported on 27 February 2020 by the Nigeria centre for disease control (NCDC, 2020) as an Italian expatriate who returned to Nigeria through the Murtala Mohammed International Airport (MMIA), Lagos, on 25 February 2020. Thus, it was established early enough that transportation policies that could impinge on travel behavior, such as international travel and surface modal change, would have to be promulgated and enforced to contain this highly contagious novel coronavirus disease. Subsequent incidences, as the second case recorded in Nigeria, were through local community contacts. As air transportation became a carrier for the first incident cases in most countries, surface transportation became a conduit for the spread through interstates, state-wide, and communities. Nigeria's COVID-19 index case was routed through the MMIA, which is close to residential neighborhoods (Faiyetole and Ibrahim, 2019; Faiyetole and Sivowaku, 2021), and the airport has vast passenger movement (Faiyetole and Yusuf, 2018). The COVID spread-containment policies, such as social distancing protocol, and a gamut of measures that prevent physical contact, were implemented to curtail the spread of COVID-19 (De Vos, 2020; Dzisi and Dei, 2020; Gkiotsalitis and Cats, 2020; Tirachini and Cats, 2020; Bhaduri *et al.*, 2020; Hadjidemetriou *et al.*, 2020; Wilder-Smith and Freedman, 2020).

The alarming spread rate worldwide informed the establishment of the presidential task force (PTF) on COVID-19 by the Federal Government of Nigeria on 9 March 2020, saddled with the responsibility, amongst others, to contain the spread of COVID-19 and mitigate its impact on the overall economy (PTF, 2020). In that capacity, the PTF works with government agencies across the board, particularly with the NCDC, to formulate policies and guide its direction with solutions that could mitigate the spread of the virus and cushion its economic impact on its citizens. Consequently, Nigeria implemented a 3-phase COVID-19 spread containment policy, including a total lockdown from 30 March 2020 that partially reopened on 4 May 2020 (Phase 1). Phase 2 of the policies, effective from 2 June 2020, saw the 'ban on non-essential inter-state passenger travel, the partial and controlled interstate movement of goods and services, and mandatory use of face masks or coverings in public' (IMF, 2021). Ferguson *et al.* (2020) warned about the implication of relaxing the interventions (FMH, 2020). Subsequent relaxation of the enforcement of the spread-mitigative policies from the start of phase 3 on 3 September 2020 could relate to the spikes in the cases from December 2020, suggesting that Nigeria may have slipped into its second wave of COVID-19 infections (BBC, 2020).

Negative binomial regression models revealed geographic disparities in the US COVID-19 case and death rates, positively associated with the nearest airport's proximity and passenger volume. Using Cox regression, an association of transportation with the virus quickness rate revealed a more significant risk for cases and death rates within a 25 miles distance compared to counties 50 miles from the airport (Gaskin et al., 2020). This study showed how transportation, land, and air have contributed to introducing and spreading the new coronavirus disease.

While surface transportation includes the movement of people or goods by roads, trains, or ships, hard-surface (land) transportation modes are non-motorized transport – pedestrian system and bicycles – (Bigger, 2019), rails, motorcycles, and the public and private motor vehicles that run on roads. These hard-surface transportation means are typical of urban mobility in Nigeria. The road is, in fact, the most extensively used transportation mode (Mogaji, 2020; Nwafor and Onya, 2019) in Nigeria. Particularly in Lagos, the widely used road transportation network coupled with the highest population density in Nigeria constitutes a bottleneck regarding the unimaginable traffic situations within the metropolis. Lagos's vast population density and high travel intensity make it a hotspot for spreading infectious diseases like the novel coronavirus disease. Since the index case was detected, Lagos state has continuously turned out the highest number of confirmed COVID-19 cases per day, cumulatively constituting (38.01 percent) of the total number of incidents as of 26 July 2021 (Statista, 2021), as depicted in Figure 2. Ondo State (2.18 percent) is in the category of states with low COVID-19 confirmed cases (Statista, 2021).

So far, a few COVID-19 studies have explored transportation impacts in Nigeria. Mogaji (2020), for example, focused on Lagos. The study revealed that restricted travel correlated more with participants' economic activities, followed by their social and religious activities. The economic and social impacts of the COVID pandemic are respectively consequential upon the drop in ridership occasioned by a drop in travel demands resulting in congestion-busting and a reduction in air pollution (De Vos, 2020; Carrington, 2020). Hensher *et al.* (2021) showed that COVID-19 significantly impacted work travel behavior, such as the one informed by the lockdown's flexible work-from-home arrangements, which resulted in a short-time reduction in money and time costs as evidenced in a Greater Sydney Metropolitan Area study. Qum and Wang (2020) considered externality pricing, through monetary penalties, for violations of activities, such as lockdown and travel restrictions policies, which could potentially increase the spread of COVID-19.

Further on transportation sustainability, the advantage of public transportation over private car use is apparent regarding emission and traffic congestion. However, the proximity information of the plausibility of being infected by COVID-19 can potentially influence a modal shift from environmentally more sustainable public transportation to less-sustainable private car use for an urban and long-distance commutes (Gutiérrez et al., 2020). Dong *et al.* (2021) examined the passengers' perceptions of safety and satisfaction toward using public transportation during COVID, asserting that its psychological effects (Parady *et al.*, 2020) will possibly linger in the post-COVID era. Thus, they recommended that to avoid a modal switch from public to private transportation, there would be a need to eliminate the lingering effects of the pandemic on the public transportation system. Emphatically, Abdullah *et al.* (2020) revealed a significant shift from public transportation to private and non-motorized modes of transportation due to concerns about COVID-19 infections. They considered trip purpose, mode choice, distance traveled, and frequency of trips for the primary travels for international respondents from more than 15 countries. About (70 percent) of the respondents were from south-east Asian countries and showed significant differences in the variables before and during the pandemic (Abdullah *et al.,* 2020). It was evident that pandemic-related factors (i.e., infection concern, social distancing, passengers wearing nose or face masks) significantly informed the respondents' modal choices during the pandemic. The frequency of trips for work as a primary trip purpose reduced from (17 percent) pre-COVID to (5 percent) during the pandemic. Their results further show that the frequent trips for essential workers significantly reflect (p<.0001) who mostly commuted for work during the pandemic. Multinomial logistic regression revealed that the chances of choosing private relative to public transportation increased with long-distance trips and pandemic-related factors. Hook et al. (2021) suggested a general decrease in directed trips but increased compensation for decreased car use with undirected and active trips.

From the literature, it is apparent that the COVID-19 pandemic has impacted transport in many unsustainable ways. Therefore, this study aimed to examine the travel change influenced by the COVID-19 spread-mitigative protocols in southwestern Nigeria and developed an evidence-based sustainable travel behaviour policy framework effective pre-, during, and post-pandemic.

3. DATA AND METHODS

The study employed a self-reported method through structured and standardized survey questions randomly administered to respondents from the study area. The questions asked were to elicit information on travel change. The questionnaire included questions such as i) what is your usual mode of transport pre-COVID, what mode of transport do you use or prefer due to COVID-19 impact, and consequently, how much change has COVID-19 caused in your modal choices? ii) how often do you usually go out pre-COVID, and due to the COVID-19 lockdown, how has COVID-19 affected your travel purpose, and how have the restriction protocols affected your movement generally? Demographic questions included the state of residence at the time of the first wave of COVID-19 lockdown, age, and employment types. The sample demographics included participants of all ages from two states in Nigeria, Lagos (38.01 percent) and Ondo state, with a (2.18 percent) cumulative total of COVID-19 cases as of 26 July 2021 (Statista, 2021).

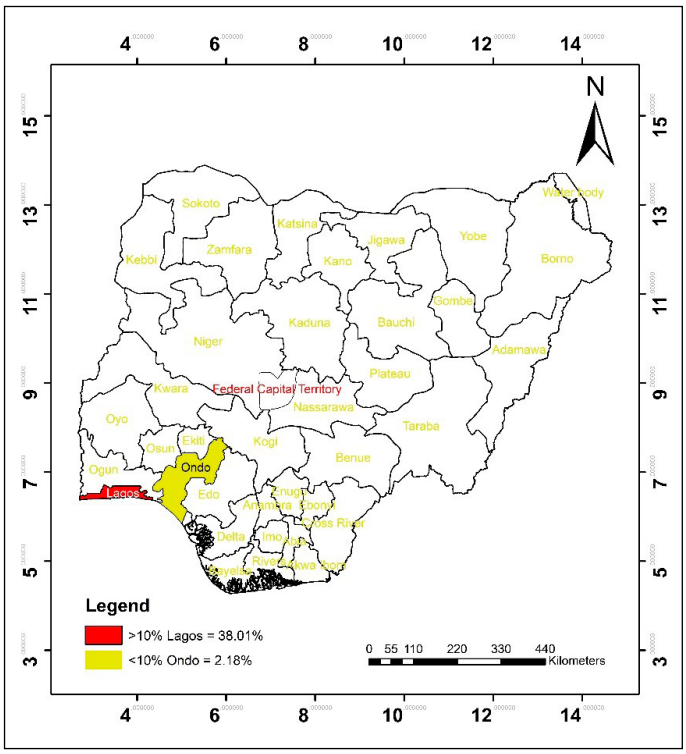

Figure 2: Map of Lagos (Red) and Ondo (Yellow) study areas showing the percentage of COVID-19 confirmed cases in the two states relative to the total for the country as of 26 July 2021. The other red text, the Federal Capital Territory, equally contributed above (>) 10 percent as Lagos (highly impacted states). The yellow text states had less than (<) 10 percent as Ondo (lowly affected states).

These two states represented the most and low-COVID-19-impacted, respectively; the choice of the two states is a fair representation and a sound signature of southwestern Nigeria's COVID spread rate. The study area (see Figure 1), thus, has a combined population size of (N=17,222,300: City Population, 2016). It translates to a representative n = 402 within a (95 percent) confidence interval, using Taro Yamane's Equation

$$(1) \quad n = \frac{N}{1+N(e^2)}$$

where N is the population size, and e is the error margin.

The questionnaire administration to the respondents in the study area used a combined simple random sampling technique and an ad hoc sampling method. Lienke et al. (2018) used ad hoc sampling for lateral and longitudinal states as an online sampling strategy. The combination yields breakpoints involving a bi-level candidate evaluation strategy planning for on-road automated driving. This present study used ad hoc sampling, a method whereby the questionnaire was sent to an online forum of a cohort of fresh graduates from different parts of the country participating in the Lagos State camp of the national youth service corps (NYSC, 2020) in November. The selection of participants in the cohort is made chiefly considering objectives 6, 8, 10, 11, and 12 of the NYSC (2020) scheme. This ad hoc sampling, however, came with the advantage of increasing the education and awareness profile of the respondents because this class of respondents has a university degree or its equivalent. From Faiyetole (2022: 9) and in line with Lienke et al. (2018) combination procedure, however, some participants in the selected cohort were sieved out in the course of the analysis (see Table 1) because they lived outside the study area during the first wave of COVID, allowing that data from the conventional simple random sampling technique, which was done face-to-face within the study area, dominated. The traditional simple random sampling technique involved administering the questionnaire to respondents face-to-face at commercial motor parks, residential areas, and streets in the study area from August to November 2020. The final sample size is representative of the two states, with a combined 78.9% of the total sample population, as shown in Table 1. The respondents, who were well aware of the COVID-19 containment protocols, i.e., with policy to reduce vehicle passenger occupancy and use of nose masks before boarding a vehicle, enthusiastically participated in the survey and expressed they found the questions very relatable. A few were circumspect and avoided touching the paper questionnaire for fear of being COVID-19 infected despite wearing nose masks while administering the questionnaire and making hand sanitizer available to boost their confidence. There was a case of a respondent demanding an incentive before filing the questionnaire. This request was not obliged; instead, the respondent was enlightened on the importance of the study and how it could potentially influence policy that could benefit all (Faiyetole, 2022).

3.1. Data analytical techniques

The questionnaire consisted of Likert-type questions that found analytical suitability in ordinal logistics regression (OLR), following Faiyetole (2022) and Faiyetole and Sivowaku (2021) procedures. Further, the questionnaire is the most appropriate tool for this study because it answers standardized questions, making it easy for respondents to interpret in the same way. They are used for descriptive or explanatory research and allow the identification and description of variability in different phenomena (Saunders et al., 2009). The variables for each context were subjected to variance inflation factor (VIF) tests, with reported results of not more than 1.868, indicating that the VIF is not inflated. Therefore, multicollinearity was not a problem (ARA, 2018; O'Brien, 2007), making variables ideal predictors for the study models.

3.2. Validity and reliability of the instrument

Validity refers to the ability of the questionnaire to measure the objectives it set out to achieve (Saunders et al., 2009). On the other hand, reliability is the degree of consistency in producing the same results for the measures of the same variables. In other words, the idea behind reliability is that critical results must be more than a one-off finding and be characteristically repeatable. A pilot test was undertaken to determine the clarity and validity of the survey tool. As a result of the pilot test, some of the questions were rewritten to ease comprehension. Control checks were ensured by asking the same question differently to increase the validity of self-report claims. Multiple statistical techniques were applied to enhance the analysis' robustness and improve the results' reliability. Consequently, in addition to the ordinal logistics regression model applied, descriptive statistics and correlation's ordinal-to-ordinal cross-tabulation with Kendall's tau-b procedure (Coleman, 2013) were used on the data. The reliability of the results obtained from the descriptive and correlation to the regression techniques are consistent, as shown in subsections 4.1, 4.2, and 4.3, respectively.

4. RESULTS

4.1. Descriptive statistics for the survey demographics

The participation rate was 100 percent (n=402), plausibly attributable to the general disruption to life in its entirety due to the pandemic. Table 1 shows the descriptive statistics for the demographic characteristics of the survey participants. Approximately nine-tenths (85.8 percent) of participants resided in southwestern Nigeria. The region had the highest turnout, with Ondo state (43.8 percent) and Lagos state (35.1 percent), with about four-fifths (78.9 percent) of the total respondents. The ages ranged from <18 to 50>. Almost two-fifths (43.3 percent) of the participants were between 21 and 30 years old, followed by (17.4 percent) aged 31-40 years, whereas 50> years old respondents made up (9.7 percent) of the total study participants. Nearly three-tenths (32.8 percent) were business owners or self-employed. In comparison, (21.9 percent) were essential workers, doctors, nurses, food sellers, security personnel, or others with critical services during the lockdown period, tasked to ensure healthcare delivery or compliance with the COVID protocols.

The study showed that during the pre-COVID period, (45.5 percent) of the study participants used public vehicles as their primary means of transportation; however, owing to the COVID-19 pandemic, there was a preference for private car use (49.8 percent), while the preferences for public transportation dropped to (27.9 percent). It represents a (17.6 percent) drop in public transportation modes, while the preferential use of private means of transportation increased by (17.5 percent) owing to COVID-19, as shown in Table 2. The inclination toward private vehicle use over public transport is consistent with existing literature, such as Abdullah *et al.* (2020) and Faiyetole (2022). Like the preferences for private cars owing to the COVID-19 outbreak, there was equally an increase in the preferences for motorcycle means of transportation, this time, (0.8 percent) marginal. Furthermore, the bicycle as a sustainable means (De Vos, 2020) of transportation shows a preferential increase, albeit very marginal (0.5 percent), from pre-COVID (0.7 percent) to (1.2 percent) during COVID, which further supports the findings by Abdullah *et al.* (2020) regarding non-motorized transportation mode. Conversely, walking shows a preferential decrease to (3.7 percent) from the (5.0 percent) pre-COVID period. Remarkably, the participants' preferences for the rail system shot up by (0.5 percent) from the pre-COVID era.

S/N	Characteristics	Percentage	Remarks
A1	**State resident during the lockdown**		
1	**Lagos**	**35.1***	**Sufficient**
2	**Ondo**	**43.8***	**Sufficient**
3	Ekiti	1.7	Insufficient
4	Ogun	2.2	Insufficient
5	Osun	1.7	Insufficient
6	Abuja	2.7	Insufficient
7	Kwara	.7	Insufficient
8	Kogi	.7	Insufficient
9	Delta	1.0	Insufficient
10	Edo	1.5	Insufficient
11	Akwa Ibom	.7	Insufficient
12	Cross River	.5	Insufficient
13	Benue	.2	Insufficient
14	Oyo	1.2	Insufficient
15	Niger	.5	Insufficient
16	London	.2	Insufficient
17	Rivers	.5	Insufficient
18	Nasarawa	.2	Insufficient
19	Plateau	4.5	Insufficient
20	**Other states**	**20.7**	**Insufficient**
A2	**Regional residence during the lockdown**		
1	**South-West (S/N=1, 2, 3, 4, 5 & 14)**	**85.8***	**Sufficient**
2	North-Central (S/N=6, 7, 8, 13, 15, 18 & 19)	9.7	Insufficient
3	Niger-Delta (S/N=9, 10, 11, 12 & 17)	4.2	Insufficient
4	UK (16)	.2	
5	**Other Regions (S/N=6, 7, 8, 9, 10, 11, 12, 13, 15, 17, 18, & 19)**	**14.1**	**Insufficient**
B	**Age of the respondents**		
1	<18	6.7	
2	18 – 20	8.2	
3	21 – 30	43.3	
4	31 – 40	17.4	
5	41 – 50	14.7	
6	Above 50	9.7	
C	**Employment type**		
1	Essential Workers	21.9	
2	Non-essential Workers – public	11.7	
3	Non-essential Workers – private	12.7	
4	Self–employed / Business owners	32.8	
5	Unemployed	20.9	

NOTE: Asterisk (*) implies that the variable was sufficiently referentially quantified (see Table 6).

Table 1: Demographics of the survey respondents (*n*=402) for whom data were available for analysis

Regarding the travel restrictions protocol, the study shows a (3 percent) decline from pre-COVID to the COVID commuting period, from Monday to Friday, the typical workdays for most workers. The commuting lifestyle drastically changed, such that (40.8 percent) went out less than five days during the usual 5-day working week from (19.7 percent), representing a (21.1 percent) dip, which implied that the 'don't-go-to-work' policy impacted the participants commuting patterns. The drop in the commuting period during weekdays owing to COVID is generally consistent with the commuting dip observable during recessions (Herriges, 2017; BLS, 2014). Consequently, the participants reduced their everyday commuting days from (43 percent) pre-COVID to (14.9 percent) during the COVID-19 period, representing the most considerable change of (-28.1 percent). While a (7.4 percent) rise in weekend travel patterns is shown, the participants were plausibly satisfying their motion needs in undirected travels (Hook *et al.*, 2021) or travel exigencies because the lockdown policy was less stringent during the weekend window. Furthermore, there were noticeable increases in the fortnightly and monthly scheduled commuting owing to the COVID-19 outbreak and the imposed spread-mitigative protocols. Overall, the protocols regarding travel restrictions and lockdowns were primarily complied with during the first wave of the new coronavirus pandemic, supported by Abdullah *et al.* (2020), among other authors.

4.2. The extent of preferential modal shift and travel change

The evidence of change in mode preferences and travel patterns has been shown in Section 4.1. This section further investigates the extent of change triggered by COVID-19 travel protocols. Kendall's tau-b correlation coefficients, asymptotic standard errors (ASE) assuming the null hypothesis, and statistical significance are shown in Tables 3, 4, 5, and 6.

4.2.1. The extent of preferential transportation means change during COVID-19

In Table 3, Kendall's tau-b correlation coefficient (tau-b = 0.093) shows a weak but positive relationship. It is significant for the extent of mode preferences at ($p = 0.032$), implying that the respondents indeed at least wished for a means of transportation change if they could not afford a shift, in reality, owing to the COVID-19 impact. The extent of mode preferences shifts to private vehicular use and is consistent with Table 2, where a (17.5 percent) increase from the pre-COVID to COVID period is evident. The respondents thus had a preferential shift from public transportation (34.1 percent) to private vehicle use at no extent option (48.2 percent). About forty-five (54.3) percent of a little extent choice in private vehicle use shifted from (29.6 percent) public transportation use pre-COVID, while (24.6 percent) in public transportation mode preferences to (55.7 percent) private vehicle use at some extent of change option. To a large extent, choice (24.4 percent) of respondents used motorcycles, and (19.2 percent) of public transportation had modes preferences shift to (50 percent) private vehicle use. The respondents thus considered a modal shift in the absolute extent at (44.7 percent) in the private vehicle preferences. Convincingly from Table 3, the survey participants considered mode preferences change to private vehicular use during COVID from pre-COVID patterns.

Characteristics	Frequency	Percent	Frequency	Percent	Percent
	Pre-COVID transportation means		**During COVID preference**		**Change**
Public transportation	183	45.5	112	27.9	-17.6
Private vehicle	130	32.3	200	49.8	17.5
Train	3	0.7	5	1.2	0.5
Motorcycle	62	15.4	65	16.2	0.8
Bicycle	3	0.7	5	1.2	0.5
Walking	20	5	15	3.7	-1.3
No response	1	0.2	-	-	
	Pre-COVID daily travel patterns		**During COVID patterns**		
Monday to Friday	93	23.1	81	20.1	-3
Less than five days btw Monday and Friday	79	19.7	164	40.8	21.1
Weekends only	26	6.5	56	13.9	7.4
Every day of the week	173	43	60	14.9	-28.1
Fortnightly	9	2.2	19	4.7	2.5
Monthly routine	20	5	21	5.2	0.2
No response	2	0.5	1	0.2	

Table 2: Descriptive statistics of transportation means and travel patterns pre- and during COVID-19

The extent of preferential transport means change due to COVID	Public transportation	Private vehicle	Train	Motorcycle	Bicycle	Walking	Tau-b coeff.	ASE	Approximate T[b]	p-value
To no extent	34.1	48.2	0	14.1	0	3.5	0.093	0.043	2.148	0.032
Little extent	29.6	54.3	0	12.3	3.7	0				
Some extent	24.6	55.7	3.3	14.8	0	1.6				
Large extent	19.2	50	1.3	24.4	0	5.1				
Absolute extent	28.7	44.7	1.1	16	2.1	7.4				

Note: Approximate T[b] value - using the asymptotic standard error assuming the null hypothesis. ASE – Asymptotic standard error

Table 3: The extent of preferential transportation means change due to COVID

The impact of travel restrictions on outings from pre-COVID travel pattern	Monday to Friday	Less than five days between Monday and Friday	Weekends only	Every day of the week	Fortnightly	Monthly routine	Tau-b coeff.	ASE	Approximate T[b]	p-value
Restricted within the residential locale	32.1	2.7	4.7	37.7	0	3.8	0.108	0.043	2.542	0.011
Restricted more within the LGA	24.7	16.4	16.4	32.9	4.1	5.5				
Restricted within the state	17.5	16.8	2.9	55.5	2.2	5.1				
Restricted more within the country	20.3	24.1	6.3	39.2	3.8	6.3				

Note: Approximate T[b] value - using the asymptotic standard error assuming the null hypothesis. ASE – Asymptotic standard error

Table 4: The impacts of travel restrictions on outings from pre-COVID travel patterns

4.2.2. The impacts of travel restriction protocols on outings from pre-COVID travel patterns

A Kendall's tau-b correlation coefficient (tau-b = 0.108) shows significance for the impacts of travel restrictions at (p = 0.011), as shown in Table 4. The respondents' travel coverage, geography, or distances during COVID were significantly impacted. The travel restriction protocol impact was felt every day of the week during COVID; for example, about two-fifths (37.7 percent) of the survey participants were restricted within their locality (5.6 percent) more than those who felt this impact only during the typical workdays, i.e., Monday to Friday. During the typical workdays, fewer people were restricted within their local government areas and less within their states of residence or work. However, about three-fifths (55.5 percent) of the respondents, representing the most impact, were restricted within their states of residence or work every day, relatable to BLS (2014) regarding the dip in travel time experienced during recessions, in direct violation of Marchetti's constant (Kung et al., 2014; Marchetti, 1994), during normal situations. It typically connotes the differential handling of the travel restriction protocols by the different states' governments. Of course, the implementation of the travel restriction policy is enforced more at the borders of the states. Expectedly, due to the lockdown and travel restriction protocols, international flights were completely grounded, as reflected in their everyday impact (39.2 percent) on participants with international travel plans.

4.2.3. Travel purposes with daily travel patterns and employment types from pre-COVID to COVID period

With a significant (p = 0.026) for Kendall's tau-b correlation coefficient (tau-b = -0.097), a negative and weak relationship between variables reveals COVID-19 had a significant impact on travel patterns, as shown in Table 5. About five-tenths (54.7 percent) of the respondents impacted every day of the week commuted only to their places of work. As shown in Table 1, the workers examined here include the essential workers, medical and security personnel, and food sellers. Others are non-essential workers, public and private entities, self-employed, and the unemployed. Respondents who visited the health units or isolation centers only did that during the weekdays and less than five days between Monday and Friday (34.8 percent). About two-fifths (33.9 percent) still went out for public functions every day of the week. At the same time (37.5 percent) went out for exercise and sports activities less than five days between Monday and Friday, while (34.8 percent) went out for leisure, essentially in the form of undirected travel (Hook et al., 2021).

As shown in 6, Kendall's tau-b coefficient of correlation shows a highly significant value (p = 0.000) with a comparatively stronger relationship between variables (tau-b = 0.371); thus, employment types are significantly associated with where the survey participants visited during the COVID pandemic. Approximately three-tenths (31.4 percent) of the essential workers and (33.2 percent) of the self-employed or business owners commute strictly to their places of work. In the same light, about two-fifths (39.1 percent) of the business owners and unemployed (34.8 percent) did visit the health units or the isolation centers, plausibly for socio-psychological reasons. About thirty-five (35.6) percent of the self-employed had a travel pattern that skewed to attending public functions more than other workers. Unsurprisingly, the unemployed dominate sports and exercise (62.5 percent) and leisure (46.3 percent) travel purposes during COVID.

4.3. The ordinal logistics regression and the COVID transport variables

The results, as shown in Table 7, with the F-statistic of the ANOVA (analysis of variance), show significance for both of the models, preference for a modal shift at (F = 6.078, p = 0.000), and the extent of travel change (F = 9.469, p = 0.000). Reveal that the participants in the age group 31-40 years old and

The extent of COVID outings with pre-COVID travel purpose	Monday to Friday	Less than five days between Monday and Friday	Weekends only	Every day of the week	Fortnightly	Monthly routine	Tau-b coeff.	ASE	Approximate T[b]	p-value
Strictly to the place of work	23.1	11.1	4.9	54.7	2.2	4	-0.097	0.044	-2.226	0.026
Strictly at the health unit or IC	34.8	34.8	8.7	8.4	4.3	8.7				
Still, go out for public functions	18.6	30.5	10.2	33.9	0	4				
For sports and exercise	20.8	37.5	16.7	20.8	4.2	0				
Still, go out for leisure	22.7	27.3	4.5	34.8	3.0	7.6				

Note: Approximate T[b] value - using the asymptotic standard error assuming the null hypothesis. ASE – Asymptotic standard error

Table 5: The COVID outings due to travel purposes from pre-COVID daily travel pattern

The COVID outings due to travel purposes and employment types	Essential workers	Non-essential workers - Public	Non-essential workers – Private	Self-employed / business owners	Unemployed	Tau-b coeff.	ASE	Approximate T[b]	p-value
Strictly to the place of work	31.4	14.2	15.9	33.2	5.3	0.371	0.036	10.110	0.000
Strictly at the health unit or IC	17.4	8.7	0	39.1	34.8				
Still, go out for public functions	11.9	13.6	10.2	35.6	28.8				
For sports and exercise	4.2	0	8.3	25	62.5				
Still, go out for leisure	7.5	7.5	9	29.9	46.3				

Note: Approximate T[b] value - using the asymptotic standard error assuming the null hypothesis. ASE – Asymptotic standard error

Table 6: The COVID outings due to travel purposes and employment types from pre-COVID to the COVID period

above are significantly associated with the COVID travel change, especially for the age group 41-50 years old, with the lowest odds ratio (OR), shows an extreme statistical significance (.102 (.030-.351), Wald χ^2 (1) = 13.156, p<.0001), see Supplementary Table. The evidence for altered travel type, significantly skewed toward going out less than five days in a working week (between Monday and Friday) (.295 (.087-.997), Wald χ^2 (1) = 3.858, p = .050), went out more during the weekends (.191 (.049-.739), Wald χ^2 (1) = 5.752, p = .016), and the fortnightly scheduled travelling (.134 (.029-.622), Wald χ^2 (1) = 6.574, p = .010). These results indicate that travel behavior impacted by COVID-19 is consistent with Abdullah *et al.* (2020). Relative to London (the UK), the OR for a participant going out during the lockdown is highest in the Niger-Delta Region (9.968) while it is (6.429) in the South-West region, and of course, much lower in Ondo state (1.019) of the country. The results show that with the unemployed as the reference, the statistically significant odd for the essential workers going out during the COVID lockdown period is lowest (.057 (.024-.137), Wald χ^2 (1) = 41.164, p<.0001) but highest for business owners (.244 (.130-.458), Wald χ^2 (1) = 19.300, p = .0001). A significant odds ratio was observed for participants restricted within their local government areas (.468 (.221-.989), Wald χ^2 (1) = 3.953, p = .047). Regarding COVID-19 spread-mitigative policy restricting the vehicle-passenger capacity from the erstwhile, the result revealed that going out, the passengers felt the impact of the policy, either as being complied with (p = .004) or flagrantly disobeyed (p = .006), with strikingly similar ORs. On the Likert scales of does not affect, mildly, neutral, and moderately with mostly referenced out, risk perception is highest when considering the 'does not affect' ordered option for the social distancing protocol. The extent of travel during the first wave of COVID was largely influenced by the travel restrictions or the lockdown policy and essentially obeyed depending on the criticality of the employment type, healthcare delivery, or the enforcement of the COVID-19 spread-mitigative protocols. Regarding the preference for a modal shift, the result revealed that the younger ages 18-30 have higher odds ratios for changing from their usual mode of transportation to a more preferred one. The oldest participants, 50 years old>, have the lowest odds ratio of (1.672 (.567-4.935)) in the age category of the preference for a modal shift. Regarding modal shift, respondents from Ondo state show a low odds ratio of (.595 (.070-5.093)). The non-essential workers show a significant association for a modal shift than the essential workers and the self-employed or business owners. The participants making long-range travels to destinations farther away than their local government areas up to interstate travels do have quite a low odds ratio of (.920 (.537-1.573)) using different means of transportation for their trips. It implies that passengers prefer a change to a more convenient means of transportation for longer trips. Thus, transportation change is significantly associated with vehicles carrying the usual number of passengers (.231 (.062-.860), Wald χ^2 (1) = 4.778, p = .029). The participants who chose mildly regarding the effect of social distancing protocol on the level of transportation change owing to COVID-19 are of high odds estimate (1.511 (.568-4.020)). On the contrary, there is evidence of an ascent gradient from (.297 (.118-.661), Wald χ^2 (1) = 8.407, p = .004) to (.768 (.432-1.366)) regarding the effect of surgical or nose masking protocol on the extent of means of transportation change. For every mode of transportation examined, the odds of changing to a preferred means of transportation were higher during COVID than pre-COVID. The odds, for example, for public vehicle changed from (.252) pre-COVID to (.282), private car (.141) pre-COVID to (.406), motorcycle (.199) pre-COVID to (.470), bicycle (.187) pre-COVID to (.635), and walking (.248) pre-COVID to (.1.060). Generally, the OLR results are consistent with the descriptive results shown in Section 3.1 and the correlation results shown in Section 3.2.

5. DISCUSSION AND CONCLUSIONS

During the pandemic, as experienced during Phase 1 and phase 2 COVID-19 interventions, and immediately afterward, urban mobility and travel behavior were seriously altered, leading to unsustainable transportation options and poor travel behavior that could lead to unhealthy consequences. First, Marchetti's hypothesis is analogous to travel patterns during routine situations, such that the constancy in commuting time is comparable to the recurrence in outing patterns, for example, during typical workdays. It is concurrent with the commuting time dips found during recessions (BLS, 2014) and drops in outing frequencies and geographical extent (see Tables 4 and 5). Based on the impacts of travel restrictions on pre-COVID travel patterns and the COVID outings due to travel purposes from pre-COVID daily travel patterns analysis. For example, there are dips in weekday commuting and geographical extent mainly due to travel restrictions, especially for non-essential workers. Second, expectedly while commuting dominated the travel purpose during COVID, leisure, sports, and exercise trips increased, showing evidence of motion needs or travel for travel. Third, the preferential modal shift from public to private transportation is unsustainable. Thus, juxtaposing subsections 2.1.1, 2.1.2, and 2.1.3 with the results in sections 4.1, 4.2, and 4.3, i.e., the invalidity of Marchetti's hypothesis (subsection 2.1.1) analogy during COVID-19, as depicted in the weekday commuting dips and geographic travel restrictions, and Rodrigue's principle of modal shift (subsection 2.1.2), in this case, influencing unsustainable options, influenced potential preferential shifting from public to private vehicular use. The interpersonal behavior and social practice theories (subsection 2.1.3) inform the COVID-19-stimulated sustainable travel behavior policy framework, as shown in Figure 3.

Essentially, the framework is consequential upon the interactions between TIB and SPT, i.e., interpersonal behavior informing general social practice, found relevant and appropriate for sustainable policy framework pre-, during, and post-pandemic, such as the COVID-19 situations. It is a pleasing interplay of the factors that border around interpersonal behavior and social practice, ultimately leading to formed travel behavior. Thus, it is pertinent, considering Faiyetole (2019) had opined that preferences, which are a result of different types of interactions, lead to changed behavior and social practices. More so, that government policies, such as the COVID-19 lockdown and travel restrictions protocols that form the variables in this study, influence the dynamism of travel behavior and social practices during the pandemic and possibly into the foreseeable future. Notably, the study results (see Table 7) have shown COVID-19 caused a preferential modal shift (see Table 3) and change in outing patterns (see Table 4). It impacts interactions with daily travel purposes and patterns (see Table 5) and travel purposes with employment type (see Table 6).

Further, the SPT, based on three interdependent elements, materials, competence, and meaning, is vital to social practices (Reckwitz, 2002; Shove *et al.,* 2012). For this study, the materials signify vehicular objects, while competencies imply invention and innovation or vehicular modifications. Meaning is a knowledge state of mind, mental, emotional, attitude, habit, and all the other social forms. The theories of interpersonal and social practices essentially informed the results based on the COVID-19 spread mitigative protocols, such as social distancing and travel restrictions that infringe on vehicular size and the seating architecture plausibly created panic or not, dictating preferential modal choices. Thus, factoring all the associated factors, as shown in Figure 3, a holistic pre-, during and post-pandemic transportation policy can be developed going forward.

Covariates	Level	Preference for a modal shift	VIF	Extent of travel change
Age	<18 years old (ref.)	-	P = 1.070; E =1.069	-
	18-20 years old	2.106(.752-5.902)		.366(.127-1.054)
	21-30 years old	1.981(.833-4.712)		.552(.233-1.308)
	31-40 years old	1.700(.656-4.407)		.345(.126-.943)*
	41-50 years old	1.822(.674-4.923)		.102(.030-.351)****
	50 years old>	1.672(.567-4.935)		.221(.063-.776)*
Residence	Lagos state	.739(.087-6.267)		1.470(.193-11.180)
	Ondo state	.595(.070-5.093)		1.019(.134-7.739)
	South-West	6.130(.752-49.982)		6.429(.361-114.595)
	Niger-Delta	8.683(.831-90.704)		9.968(.461-215.528)
	North-Central	13.368(1.488-120.106)*		9.356(.486-179.972)
	UK (ref.)	-		-
Employment type	Essential workers	1.735(.883-3.412)	P = 1.046; E =1.043	.057(.024-.137)****
	Non-essential public	2.247(1.022-4.939)*		.230(.095-.553)***
	Non-essential private	2.420(1.207-4.850)*		.122(.054-.275)****
	Self-employed / business	1.500(.830-2.712)		.244(.130-.458)****
	Unemployed (ref.)	-		-
Travel restrictions	Locality	1.503(.814-2.779)	P = 1.014; E =1.014	1.092(.559-2.134)
	Local Govt. Area	1.544(.818-2.914)		.468(.221-.989)*
	State	.920(.537-1.573)		.823(.449-1.507)
	Country (ref.)	-		-
Social distancing	Does not affect	.567(.237-1.353)	P = 1.862; E =1.836	2.335(.840-6.490)
	Mildly	1.511(.568-4.020)		2.018(.625-6.519)
	Neutral	.673(.324-1.395)		1.714(.745-3.944)
	Moderately	.615(.339-1.114)		1.899(.924-3.902)
	Mostly (ref.)	-		-
Surgical masking	Does not affect	.279(.118-.661)**	P = 1.868; E =1.849	.749(.278-2.017)
	Mildly	.307(.124-.762)**		.607(.200-1.842)
	Neutral	.645(.310-1.343)		.492(.215-1.128)
	Moderately	.768(.432-1.366)		.588(.291-1.187)
	Mostly (ref.)	-		-
Pre-COVID mode	Public vehicle	.252(.014-4.579)	P = 1.173	
	Private cars	.141(.008-2.616)		
	Motorcycle	.199(.011-3.708)		
	Bicycle	.187(.005-7.778)		
	Walking	.248(.012-5.213)		
	Train (ref.)	-		
Preferred mode due to COVID	Public vehicle	.282(.040-1.993)	P = 1.192	
	Private cars	.406(.059-2.803)		
	Motorcycle	.470(.064-3.443)		
	Bicycle	.635(.050-7.981)		
	Walking	1.060(.113-9.919)		
	Train (ref.)	-		
COVID travo-temporal pattern	Monday-Friday		E =1.042	.367(.104-1.301)
	Less 5days btw Mon-Fri			.295(.087-.997)*
	Weekends			.191(.049-.739)*
	Everyday			.598(.157-2.278)
	Fortnightly			.134(.029-.622)**
	Monthly (ref.)			-

Odds ratios of the self-reported means change and the extent of commuting as no change, minor change, neutral, moderate, or significant change; ref. denotes reference category; *p*-values for odds ratios that are statistically significant with asterisks (*<.05; **<.01; ***<.001; ****<.0001).

Table 7: Odds ratios (95 percent CI) from ordinal logistic regression models for preference for a modal shift and the extent of travel change, adjusted for some demographics and COVID protocols. ANOVA: Preference for a modal shift (F – 6.078, p = 0.000); The extent of travel change (F – 9.469, p = 0.000).

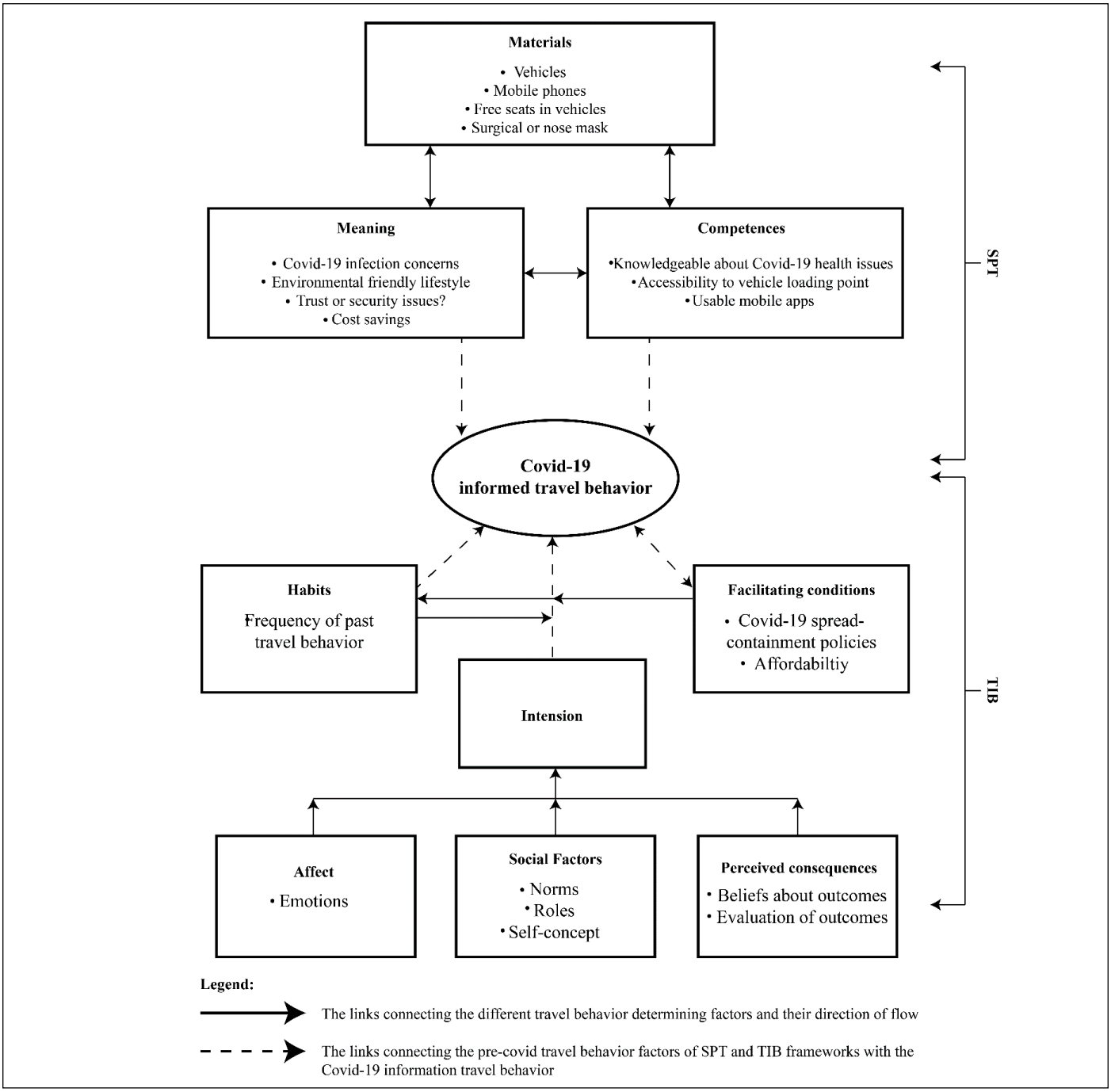

Figure 3: COVID-19 stimulated sustainable travel behavior policy framework

Hence, as we advance post-COVID, proactive and sustainable transportation policies will be critical in future pandemic impacts (Dong *et al.*, 2021; Parady *et al.*, 2020). The COVID-19 informed travel behavior framework considering hybridized SPT and TIB could be a good starting point for formulating and implementing the future, holistic, sustainable transportation policy pre-, during, and post-pandemic.

Conclusively, the study makes an empirical contribution to the literature by exploring the extent of mode preferences and travel change between Phase 2 and the immediate periods that witnessed the initial relaxations of the COVID-19 spread mitigative protocols in southwestern Nigeria. The study shows a preferential shift from public transportation to private vehicular use, implying an impetus for a modal change was set during the pandemic. If allowed, a modal shift is inevitable post-COVID and a subsequent intractable maturity phase, especially with improved purchasing power. Specifically, the travel restrictions policy was stringently enforced during Phase 2 of the PTF COVID-19 economic policy. It impacts travel change in geography, purpose, and time of the week they traveled. Evidence of exigent or undirected travel implies the imperativeness of motion-needs trip purposes, especially for health concerns. Motion needs or active trips are also essential in leisure travel and travel exigencies despite the stringent lockdown and travel restrictions policies during the COVID-19 pandemic.

While commuting dominates the travel purpose frame of the change evidenced during the COVID-19 pandemic, especially the essential workers, such as doctors, nurses, security officials, et cetera, during the regular weekdays and weekends. Thus, the takeaways from the study are in two folds. Commuters prefer private vehicular use, especially if they can afford it. The lockdown and travel restrictions cannot be total, considering that essential workers must commute during the pandemic. Summarily, the contributions in the study show that the COVID-19 mitigative policies impacted travel behavior, causing changes, especially as it relates to urban mobility. Based on the findings, synergistic state border

management officially developed into the state's transportation policies intuitively made functional during a pandemic is recommended. It is also imperative to stem down the plausible modal shift post-COVID, even with an improved socio-economic status of the citizens, and continue to promote and further the use of public transportation for sustainability purposes. Motion needs exigencies must be factored into any future pandemic-related mitigative policies, such as travel restrictions or lockdowns. On this note, there could be a need for a systemic, holistic, and robust transportation policy that could withstand the pandemic's forces to influence unsustainable travel behavior changes. Therefore, a COVID-19 travel behavior framework could be a good starting point for developing holistic and systemic transportation policies, sustainable, pre-, during, or post-pandemic. Specifically, the *materials*, the most crucial transportation hardware, such as roads and vehicles, could be innovatively developed or designed with a pandemic in mind, designed to cater for physical distancing and hygiene during commuting. The *meaning*, an understanding that largely dictates the mental position, for example, an environmentally friendly lifestyle, could be encouraged at all times, pre-, during, or post-pandemic. Thus, the citizens could develop an ideal habit for all periods. Knowledge pipes on pandemics could be designed into the curricula to help prepare citizens' minds – competencies – for any eventuality, thereby aiding mental preparedness for future pandemics. Beyond the study's merits, the limitations include hybridizing the random sampling technique with an ad hoc online sampling process, which could be innovative since the respondents came from different geographies; hence unintentional randomness, treated and sieved out for the study area with the analytical techniques.

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