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Understanding public transport use intention post Covid-19 outbreak using modified theory of planned behavior: Case study from developing country perspective

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A B S T R A C T

Use of public transportation by regular commuters can help to reduce congestion and pollution in cities. Improving public transportation facilities may not be sufficient to improve its use and understanding the factors that determine use intention may help to improve public transport use specially for young adults who travel for work regularly. The current work aims to systematically assess public transport use intention for regular commuters below the age of 45 years, who may continue using or switch to public transport when facilities improve in Indian context post Covid-19 outbreak using a modified Theory of Planned Behavior framework. The work considers public transport improvement from two aspects, first, improvement in availability, which ensures less crowding, so that peoples’ perceived safety improves from social distancing perspective and second, reduced travel times. It could be observed from this study that out of the demographic variables annual family income and education significantly affected use intentions but not family size and gender. It was observed in Indian context that social norms significantly affected public transport use intentions, but not an individual’s attitude indicating that individuals are more concerned about social mandates over their personal preferences. Also, a person who has traveled in public transport mode in recent past was observed to have greater intent to continue using public transport than those who did not. Interestingly, people with higher income and education levels showed greater intent of public transport use. The observations from this study may be used for designing focused interventions to improve public transport use intentions in developing countries like India.

1. Background and objectives

Rapid urbanization, growing vehicle ownership and increasing population and travel demand in cities are associated with increased congestion and pollution levels. It is important that personal vehicle use be discouraged and public transportation promoted for regular local commuting in congested cities (Yuda Bakti et al., 2020; Ujjwal, et al., 2021; Bandyopadhyaya, et al., 2018). Public transportation infrastructure in many places may not be adequate to meet travel demand but even at places where availability is not a concern, utilization of public transport modes is not optimum. A study in Poland revealed that public perception of public transportation is associated with discouraging factors like traffic congestion, pollution, number of transit changes, longer travel routes and delays (Ramos, et al., 2019). Effectively managing travel demand and supply and ensuring that the available roads remain uncongested even during peak travel times is challenging. Researchers worldwide have tried to understand the factors which, if improved for a public transport facility, will improve commuters’ perception about, their intention to use and their actual use of the facility. Improving certain aspects of alternative public transport modes may not ensure improved ridership. Focused interventions influencing peoples’ perception about public transport modes, their awareness about problems related to private vehicle use and their willingness to accept responsibility has been found to effectively influence their travel behavior. Better understanding of these aspects may be achieved through systematically studying an individual’s intention to engage in a behaviour through psychological or behavioral change models which aim to explain self-controllable human behaviors and analyze behavioral intent, which forms the basis for any behavior. The most popular psychological model, Theory of Planned Behavior (TPB), assumes that

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behavioral intent is influenced by attitude and belief towards the consequences of a particular behavior or action; their subjective and social norms and their control over the behavior (Ajzen, 1985).

Over the years, various researchers have used TPB, its extensions and modified TPB in combination with other psychological models to understand intentions and actual mode choice behavior across the world. It has been observed that a person who believes that a behavior will lead to positive outcomes will have favorable attitude towards performing the behavior and vice versa (Ajzen, 1985). The use of public transport is usually associated with positive outcomes of reduced pollution and congestion. Attitude towards a behavior, subjective norms and perceived control over behavior can often predict behavioral intentions accurately (Ajzen, 1991). Behavioral beliefs are expected to be significantly related to attitude, normative beliefs to subjective norms and control beliefs to perceived behavioral control. However, the nature of the relationships may vary (Ajzen, 1991). Some researchers in India and China studied peoples’ intention to adopt electric vehicles, with a focus on reducing pollution, using extended TPB (Shalender and Sharma, 2021; Wang, et al., 2016). Jing et al., (2019) used extended TPB to understand factors that affect intentions to use automated vehicles. Shi et al., (2017) studied the intention of people to reduce pollution through use of public transportation and purchase of electric vehicles. Si et al., (2020) studied factors influencing bike sharing intent in China using extended TPB with an aim to ensure sustainable mobility. Bird et al., (2018) studied peoples’ intent to walk or cycle for commuting using extended TPB with focus on health benefits as positive outcome.

It has been observed from earlier studies that a wide range of psychological factors influence intent and choice of a given mode of transport. It has also been observed that mode choice greatly depends on trip purpose (Shaaban and Maher, 2020). People’s mobility necessity and their perception of mobility related consequences of alternative modes moderates attitude and intentions of use of public transport. This may increase preference for private car use because public transport modes may not sufficiently meet the need for speed or travel times, convenience, flexibility and spontaneity (Haustein and Hunecke, 2007; Forward, 2019). It has also been observed that inconveniences, and environmental factors like perceived danger or crime records in the neighborhood affect walking and cycling behaviour, which often act as the last mile connectivity option, for assessing public transport modes (Bird, et al., 2018; Claudy and Peterson, 2014; Aditjandra, et al., 2016).

Policy measures aiming to improve attractiveness of public transport like providing bus pass and operational aspects like safety, security, reliability and timeliness affect the willingness to switch to public transport modes (Heath and Gifford, 2002; Chowdhury, 2016). TPB and modified TPB has been widely used to understand public transport use intentions (Zhao, et al., 2011; Heath and Gifford, 2002). Public transport use was observed to improve by improving passengers’ feedback which is influenced by their perceived quality, attitude, subjective norm, moral norm, and environmental norm (Yuda Bakti et al., 2020). It has also been observed that travel time, waiting time, direct connections, comfort and travel cost significantly influence shift to a new public transit mode. Perceived behavioural control, positive attitude towards transit and support from family and friends can improve public transport use (Devika and Harikrishna, 2020). Proper information about public transport schedules was observed to improve passenger’s use intention (Farag and Lyons, 2010). Zou et al., (2013) observed that attitude significantly affects bus use and people who own private cars are more influenced by subjective attitude rather than objective condition of buses. Brohi et al., (2021) observed that attitude is more important than subjective norm or perceived behavior control in deciding intention to use public transportation. Studies in Malaysia and Pakistan (Ambak, et al., 2016; Brohi, et al., 2021) showed that cost saving interest will encourage public transport use for choice riders. However in a study of car users in Poland (Urbanek, 2021) it was observed that price is not important.

It has also been observed that perceived transportation security, knowledge, price and convenience in terms of time and schedule influences attitude towards public transportation use (Scott, George, & Przybylowski, 2016). Sumaedi, et al., (2016) observed that passengers’ intention to continue using public transportation is influenced by attitude, subjective norm and image but not influenced by perceived value or perceived behavior control. However, another researcher (Shi, et al., 2017) observed that self-efficacy or confidence in behavior affected the intention of taking public transportation positively, while perceived control affected intention indirectly by moderating the relationship between subjective norm and intention. Liu et al., (2017) observed that perceived norm, attitude and perceived behavior control over car-use reduction, significantly affected the intention to reduce car use and personal norms mediated the relationships between awareness of consequences, ascription of responsibility, perceived subjective norm and intention to reduce car use. Peng et al., (2014), in a study on intercity travel mode choice in China, observed that descriptive norm and habit significantly explained variance in intention of using a particular mode. Various researchers have also observed that socio-demographic characteristics like household size, household income, age, gender, career, education and car ownership affect public transport use (Aditjandra, et al., 2016; Shaaban and Maher, 2020; Peng, et al., 2014). It was also observed that passengers’ current mode choice i.e. their travel habit significantly influences attitude, subjective norm, perceived behavior control and switching intentions for public transport modes (Chen and Chao, 2011; Chen, et al., 2019; Fu and Juan, 2016; Peng, et al., 2014). The researchers observed that it is difficult for individuals to break habitual behavior of private vehicle use and switch to public transport modes.

Importance of Safety in public transportation has increased post Covid-19 outbreak, and the significance of the term has now a wider perspective. The demand for public transportation declined in many countries as observed by some researchers (Przybylowski, et al., 2021). This is also evident from increased sale of automobiles. However, Awad-Núñez et al., (2021), in a study of public transport services in Spain, observed greater willingness to use public transport and shared services when better safety facilities are provided but at no extra cost. This indicates that with safety, concern for cost has also increased. However such studies are limited and not available in context of developing country like India. The perception about cost and safety vary widely and socio-demographic characteristics play an important role. Also as observed from earlier studies a person’s travel habit plays an important role in his or her willingness or intention to use public transport. Habit was measured as an ordered variable showing number of days the person uses private vehicle per week in 1 – 5 scale (Chen and Chao, 2011) or as a binary variable (Fu and Juan, 2016). Peng et al., (2014) measured habit using Verplanken and Orbell’s Self-Report Habit Index. However in all cases habit was considered as an independent construct and not as socio-demographic characteristic, which may be more appropriate. Moreover, the studies aiming to assess use intent of public transport focus on peoples’ intention of using public transport in future but had not tried to assess whether their intention changes with improved safety or time aspects.

In this background the current work aims to systematically assess public transport use intention for regular commuters below the age of 45 years, who may continue using public transportation modes or switch to public transportation modes when facilities improve in Indian context post Covid-19 outbreak using a customised version of standard TPB framework (Ajzen, 1991). The current work examines travel habit as an integral part of socio-demographic characteristics. The work considers public transport improvement from two aspects, first, improvement in availability, which ensures less crowding, so that peoples perceived safety improves from social distancing perspective and second, reduced travel times. Safety in public transport was defined for this work as “freedom from risk of contaminations that may result in infectious diseases which may be caused due to overcrowding in public transport modes”. The study systematically aims to understand in detail:
Influence of socio-demographic factors like gender, education, family size, income and travel habit on behavioral beliefs (BB), normative beliefs (NB) and control beliefs (CB) and thereby public transport use intentions.

Influence of BB on attitude, NB on subjective norms (SN) and CB on perceived behavioral control (PBC)

Influence of attitude, SN and PBC on intention to use public transport

Whether public transport use intention changes with improvements in public transport availability and travel time

In this work data from two Indian cities namely Patna and Kolkata was used and the survey was partially conducted by face to face interview and partially by online e-mail survey. The conceptual framework of the study is discussed in the next section. Section 3 describes the data used in this study. Section 4 provides the analysis and discusses the major findings. Section 5 provides the major conclusions from the study and highlights the policy recommendations that could be proposed for positively influencing public transport use intentions in the perspective of developing countries.

2. Conceptual framework of the study

The aim of this study was to understand in detail how a person’s socio-demographic profile influences his/her beliefs and attitude which in turn is believed to affect their intention of public transport use. The TPB framework was customized for this study and the conceptual framework used is provided in Fig. 1.

The conceptual framework, adopted from (Ajzen, 1991), shows the latent variables in the study and the manner in which these variables are expected to be related to or to affect each other. Nine hypotheses, H1 through H9 depicted in the conceptual framework, were framed to understand whether the relationships between the latent variables are statistically significant. Table 1 provides the research questions and details the hypotheses mentioned in Fig. 1.

The socio-demographic factors, beliefs, attitudes, norms and intentions referred in the conceptual model are latent variables i.e. not directly measured but are measured through variables detailed in Table 2. The measured variables form the survey questionnaire. Each item of the questionnaire, i.e. the measuring variables mentioned in Table 2, were developed as per guidelines and methodology suggested for questionnaire development using constructs of Theory of Planned Behavior (Ajzen, 2006).

It may be observed from Table 2 that five socio-demographic variables namely gender, education, family income, number of family members in household and whether the person uses public transport regularly for commuting were considered as background factors that may affect a person’s beliefs and in turn his intention to use public transport. Use intention or intention of people to use public transport, was measured using three variables, intention to use public transport availability and travel time and use public transport if availability improves and if the speed of travel improves in future.

Attitude towards use of public transport was assessed using four variables related to convenience, comfort, time saving and perception about safety of public transport in the city. The effect of each of these variables on attitude may be obtained from the model. Attitude may be explained through behavioral beliefs which were assessed through two variables namely the belief that using public transport will help to reduce congestion in the city and the belief that reducing congestion in the city is important. Subjective norm is measured through three variables namely whether the person most important to him approves of his using public transport, whom the respondent listens to when deciding about commuting mode and whether he travels by the public transport.
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Table 2

| Latent Unobserved Variables | Measured Variables | Code | Observed measures |
|-----------------------------|--------------------|------|-------------------|
| **Socio-demographics**      | Gender             | Gen  | Female (0); Male (1) |
|                             | Education          | Edu  | School Level (1); Graduate (2); Post Graduate and above (3) |
|                             | Annual Family Income (Rs.) | Inc  | <5 lakhs (1); 5 – 10 lakhs (2); 10 – 15 lakhs (3); >15 lakhs (4) |
|                             | Use public transport regularly | RegCom | Yes (1); No (0) |
| **Attitude**                | My travelling to work on public transport is/ will be convenient | Aconv | 1 (Strongly Agree) to 7 (Strongly Disagree) |
|                             | My travelling to work on public transport is/ will be comfortable | Acomf | 1 (Strongly Agree) to 7 (Strongly Disagree) |
|                             | My travelling to work on public transport is/ will be time saving | Atimesav | 1 (Strongly Agree) to 7 (Strongly Disagree) |
|                             | Use of public transport in the city is safe in terms of social distancing in pandemic situation | Psafe | 1 (Strongly Agree) to 7 (Strongly Disagree) |
| **Subjective Norm**         | Most people who are important to me approve/ will approve of my travelling by public transport | Napprove | 1 (Strongly Agree) to 7 (Strongly Disagree) |
|                             | When it comes to choosing daily commuting mode, I listen to my (options) | Dummy coded | L_Family (10) L_Friends (01) |
|                             | Family (L_Family) | Acquaintances (Friends (L_Friends) Acquaintances) | NusePT | 1 (Strongly Agree) to 7 (Strongly Disagree) |
|                             | Most people like me to travel by public transport to their work | BCConfidence | Behaviour |
|                             | I am confident that I can travel by public transport | BCControl | Behaviour |
|                             | My travelling in public transport is up to me | BBCongestion | Behaviour |
| **Control Beliefs**         | My travelling in public transport helps to reduce traffic congestion in city | OECongestion | Behaviour |
|                             | Reducing traffic congestion in city is important | NBPT | Behaviour |
|                             | My family thinks that I should travel in public transport for work | NBListen | Behaviour |

The person to whom the respondent listens to when deciding about commuting mode may be family, friends or other acquaintances (including colleagues or neighbors) and were considered as three distinct binary variables during modeling.

The measuring variables considered in Table 2 were taken from previous published research on transport mode choice or public transport use intention studies. Socio-demographic features like gender, education etc. has been used by earlier researchers to understand public transport use intention (Haustein and Hunecke, 2007; Bird, et al., 2018; Chaubal and Peterson, 2014; Forward, 2019; Aditjandra, et al., 2016), time saving aspect was considered by some researchers (Ramos, et al., 2019; Heath and Gifford, 2002; Chaudhary, 2020) and safety aspect post pandemic outbreak was considered by few other researchers (Awad-Núnez, et al., 2021; Przybylowski, et al., 2021). The subjective norms measuring variables and comfort has been considered by various researchers for studying public transport use intention (Haustein and Hunecke, 2007; Bird, et al., 2018; Chaubal and Peterson, 2014; Forward, 2019; Aditjandra, et al., 2016), time saving aspect was considered by some researchers (Ramos, et al., 2019; Heath and Gifford, 2002; Chaudhary, 2020) and safety aspect post pandemic outbreak was considered by few other researchers (Awad-Núnez, et al., 2021; Przybylowski, et al., 2021). The subjective norms measuring variables had been considered by researchers for measuring public transport use intentions (Devika and Harikrishna, 2020; Shalender and Sharma, 2021; Yuda Bakti et al., 2020; Brohi, et al., 2021). The PBC variables about confidence and freedom to travel by public transport had been used by Devika & Harikrishna (2020) and Brohi, et al., (2021). Behavior or habit, another variable included in PBC, has been used by various researchers (Chen and Chao, 2011; Fu and Juan, 2016; Peng, et al., 2014). Belief about role of public transport in reducing traffic congestion has been studied by Ramos, et al., (2019). Normative belief related variables have been used by Liu, et al., (2017) and Peng, et al., (2014). Control beliefs variables related to expected improvement in public transport in future has not been studied. However, some studies (Awad-Núnez, et al., 2021; Heath & Gifford, 2002; Chowdhury, 2016) have observed that policy measures aiming to improve public transport facilities can improve willingness to use. Use intention related variables have been used by Heath & Gifford (2002), Wang, et al., (2016) and Zou, et al., (2013).
The present study aims to analyze the use intention of public transport as a function of commuter’s socio-demographic characteristics, their beliefs and their personal and social norms, which in turn may be measured with measurable characteristics detailed in Table 2. The Structural Equation Modelling (SEM) framework enables modeling of the use intention by considering both latent and measureable variables. The SEM model permits the evaluation of nature and strength of the relationships among these variables using the latent variable and measurement models. The latent variable model may be represented as equation 1.

\[ x = \psi x + \omega x + \zeta \]  

(1)

where, \( x \) is an \( m \times 1 \) vector of the latent variables, \( y \) is an \( (n \times 1) \) vector of the measured variables, and \( \zeta \) is an \((m \times 1)\) vector of random errors. The elements of the \( \psi \) (\( m \times n \) matrix) and \( \omega \) (\( m \times n \) matrix) matrices are the structural coefficients of the model. The basic equations of the measurement models can be written as in equations 2 and 3.

\[ x = \lambda_x \xi + \delta \]  

(2)

\[ y = \lambda_y \eta + \epsilon \]  

(3)

In equation 2, \( x \) and \( \delta \) are column (q) vector related to the observed variables and error, respectively and \( \lambda_x \) is a \((q \times n)\) structural coefficient matrix for the effects of the latent variables. In equation 3, \( y \) and \( \epsilon \) are column (p) vectors related to the measured variables and error, respectively; \( \lambda_y \) is a \((p \times m)\) structural coefficient matrix for the effects of the latent variables on measured ones.

3. Data

This questionnaire was administered to 340 respondents from Patna and Kolkata, India, who commute regularly, out of which 303 responses were complete and could be used. Data was collected in the months of July, August and September 2020 and July 2022, partially by online survey and partially by face to face interviews. The sample size of 303 may be considered adequate for 90% confidence level. The minimum sample size required is 271 from 138 crore population (the current Indian population size), as calculated using equation 1 (Krejcie and Morgan, 1970).

\[ S = \chi^2 NP(1 - P) + d^2(N - 1) + \chi^2 P (1 - P) \]  

(1)

where, \( S \) is the required sample size, \( \chi^2 \) is the table value of chi-square for 1 degree of freedom at 90% confidence level (2.705), \( N \) is the population size, \( P \) is the population proportion (considered 0.5 for maximum required sample size), \( d \) is the degree of accuracy expressed as proportion (0.05).

Only young population up to 45 years of age were targeted who are more likely to think of switching to public transport modes. Among the respondents 68.6% were males and the remaining were females. In terms of educational qualifications, 6.9% of respondents studied till school level, 56.4% were graduates and 36.7% were at least post graduates. Annual family income (in Indian rupees) was less than 500,000 for 53% respondents, 500,000 to less than 1000,000 for 32% respondents, 10,00,000 to less than 15,00,000 for 9.8% respondents and greater than 15,00,000 for 5.2% respondents. In terms of household size, 1.8% respondents had up to 2 members in the household, 50.9% had 3 to 4 members and 47.3% had 5 or more members. Among the respondents 48.5% were regular public transport users and the rest did not use public transport regularly.

4. Analysis and discussions

The present study analyses the use intention of public transport as a function of commuter’s socio-demographic characteristics, their beliefs and their personal and social norms. These latent variables were measured with measureable characteristics detailed in Table 2. The number of items, means, standard deviations and Cronbach’s alpha coefficients were calculated for all latent variables to show the internal consistency of the scales used for measuring the latent variables and shown in Table 3. It may be observed that all the values of alpha are above 0.7 and may be considered acceptable (George and Mallery, 2003).

In this work, the SEM model was developed using IBM-SPSS-AMOS-20. Maximum Likelihood Estimate (MLE) method was used to estimate the model parameters. Fig. 2 shows the standardized coefficients of the paths showing relations between the latent variables. The indicators for SEM model fit are shown in Table 4.

It may be observed from Table 4 that the \( \chi^2/df \) is less than the minimum acceptable value of 5. Also RMSEA is less than 0.08 which is acceptable. The model test values of NFI and CFI also indicate acceptable fit.

Table 5 shows the relationships between the unobserved latent variables and tests their significance. This table enables testing the hypotheses stated in Table 1. The standardized coefficients or standardized regression weights are depicted in Fig. 2. The regression weight estimate, in each case, shows rate of change of the dependent variable for 1 unit change in the independent variable. For example for Normative Beliefs—Demographics indicates that when Demographics goes up by 1, Normative Beliefs goes up by 4.003. The regression weight estimate, 4.003, has a standard error of about 0.873, which is a measure of its scatter. The critical ratio is obtained by dividing the regression weight estimate by the estimate of its standard error using equation 4. P value or prob value, which is a function of \( z \), estimated from normal distribution assumption, is the probability of regression weight being equal to zero. Thus, having very low prob value shows that there is a significant correlation between the variables.

Critical Ratio (CR) = \( z = \frac{4.003}{0.873} = 4.587 \) (3)

It may be observed from Table 5 that two regression weights for latent variable relations were fixed to 1, as it was required for model estimation. When the standardized regression weight estimates of the variable for which the regression weight had been fixed to 1 were compared with other latent variable relationships, the significance of the variable could be observed even when the hypothesis is not explicitly stated. The regression weight estimates for all cases were found to be significant except for the relation between attitudes and use intentions for public transport. From the estimated relationships and significance of the relationships between the latent variables the research questions formulated in Table 1 could be answered. Statistically significant relationships could be observed between an individual’s socio-demographic characteristics and his beliefs, his beliefs and norms and norms and perceived behavior control and use intentions. However, it was observed that an individual’s attitude did not significantly influence his intention of public transport use. This is contrary to what was observed in other countries (Zou, et al., 2013; Bird, et al., 2018; Farag and Lyons, 2010). The estimates of all the significant relationships are shown in Table 5.
positive.

Table 6 provides the regression weight estimates and their significance and the standardized regression weights for the relationships between the latent unobserved variables and the corresponding variables used to measure these latent variables.

Table 6 shows that while estimating the contribution of measured variables, one of the measured variable regression weight was fixed at 1 for each latent variable, as required for developing the model. However, when the standardized regression weight estimates of other measured variables were compared with the variable for which the regression weight was fixed to 1, the significance of the variable could be observed. The observed variable which measures an individual's preference on listening to family, friend or acquaintance while choosing mode of commuting was dummy coded and the variable of listening to acquaintance was taken as base variable. Thus, the coefficients of listening to friends and family estimated are in comparison to the base variable coefficient, which was taken as 0.

The effects of the individual measured variables on an individual's beliefs and public transport use intentions may be inferred by following the paths in the model shown in Fig. 2. Understanding the nature of relations will help understand the focus of policy measures to be designed for improving individual's public transport use intentions. Thus, the significant path relationships are illustrated and depicted in Table 7. The standard coefficients for each path are taken from Table 5 and Table 6. The path coefficients between the latent variables are also shown in Fig. 2.

Table 6 and Table 7 enables making inferences about how well the measuring variables measure the underlying latent variables and the nature of the relationships of these variables with public transport use intentions. Annual family income, regular use or non-use of public

| Table 4 |
| SEM Model Fit Results. |
| Indicator for SEM model fit | Ideal indicator value | Model test value |
|--------------------------------|------------------------|------------------|
| CMIN/DF | Less than 5 | 3.142 (961.45/306) |
| Root mean square error approximation (RMSEA) | Maximum 0.08 | 0.075 |
| Normed fit index (NFI) | Acceptable above 0.8 (Doll, et al., 1994; Baumgartner and Homburg, 1996) | 0.859 |
| Comparative fit index (CFI) | 0.801 |

| Table 5 |
| Relationships between unobserved variables/ Hypothesis Test results. |
| Latent Unobserved Variables | Standardized Coefficient | Regression Weight Estimate | Standard Error | Critical Ratio | P | Inference |
|-------------------------------|--------------------------|----------------------------|----------------|----------------|---|-----------|
| Behavioral Beliefs <— Demographics | 0.941 | 1.000 | 1.304 | 3.844 | 0.000* | Accept alternate hypothesis H2 |
| Normative Beliefs <— Demographics | 0.99 | 5.014 | 1.573 | 6.420 | 0.000* | Accept alternate hypothesis H3 |
| Control Beliefs <— Demographics | 0.736 | 7.268 | 1.364 | 4.531 | 0.000* | Accept alternate hypothesis H4 |
| Attitude <— Behavioral Beliefs | 0.761 | 6.180 | 0.777 | 4.795 | 0.000* | Accept alternate hypothesis H5 |
| Perceived Behavioral Control <— Control Beliefs | 0.854 | 0.526 | 0.326 | 5.877 | 0.000* | Accept alternate hypothesis H6 |
| Subjective Norms <— Normative Beliefs | 0.968 | 1.916 | 0.613 | 1.000 | 0.000* | Accept alternate hypothesis H7 |
| Use Intention <— Perceived Behavioral Control | 0.658 | 0.730 | 0.154 | 4.739 | 0.000* | Accept alternate hypothesis H8 |
| Use Intention <— Subjective Norms | 0.613 | 1.000 | 0.125 | −1.212 | 0.226 | Reject alternate hypothesis H9 |
| Use Intention <— Attitude | -0.132 | -0.152 | 0.125 | 1.212 |

* Significant at 99 %
higher will be the person’s public transport use intentions. Also a person who uses public transport regularly will have higher levels of use intentions than those who do not use public transport regularly. Family size and gender were not observed to be significantly influencing public transport use intentions.

### Table 6
Relationships between unobserved variables and their underlying measured variables.

| Latent Unobserved Variables | Observed Variables (Code) | Standardized Coefficient | Regression Estimate | Standard Error | Critical Ratio | P   |
|-----------------------------|---------------------------|--------------------------|---------------------|---------------|---------------|-----|
| Socio-demographics          | Edu                        | 0.257                    | 1.000               |               |               |     |
|                             | Inc                        | 0.246                    | 1.401               | 0.423         | 3.134         | 0.000*|
|                             | Size                       | -0.086                   | -0.307              | 0.213         | -1.438        | 0.151 |
|                             | Gen                        | 0.066                    | 0.204               | 0.180         | 1.133         | 0.257 |
|                             | RegCom                     | 0.206                    | 0.689               | 0.223         | 2.968         | 0.003*|
| Behavioral Beliefs          | OECongestion               | 0.107                    | 1.000               |               |               |     |
|                             | BBCongestion               | 0.472                    | 5.638               | 1.269         | 4.443         | 0.000*|
| Normative Beliefs           | NBFollow                   | 0.364                    | 1.000               |               |               |     |
|                             | NBUsePT                    | 0.623                    | 1.769               | 0.310         | 5.708         | 0.000*|
|                             | NBListen                   | 0.562                    | 1.541               | 0.280         | 5.511         | 0.000*|
|                             | NBPT                       | 0.722                    | 2.232               | 0.375         | 5.950         | 0.000*|
| Control Beliefs             | Ftime                      | 0.742                    | 1.000               |               |               |     |
| Attitude                    | Acconv                     | 0.736                    | 1.000               |               |               |     |
|                             | Acconf                     | 0.681                    | 0.936               | 0.070         | 13.292        | 0.000*|
|                             | Atimesav                   | 0.585                    | 0.777               | 0.098         | 7.945         | 0.000*|
|                             | Psafe                      | 0.621                    | 0.875               | 0.103         | 8.472         | 0.000*|
| Subjective Norm             | Napprove                   | 0.717                    | 1.000               |               |               |     |
|                             | L_Family                   | -0.189                   | -0.060              | 0.020         | -3.029        | 0.002*|
|                             | NotePT                     | 0.758                    | 1.053               | 0.087         | 12.155        | 0.000*|
|                             | L_Friends                  | 0.086                    | 0.222               | 0.016         | 1.388         | 0.165 |
|                             | PBC                        | 0.437                    | 1.000               |               |               |     |
|                             | BCCongression              | 0.653                    | 1.328               | 0.206         | 6.434         | 0.000*|
|                             | Behaviour                  | 0.717                    | 1.852               | 0.281         | 6.596         | 0.000*|
| Use Intention               | Intent                     | 0.706                    | 1.000               |               |               |     |
|                             | UseAvail                   | 0.637                    | 0.669               | 0.060         | 11.158        | 0.000*|
|                             | UseTime                    | 0.554                    | 0.589               | 0.061         | 9.643         | 0.000*|

* Significant at 99%

### Table 7
Nature of relationships of measured variables with use intentions.

| Paths with standardized coefficients | Nature of relationship |
|--------------------------------------|------------------------|
| Education → Demographics             | Positive(0.257 × 0.99 × 0.968 × 0.658) = 0.162 |
| Education → Socio-demographics       | Positive0.257           |
| Education → Subjective norms         | Positive0.999           |
| Education → Use Intentions           | Negative0.968           |
| Income → Demographics                | Positive0.658           |
| Income → Subjective norms            | Positive0.658           |
| Income → Use Intentions              | Positive0.954           |
| Regularcomuting → Demographics       | Positive0.256           |
| Regularcomuting → Socio-demographics  | Positive0.999           |
| Regularcomuting → Use Intentions     | Positive0.988           |
| NBFollow → Normative beliefs         | Negative0.562           |
| NBFollow → Subjective norms          | Positive0.658           |
| NBFollow → Use Intentions            | Positive0.383           |
| NBUsePT → Normative beliefs          | Positive0.562           |
| NBUsePT → Subjective norms           | Positive0.658           |
| NBUsePT → Use Intentions             | Positive0.562           |
| NBListen → Normative beliefs         | Negative0.562           |
| NBListen → Subjective norms          | Positive0.658           |
| NBListen → Use Intentions            | Positive0.658           |
| NBFPT → Normative beliefs            | Positive0.722           |
| NBFPT → Subjective norms             | Positive0.968           |
| NBFPT → Use Intentions               | Positive0.658           |
| Ftime → Control beliefs              | Positive0.730           |
| Ftime → Perceived behavior control   | Positive0.854           |
| Ftime → Use Intentions               | Positive0.613           |
| NBApprove → Subjective norms         | Positive0.717           |
| NBApprove → Use Intentions           | Positive0.656           |
| NBFamily → Subjective norms          | Positive0.199           |
| NBFamily → Use Intentions            | Negative0.124           |
| BCCongression → Perceived behavior control | Positive0.437 |
| BCCongression → Use Intentions       | Positive0.617           |
| BCCongression → Use Intentions       | Positive0.617           |
| BCControl → Perceived behavior control | Positive0.730 |
| BCControl → Use Intentions           | Positive0.384           |
| BCControl → Use Intentions           | Positive0.384           |
| BCConfidence → Perceived behavior control | Positive0.435 |
| BCConfidence → Use Intentions        | Positive0.617           |
| BCConfidence → Use Intentions        | Positive0.617           |
| Behavior → Perceived behavior control | Positive0.717 |
| Behavior → Use Intentions            | Positive0.613           |
| Behavior → Use Intentions            | Positive0.613           |

transport and education may be observed to significantly measure socio-demographic characteristics with positive slope indicating direct relationships. Higher the family income and education level of a person, higher will be the person’s public transport use intentions. Also a person
The two underlying measuring variables for the latent variable behavioral beliefs were significant and both have positive relations with public transport use intentions. This shows that if a person believes that his traveling by public transport can help to reduce congestion in the city and also if he believes that reducing congestion in his city is important, then his public transport use intentions will improve. Also, it could be observed that if a person listens to his family or friends who are important to him and they themselves use or approve of his use of public transport, it influences the person’s public transport use intentions positively. Future improvement in availability and time saving features or speed of public transport were observed to be significant measuring variables for control beliefs and the positive relation with use intentions show that if a person believes that availability and speed of public transport will improve in his city in near future, his use intentions will improve.

A person who listens to family, friends or acquaintances (NListen) for making his or her choice of travel mode, were observed to have positive impact on their normative belief, subjective norm and in turn public transport use intention when their family, friends or acquaintances have positive view of public transport use. All measuring variables other than L_friends was observed to be significant. It may be inferred that a person’s use intentions are significantly affected by his family and whether they themselves travel or approve of his traveling by public transport. The negative slope for L_family indicates that more a person listens to his family, lower will be his public transport use intentions.

Improved availability and speed of public transport in the city will improve a person’s public transport use intentions. Attitude was observed to be significantly affected by a person’s perception about comfort, time saving and safety of use of public transportation in the city. However, attitude was earlier observed to not have significant influence on use intentions. Also, a person who confidently stated that he or she traveled in public transport mode in past three months was more likely to have better intention to use public transport when facilities improve.

5. Conclusions and policy recommendations

The present work attempted to understand the factors that affect public transport use intentions post Covid-19 pandemic outbreak in context of a developing country like India. Modified TPB was used to develop the conceptual framework for the study. The effect of the demographic variables, beliefs, attitude and norms on public transport use intentions were studied using SEM.

It could be observed from this study that out of the demographic variables annual family income, regular use or non-use of public transport and education significantly affected public transport use intentions but not family size and gender. Some of these findings are similar to findings by other researchers but some findings are different.

A person’s regular use or non-use of public transport or his habitual mode choice has been observed to affect public transport use intention by other researchers also (Peng et al., 2014; Chen and Chao, 2011). If a person is a regular commuter, he is more likely to continue using public transportation but a habitual personalized vehicle user is less likely to switch to public transport modes. As social norms influenced a person’s travel mode choice, campaigns focusing on creating awareness of public transport use is expected to have a positive impact. However, tailored methods need to be designed to focus on the two groups – those who use public transport and those who do not, for the awareness campaigns to be effective. Providing better facilities for speedy travel along with increase of cost of private vehicle use may make the current private vehicle users shift to public transport. Income was observed to affect use of public transport, as observed by some other researchers and higher income groups showed less preference for public transport (Shaaban and Maher, 2020). However, interestingly in the present study, higher income and education level of a person was observed to increase his/her willingness to use public transport modes. This may be because higher income and education levels may mean greater understanding of the negative effects of private vehicle use. Family size and gender were not observed to be significant in the present study. A study in Qatar (Shaaban and Maher, 2020) had observed gender to be significant and the difference may be due to the cultural differences between the countries.

Another interesting finding was that attitude was not significant unlike observations from other studies (Yuda Bakti et al., 2020; Devika and Harikrishna, 2020; Zou et al., 2013; Sumaedi et al., 2016). Subjective norm was found to be more important than attitude in determining use intention for public transport. It may be inferred that people, even if they believe their travel by public transport is or will be more convenient, comfortable and time saving, may not actually intend to switch to public transport if their family or friends do not approve of it. Earlier researchers had observed that social norms affect intention and in some countries like China and India, social pressure plays an important role in determining a person’s choices and personal norms are considered least important (Peng et al., 2014; Wang et al., 2016; Devika and Harikrishna, 2020). The scenario may be different in other countries.

It could be observed from the present study that providing safe, convenient and comfortable mode of public transport can help to increase the use of public transport in the city. Use intention was measured by improved availability of public transport and improved speed of travel. Attitude depends on perception about comfort, convenience and safety, in terms of social distancing which became important post Covid-19 outbreak, of public transport. The positive slope indicates that if people feel more comfortable and find it is more convenient and safe mode, they are more likely to use public transport. Similar observations have been made by other researchers (Chaudhary, 2020; Devika and Harikrishna, 2020; Chen et al., 2019). Awad-Núñez et al., (2021) observed that people will switch to public transport if better safety is provided at no extra cost. Thus, providing convenient safe connectivity by public transport can help to reduce dependency on personal vehicle use. Also conducting awareness campaigns about ill-effects of private vehicle use and pro-active promotion of public transport to target groups through providing incentives may help reduce private vehicle dependency.

There were some interesting findings from this study, which may be useful in designing policy measures with aim of improving individual’s public transport use intentions. Two interesting facts were observed. Firstly, an individual’s choice of travel mode is more influenced by social norms rather than their personal choice or belief that public transport use reduces congestion. Secondly convenience of travel and safety provided by the mode in terms of scope of social distancing increased their willingness to use the mode. Thus, campaigns focusing on improving perception of people about public transport modes may improve social acceptability of public transport use and, in turn, improve public transport use intentions. Also, campaigns highlighting the good features of public transport modes, their improved availability and reduced travel times in different programs can improve public transport use intentions. Taking up schemes like priority signals for public transport which in turn improve the travel time and highlighting them in the awareness programs can also improve the use intentions. Moreover, improving facilities and public transport infrastructure in the city can improve the intention to use public transport modes. Using private vehicle in a congested city is often time taking and costly. The public transport improvement may help reduce use of personalized vehicles for regular commuting and ease city traffic congestion. Further work may be done to understand whether intentions to switch will depend on factors like distance commuted regularly, the type of personalized vehicles used – like car, motorcycles or hired vehicles and the cost difference on switching.
Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Aditjandra, P.T., Cao, X.J., Mulley, C., 2016. Exploring changes in public transport use and walking following residential relocation A British case study. Retrieved from J. Transp. Land Use 9 (3), 77-95. https://www.jstor.org/stable/26023231.

Ajzen, I., 1985. From Intentions to Actions: A Theory of Planned Behavior. Retrieved from In: Kuhl, J., Beckmann, J. (Eds.), Action Control: From Cognition to Behavior. Springer-Verlag. pp. 11-39. https://datamam.com/fdsap/Up2013/Ajzen/From%20Intentions%20to%20Actions-TPB.1985.pdf.

Ajzen, I., 1991. The Theory of Planned Behavior. Organ. Behav. Hum. Decis. Process. 50 (2), 179-211. https://doi.org/10.1016/0749-9978(91)90020-7.

Ajzen, I., 2006. Constructing a Theory of Planned Behavior Questionnaire. Retrieved the work reported in this paper.

References

Chen, C.-F., Chao, W.-H., 2011. Habitual or reasoned? Using the theory of planned behaviour to understand public travel mode choice: Evidence from China. Int. J. Environ. Res. Public Health 14 (12), 1593. https://doi.org/10.3390/ijerph14121593.

Peng, J., Zhi-cai, J., Lin-jie, G., 2014. Application of the Expanded Theory of Planned Behavior to Identify the Behavioral Intention to use Public Transportation Service: Discrete Dyn. Nature Society 2014, 1–10. https://doi.org/10.1155/2014/308674.

Przyblywski, A., Stelmak, S., Suchanek, M., 2021. Mobility Behaviour in View of the Impact of the COVID-19 Pandemic—Public Transport Users in Gdansk Case Study. Sustainability 13 (364), https://doi.org/10.3390/su1310364.

Ramos, S., Vicente, P., Passos, A.M., Costa, P., Reis, E., 2019. Perceptions of the Public Transport Service as a Barrier to the Adoption of Public Transport: A Qualitative Study. Social Sci. 8 (150), 1–16. https://doi.org/10.3390/socsci805150.

Shaaban, K., Maher, A., 2020. Using the theory of planned behavior to predict the use of an upcoming public transportation service in Qatar. Case Stud. Transp. Policy 8 (2), 484-491. https://doi.org/10.1016/j.csp.2019.11.001.

Shalender, K., Sharma, N., 2021. Using extended theory of planned behaviour (TPB) to predict adoption intention of electric vehicles in India. Environ. Dev. Sustain. 23 (1), 665–681. https://doi.org/10.1007/s10668-020-00602-7.

Shi, H., Wang, S., Zhao, D., 2017. Exploring urban resident’s vehicular PM2.5 reduction behavior intention: An application of the extended theory of planned behavior. J. Cleaner Prod. 147, 663-613.

Si, H., Shi, J.-G., Tang, D., Wu, G., Lan, J., 2020. Understanding intention and behavior toward sustainable usage of bike sharing by extending the theory of planned behavior. Resour. Conserv. Recycl. 152, 104513. https://doi.org/10.1016/j.resconrec.2019.104513.

Sumaedi, S., Yarmen, M., Bakti, I.M., Rahmakwati, T., Astrini, N.J., Widianti, T., 2016. The integrated model of theory planned behavior, value, and image for explaining public transport passengers’ intention to reuse. Manage. Environ. Qual.: Int. J. 27 (2), 124-135. https://doi.org/10.1108/MEQ-03-2015-0027.

Ujjwal, J., Bandyopadhyaya, V. and Bandyopadhyaya, R., 2021. Identifying key determinants for parking management to reduce road traffic congestion for congested cities – A Structural Equation Modelling approach. Advances in Transportation Studies, 143-158, Volume 54 (Section B) – July 2021, Aracne Editrice, Italy.

Urbanek, A., 2021. Potential of modal shift from private cars to public transport: A survey on the commuters’ attitudes and willingness to switch – A case study of Silesia Province, Poland. Res. Transp. Econ. 85. https://doi.org/10.1016/j.retrec.2020.101008.

Wang, S., Fan, J., Zhao, D., Yang, S., Fu, Y., 2016. Predicting consumers’ intention to adopt hybrid electric vehicles: using an extended version of the theory of planned behavior model. Transportation 43 (1), 123–143. https://doi.org/10.1111/1545-1050.12067.

Yuda Bakti, I.G.M., Rahmakwati, T., Samaedi, S., Widianti, T., Yarmen, M., Atrini, N.J., 2020. Public transport users’ WOM: an integration model of the theory of planned behavior, customer satisfaction theory, and personal norm theory. Transp. Res. Procedia 48, 3365–3379. https://doi.org/10.1016/j.trpro.2020.08.117.

Zhou, S., Li, L., Dong, Z., Wu, B., 2011. Analyzing Public Transportation Use Behavior Based on the Theory of Planned Behavior: To What Extent Does Attitude Explain the Behavior?. In: https://doi.org/10.4118/42143.

Zou, F., Wu, X., Xiong, J., & Li, L., 2013. Analyzing Public Transportation Competitiveness Based on The Theory of Planned Behavior. ICTE 2013, (pp. 3139–3147). doi:10.1007/978-3-642-31595-455.