Satisfaction differences in bus traveling among low-income individuals before and after COVID-19

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A R T I C L E   I N F O

A B S T R A C T

Although all cities in China have promulgated public transportation control measures to choke off the spread of COVID-19, it also has brought severe changes to low-income individuals' bus traveling. However, the study focusing on satisfaction differences in bus traveling before and after COVID-19 is far under-researched, this paper therefore explored satisfaction differences among low-income individuals under socioeconomic attributes, traveling attributes, and psychological attributes by using the data consist of interviews addressed to 930 individuals in Taiyuan, China. Furthermore, the relationship between satisfaction levels and modes of traveling alone and traveling with companions by bus has also been deeply analyzed to reduce single-person driving problem. As a result, many exciting phenomena were discovered: the significant factors affecting low-income individuals' satisfaction occur "shift" on a large scale after COVID-19; risk concern has a significant positive impact on risk perception, but risk concern and risk perception have only a minor impact on satisfaction before and after COVID-19; it was found that there is a significant relationship between satisfaction levels and modes of traveling alone and traveling with companions by bus. Understanding them can be a reference for improving the travel environment between low-income individuals.

1. Introduction

Failure to keep up with the consumption levels in urban centers, low-income individuals are often forced to move away from areas with convenient transportation due to high housing costs. As a result, they travel longer distances (Kain, 1968; Blumenberg and Ong, 1998). Furthermore, this passenger group' traveling choices are limited by their financial constraints (Apparicio and Séguin, 2006), so they prefer public transportation (e.g., buses) with higher social benefits. Shen (2001) found that disadvantaged groups prefer cheap public transportation and travel at a slow pace by exploring impacts of traveling choices on them (Shen, 2001; Kawabata, 2003). De Vasconcellos (2005) pointed out that low-income individuals spend more money on public transportation but only obtain lower mobility. People tend to travel more by private cars and less by bus as their incomes rise (Paulley et al., 2006), whereas the case is quite

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the opposite for low-income commuters with IC cards (Cheng et al., 2015). Traveling by bus for low-income individuals is also influenced by social environmental factors such as street connectivity and the safety of surrounding areas at night (Lucas et al., 2018).

As with other public transportation services, the aim of buses enhancing mobility and carrying large numbers of passengers essentially is dependent on attracting and retaining passengers. Researchers have amply demonstrated the significance of public transportation service quality in retaining and attracting passengers (Hensher and Golob 2008; Board, 2013). Passengers' perspectives on service quality and performance attributes help to provide information for determining attributes that will eventually promote passenger growth (Redman et al., 2013; Board, 2013). Therefore, researchers have conducted surveys and analyses based on passenger perceptions of specific performance of transportation attributes, thereby measuring their perceptions through satisfaction (Wan et al., 2016). From the operator perspective, ensuring durable transit systems is grounded in passenger satisfaction as the key to shared responsibility because passengers are co-producers of the service quality output through their satisfaction from system-user interaction (Randheer et al., 2011). Furthermore, satisfaction ECT is also a psychological attitude indicator used to guide bus traveling reflecting passengers' internal attitudes towards bus traveling and, to some extent, determining passengers' traveling status and decisions.

Unexpectedly, in January 2020, the COVID-19 outbreak in Wuhan, China, led to a surge in confirmed cases across China, reflecting its increasing severity nationwide and globally (Feng et al., 2020). Bus, with its high capacity and intensive use, soon became one of the virus transmission media (Shen et al., 2020; Chen et al., 2020). Consequently, restrictive measures (e.g., working at home), reducing consumption (i.e., limiting home-based shopping trips), limiting community contacts, and restricting international travel were implemented throughout the country to contain the epidemic (Yilmazkuday, 2020; Silver et al., 2020). Nevertheless, people have various travel demands in the use of public transport during pandemics, e.g., daily grocery shopping trips, work trips. These policies might not only discomfort people's travel behavior, social interactions and financial status, but also their health and well-being (De Haas et al., 2020; De Vos, J. 2020). In view of these impacts, frequent bus users may seek alternative ways of traveling, and changes in traveling behaviors after COVID-19 have been confirmed by some scholars (Kwok et al., 2020; De Vos et al., 2020; Molloy et al., 2020; Engle et al., 2020). People placed a higher priority on the pandemic related concerns while choosing a transportation mode during the pandemic as compared to the general concerns, tending to use less buses during pandemic (Abdullah et al., 2020). In addition, these policies will also increase the psychological burden of bus passengers, the fear of infection and risk perception may also impact the travel modes.

Therefore, two issues arise during the COVID-19 regarding the study on low-income individuals who prefer buses: **(i)** As far as we know, there are few studies have been conducted to explain the presence or absence of differences in satisfaction with regard to various socioeconomic attributes, traveling attributes, and psychological attributes. **(ii)** Previous studies have only focused on the impacts of traveling with companions on satisfaction, while little attentions have been paid to impacts of traveling alone and traveling with companions on satisfaction among low-income individuals. Therefore, we try to achieve the following three goals in this paper: **(i)** Explore satisfaction differences in bus traveling among low-income individuals under different socioeconomic attributes, traveling attributes, and psychological attributes caused by COVID-19. **(ii)** Explore the impacts of satisfaction on presence or absence of traveling alone and traveling with companions. **(iii)** Explore the differences by comparing **(i)** and **(ii)** before and after COVID-19[a]. We think such researches have the following benefits: **(i)** Provide references for improving the environment of bus traveling for low-income individuals in the future under similar major public health events. **(ii)** Provide case studies for transportation departments to improve the proportion of bus traveling among low-income individuals in the post-COVID-19 period. **(iii)** Inspire city planners and decision makers to promote green traveling and reduce single-person driving[b] when developing some plans (e.g., environmental protection).

The remainder of this paper is organized as follows. Section 2 is devoted to the literature review. The definition of low-income individuals, questionnaire design, data collection, variable construction, and model selection are presented in Section 3. Section 4 analyzes the results to explore the impact of low-income individuals on satisfaction with bus traveling under various socioeconomic attributes, traveling attributes and psychological attributes, as well as the relationship and differences between low-income individuals' satisfaction and traveling alone or with companions. In section 5, the major conclusions and an outline of future research tasks are presented.

2. Literature review

In this section, we will analyze the previous works from four aspects including: (i) design of satisfaction, (ii) relationships among socioeconomic attributes, traveling attributes, and satisfaction, (iii) relationships between psychological attributes and traveling satisfaction, (iv) relationships between satisfaction and traveling behavior. The limitations of previous works will be concluded, and the improved works of this paper will be introduced.

Oliver's expectation confirmation theory (ECT) defines expectations, perceived performance and belief disconfirmation as a function of expectations (Oliver, 1977). Overall satisfaction in public transportation can thus be defined as the difference between expected and perceived or experienced performance. In this case, passenger satisfaction can be used to explore the perceived attractiveness of public transportation.

2.1. Design of satisfaction

Many previous articles have pointed out that bus satisfaction can be measured from seven aspects, including: convenience, comfort, speed, accessibility, affordability, safety, and reliability (Eboli and Mazzulla, 2007; Yahya, 2007; Shaaban and Khalil, 2013; Trompet et al., 2014; Wan et al., 2016; Shaaban and Kim, 2016; Ingvardson and Nielsen, 2019), providing a more comprehensive picture of

passengers' overall traveling experience. When people travel, for example, accessibility can bring them "fair happiness" (Tyler, 2015); Comfort can be reflected from cleanliness, spaciousness, and temperature inside buses (De Oña et.al., 2013). Furthermore, indicators such as punctuality, service frequency and traveling speed are the most important attributes of user satisfaction (De Oña et al, 2015, 2013; Eboli and Mazzulla, 2015, 2007; Fellesson and Friman, 2012; Friman and Gärling, 2001; Van Lierop et al, 2017; Mouwen,2015; Shen et al, 2016; Stuart et al, 2000; Tyrinopoulos and Antoniou, 2008; Weinstein, 2000; Redman et al., 2013; Allen et al., 2020, 2018; Guirao et al., 2016). However, studies have also emphasized the significance of other attributes such as staff behavior (De Oña et al., 2013; Fellesson and Friman, 2012; Friman and Gärling, 2001; Van Lierop et al., 2017; Allen et al 2020), safety and security (Fellesson and Friman, 2012; Spears et al., 2013; Stuart et al., 2000; Van Lierop et al., 2017; Allen et al., 2018; Eboli and Mazzulla, 2015; Tyrinopoulos and Antoniou, 2008; Van Lierop et al., 2017; Weinstein, 2000; Dell'Olio et al, 2011; Allen et al., 2020), and availability of information (Allen et al, 2020, 2018; Eboli and Mazzulla, 2015; Friman and Gärling, 2001; Van Lierop et al, 2017; Weinstein, 2000). other scholars have demonstrated that satisfaction with bus services depends on a variety of non-instrumental factors, such as cleanliness, privacy, safety, convenience, pressure, social interaction and scenery (Stradling et al., 2007; Eboli and Mazzulla, 2015; Tyrinopoulos and Antoniou, 2008; Van Lierop et al., 2018; Weinstein, 2000; Dell'Olio et al, 2011; Allen et al., 2020). Furthermore, Ettema (2011) has noted that satisfaction should also include cost-related cognitive components.

2.2. Relationships among socioeconomic attributes, traveling attributes, and satisfaction

Studies on satisfaction difference among social groups focus on life, products, etc. Voss (2006) has explored the impact of gender, value expression, and functional image perception on satisfaction through a study on audiences from two theaters. Male reports higher levels of satisfaction when they perceive higher levels of functional service quality. Fahey and Smyth's survey (2004) on life satisfaction found a strong correlation between higher incomes and higher satisfaction scores, but it also discovered that some poor people reported higher levels of satisfaction than the rich (Bhnke, 2008), and that being young, healthy, and employed, as well as having a partner, contribute to a satisfying life (Delhey 2004; Böhnke 2005). In explaining the difference in life satisfaction across countries, Diener (1999) also identified living standards, employment opportunities and health as the most determining factors, and found the positive impact of marriage, social relations and social networks on life satisfaction. According to Frey's findings (Frey and Stutzer, 2002), subjective well-being is an empirical approximation of personal satisfaction. However, as several studies have confirmed, socio-demographic factors account for<20% of subjective well-being (Campbell et al, 1976; Andrews and Withey 1976; Diener and Suh, 1997).

Traveling satisfaction and traveling attributes interact with each other (De Vos, 2019b). A considerable number of studies have been conducted to explore the impact of traveling time on traveling satisfaction, with the result indicating that that the longer the traveling time, the lower the level of satisfaction (Morris and Guerra, 2015; Higgins et al., 2018; Zhu and Fan, 2018a). The positive and negative impacts of traveling distance on satisfaction depend on the traveling purpose (De Vos et al., 2016; Handy & Thigpen, 2018; Mokhtarian et al., 2015; Schneider and Willman, 2019), and activities performed while traveling (via public transportation) will affect passengers' evaluation of traveling (Ettema et al., 2012; Lyons et al., 2007; Tang et al., 2018).

2.3. Relationships between psychological attributes and traveling satisfaction

Satisfaction and mode choices are linked not only to service attributes, but also to psychological aspects of passengers, such as the impact of attitudes on traveling satisfaction. De Vos et al have found a positive correlation between positive attitudes toward traveling (i.e., attitudes of liking to travel) and overall traveling satisfaction (De Vos and Witlox, 2016; Ye and Titheridge, 2017). Three studies also suggest that positive attitudes toward a transportation mode have a positive impact on traveling satisfaction when using this mode (De Vos et al, 2016; St-Louis et al, 2014; Ye and Titheridge, 2017). Friman (1998; 2001) even shows that single key events (events that differ from users' expectations) and the memory of their frequency can affect satisfaction and public transportation services. a lack of knowledge about the perceived value and satisfaction may lead to lower passenger satisfaction and lower repeat business (Gallarza and Saura, 2006). Traveling modes (bus and car), traveling time, accessibility of bus stops and the number of daily activities will affect satisfaction, emotion and subjective well-being to some extent (Ettema et al., 2011).

2.4. Relationships between satisfaction and traveling behavior

In terms of the relationship between satisfaction and traveling behavior, most studies show that car use leads to a moderate traveling satisfaction, with passengers being more satisfied than drivers, and that public transportation primarily leads to passenger dissatisfaction, particularly when taking the bus (Mokhtarian et al, 2015; De Kruijf et al., 2019). Some studies have also found that energetic traveling modes, such as walking and bicycling, are more satisfying than taking the bus, demonstrating importance of healthy activities for short-distance traveling (Morris and Guerra, 2015; Páez and Whalen, 2010; St-Louis et al, 2014; Ye and Titheridge, 2017). Taking the subway or train may provide more satisfaction, sometimes even more than driving. Surprisingly, e-bikes appeared to be perceived negatively in three Chinese studies (Ye and Titheridge, 2017; Zhu and Fan, 2018a), contradicting a Dutch study that found cyclists to be more satisfied with commuting than car users (De Kruijf et al., 2019). Indeed, the factors influencing traveling satisfaction vary depending on the choice of traveling modes (De Vos and Witlox, 2016), as some traveling attributes are associated with the use of specific traveling modes. People's perceptions on public transportation are influenced by service attributes such as punctuality, frequency, cleanliness, comfort, and people behavior (Dell'Olio et al, 2011; Van Lierop et al., 2018). Some studies have even found that traveling alone results in lower traveling satisfaction, whereas traveling with companions leads to higher

satisfaction (De Vos, 2019a; Lancée et al., 2017; Zhu and Fan, 2018b). However, research on the impact of satisfaction on traveling alone and traveling with companions is insufficient.

As the conclusion, we can find some limitations of previous works: (i) the aforementioned analyses were only conducted in a normal social setting, their results may differ in the case of COVID-19. (ii) the previous design of satisfaction indicators may not be fully applicable during COVID-19. After COVID-19, probably, people place a higher priority on the pandemic related factors to avoid the risk of COVID-19 infection, such as social distancing during bus traveling. (iii) COVID-19 may generate new psychological activities (i.e., worry about the risk of infection; concern about physical condition of other passengers). (iv) Previous studies have only focused on the impacts of traveling alone or with companions on satisfaction, little attentions have been paid to impacts of traveling alone and traveling with companions on satisfaction, and the results may also vary during COVID-19.

In order to solve the limitations mentioned above, an in-depth analysis of satisfaction before and after COVID-19 is required. Firstly, in terms of survey respondents, we chose low-income individuals as the study subject for two main reasons: (i) low-income individuals are highly dependent on bus traveling due to poor economic situation; (ii) there are a large number of low-income individuals in China and even the world. Secondly, we design an indicator structure that takes into account post-COVID-19 measures. Finally, three classical models are used as quantitative research methods to achieve the research objectives discussed and compare the differences before and after COVID-19: **(i)** we use a multi-categorical and ordered logit model to explore the differences in socio-economic attributes and travel attributes before and after COVID-19. **(ii)** structural equation model is introduced to explore the impact of low-income individuals on satisfaction with bus traveling under psychological attributes. **(iii)** we use Binary logit model to explore the relationship and difference between low-income individuals' satisfaction and traveling alone or with companions. We hope our works can provide references for transportation departments to improve the environment of bus traveling among low-income individuals in the future, and inspire city planners and decision makers to promote green traveling and reduce single-person driving.

3. Methods and data

3.1. Definition of low-income individuals

Numerous criteria can be used to define low-income individuals (Mallett, 2001; Giuliano, 2005). The International Organization for Economic Cooperation and Development (OECD) proposed the international poverty line in 1976, taking 50% of a country or region's per capita disposable income as the poverty line (Wong, 1995). Mo (1993) points out that the international poverty line serves as a reference indicator for defining low-income individuals in China's urban areas. For example, if Taiyuan residents' per capita disposable income in 2020 is 35,473 China Yuan[c] (Taiyuan Statistics Bureau, 2021), and 50% of that figure is used as the line for low-income individuals in the city, the annual per capita disposable income is 17,736.5 China Yuan. The household disposable income of each low-income individual is defined by household size, as shown in Table 1. However, in practice, when designing questionnaires, the "household income" column will be appropriately adjusted to explore efficiency. For example, if "household disposable income of 17,736.5 China Yuan and below" is replaced with "household disposable income of 17,000 China Yuan and below", the error will not have a significant impact on the overall study because the revised figure is still below the international poverty line.

3.2. Variables and models

3.2.1. Variables

(i) Socioeconomic attributes and traveling attributes

Socioeconomic factors, in general, include some common variables in the study of past traveling behaviors: household registration, gender, age, occupation (self-employed; unemployment; retirees; students; office workers or workers), education (junior high school and below; high school or technical secondary school; undergraduate or junior college; graduate student), family income, family size, disability, degree of disability (none; mild; moderate or severe), marital status (married; unmarried), family car ownership, and personal IC card ownership. Traveling attributes primarily refer to the most common reasons for using buses before and after COVID-19, such as going to work, going to school, life shopping, recreational activities, visiting relatives and friends, others (such as seeing a doctor) as well as the corresponding traveling time and distance.

Table 1
Definition of low-income individual.

The range of household disposable income in 2020 (unit: China Yuan)	Family size	Category
17736.5 (**17000**[a]) and below	1	Low-income individual
35,473 (**35000**[a]) and below	2	Low-income individual
53209.5 (**50000**[a]) and below	3	Low-income individual
70,946 (**70000**[a]) and below	4	Low-income individual
88682.5 (**85000**[a]) and below	5	Low-income individual
106,419 (**100000**[a]) and below	6	Low-income individual

[a] The standard of the questionnaire.

(ii) Psychological attributes

The new coronavirus is a virus that spread quickly and has a high infection rate (Sun and Zhai, 2020; Phucharoen et.al., 2020). Even though the virus's peak transmission has passed (Sun and Zhai, 2020), its terrible infectivity creates an indelible sense of risk, resulting in subtle changes in people's psychological mood and, eventually, traveling behavior (Kim et al., 2017). The bus, a mode of public transportation with high concentration and low social distance levels, is essential for low-income individuals (Mercado et al., 2010). However, because of the "double negative effects" of COVID-19 and economic status on bus traveling for low-income individuals, satisfaction differences in bus traveling among low-income individuals may exist before and after COVID-19. According to Kim and Abdullah (Kim et al., 2017; Abdullah et al., 2020), paying attention to COVID-19 will raise self-protection awareness among residents, affecting traveling. Based on their findings, a psychological latent-variable model of risk concern and risk perception on satisfaction with bus traveling among low-income individuals has been developed to explore the heterogeneity of satisfaction of bus traveling before and after COVID-19, as well as the impact of COVID-19 on satisfaction with buses. Risk concern usually shows that people set the corresponding risk indicators for some insoluble and insurmountable risks in the internal environment and the external environment, pay attention to the changes in its risk indicators while bearing such risks, and determines whether it has reached the risk warning value that has caused harm. And risk perception is the subjective judgment made by people about the characteristics and severity of a particular risk, as well as an important variable in measuring public psychological panic in risk perception theory (Oltedal et al., 2004; Korstanje, 2009). It requires a series of observed variables to measure because both variables are potential variables. The 5-point Likert scale was used to assess variables, with risk concern as an exogenous latent variable. Among the observed variables are:

Mask wearing: *Would you notice if other passengers on the bus were wearing?*
Level of crowding: *Would you pay attention to the crowding on the bus?*
Physical contact: *Would you mind if other passengers made physical contact with you on the bus?*
Physical condition of other passengers: *Would you pay attention to other passengers' physical conditions, such as sneezing and coughing on the bus?*
Interior environment: *Would you care if the bus is clean and odor-free?*
Risk rating of 1–5 on a scale, with 1 indicating "very unconcerned" and 5 indicating "very concerned";
Risk perception is as a potential endogenous variable, with the following observed variables:
Not wearing masks: *Would you be concerned if other passengers did not wear masks?*
Bus congestion and depression: *Would you be concerned about passengers outnumbering seats?*
Coughing and sneezing on the bus: *Would you be concerned about other passengers coughing and sneezing on the bus?*
Physical contact with other passengers: *Would you be concerned about having physical contact with other passengers?*
Non-disinfected and dirty bus: *Would you be concerned that the bus is dirty and non-disinfected?*
Risk rating of 1–5 on a scale, with 1 indicating "little worried" and 5 indicating "very worried";
(iii) Satisfaction with bus traveling.

Comfort, accessibility, and other macro-satisfaction indicators demonstrate traveling experience completely, but they are too abstract concepts to evaluate each traveler's feelings accurately. These macro-satisfaction indicators, therefore, must be elaborated further. This makes it easier for respondents to understand the indicators and accurately express their feelings when measuring in real life. At the same time, during the COVID-19, buses, as a mode of public transportation, have some attributes that make traveling difficult, such as shorter social distances. Because the novel coronavirus is transmitted via contact and droplet (Yang and Wang, 2021; Chen et al., 2020), individuals' satisfaction with bus traveling in this "terrible" traveling condition may change, such as paying more attention to social distance and epidemic prevention and control information on the bus. In summary, a system of satisfaction indicators has been established based on the macro concept and the epidemic situation, including satisfaction indicators demonstrated in previous studies, such as waiting time, arrival time, and traveling cost. Variables were measured using a 5-point Likert. A rating of 1–5 on a scale, with 1 indicating "strongly dissatisfied" and 5 indicating "strongly satisfied".

Waiting time (WT): *Are you happy with the waiting time for your desired bus at the bus stop?*
Arrival time (AT): *Are you happy with the time your bus arrives at your desired bus stop?*
Social distance (SD) (Park, 1925)**:** *Are you happy with the different spatial distances on the bus between individuals, groups, and individuals and groups depending on the degree of intimacy?*
Risk alerts (RA): *Are you satisfied with these risk alerts on the bus before COVID-19, such as the slogan "Don not put your head and hands out the window", and prevention management tips during the COVID-19, such as "Have your mask on and scan a health QR code when getting on the bus"?*
Road traffic conditions (RTC): *Do you experience traffic jams or frequent red lights while taking the bus?*
Easy to transfer (ET): *Are you happy with your current bus transfer (is the transfer distance too long?) when taking the bus?*
Traveling cost (TC): *Are you happy with the current bus prices?*
Interior ventilation (IV): *Are you satisfied with the current ventilation in the bus (does it make you feel stuffy and depressed)?*
Stability in driver's speed selection (SDSS): *Are you happy with stability in driver's speed selection (does the driver drive too fast or too slow)?*
Interior temperature (IT): *Are you happy with the temperature in the bus (any prolonged overheating or overcooling)?*
(iv) Traveling alone and traveling with companions

Traveling modes are generally defined from a variety of perspectives, including those based on traveling mode selection, traveling costs, etc., such as low-cost and car-preferred modes. Babu identified two traveling modes that people use: traveling alone and traveling with companions (Babu and Anjaneyulu, 2021). The former is used to describe someone who travels alone. The latter one refers to someone who travels with other companions. Numerous studies have found significant differences in the two traveling modes among others, such as mode of transportation (Gliebe and Koppelman, 2005; Srinivasan and Bhat, 2006, 2008; Babu and Anjaneyulu, 2021). Differences in traveling mode selection exist when traveling with companions (Ingvardson and Nielsen, 2019). Furthermore, it is a common knowledge that when a person is pleased with something, he or she may share or recommend it to others. Traveling with companions may be included if this logic is applied to public transportation. If someone is dissatisfied, he or she are more likely to travel alone. This implies that a distinct correlation between satisfaction and modes of traveling alone and traveling with companions may exist. The purpose of this paper is to study the satisfaction of modes of traveling alone and traveling with companions, as well as contributing to the solution to "single-person driving", one of the major problems of smart transportation (Tang and Tang, 2020). Smart transportation advocates for more efficient resident traveling and lower carbon emissions. However, the excessive use of single-person driving in developing smart transportation has a significant impact on traveling efficiency. This paper can serve as a reference for increasing multi-passenger bus traveling and decreasing single-person traveling by exploring the mechanism underlying satisfaction and modes of traveling alone and traveling with companions.

3.2.2. Models

(i) Socioeconomic attributes, traveling attributes, and satisfaction with bus traveling

Because the variables used to estimate satisfaction with bus traveling are multi-categorical and ordered, the model parameters can be calibrated using a multi-categorical and ordered logit model. The model is an extension of logistic regression for two or more categories (or levels) with multi-categorical and ordered variables. Logit model's goodness-of-fit is generally verified by Nagelkerke R^2 (Eboli and Mazzulla, 2009) and the statistical effects of variables are based on the Wald test P values (Eboli et al., 2016).

(ii) Psychological attributes and satisfaction with bus traveling

Structural equation modeling (SEM) is best suited for exploring the mechanism of interaction between latent variables. It is a multivariate statistical framework for studying interrelationships among multi points, allowing greater flexibility in measurement models and estimating both factor structure and factor relationships (Hoyle, 1995; Chung and Ahn, 2002). The maximum likelihood estimate (MLE) is the most commonly used estimation method, with advantages such as asymptotic unbiasedness, asymptotic validity, and scale invariance (Browne, 1982; Bollen, 1989). The measurement model and the structural model are both included in SEM. The former contains both latent and observed variables, and is used to estimate the interrelationships between the two types of variables. The latter contains latent variables and is used to explore the causal relationships between those variables.
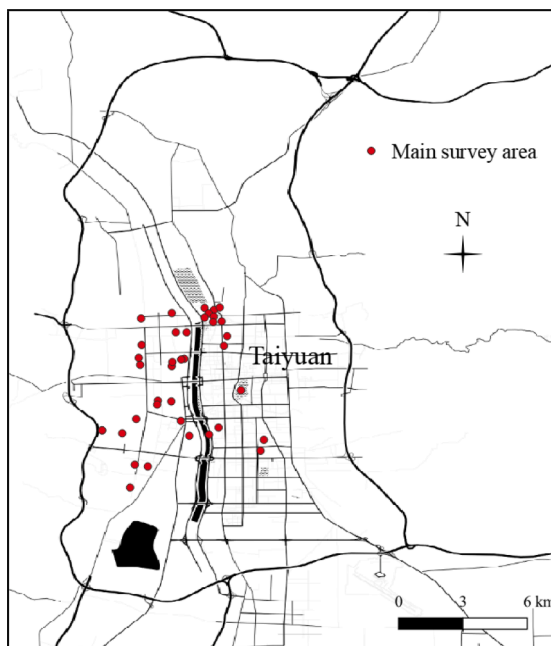

Fig. 1. Survey area.

(iii) Satisfaction with bus traveling and traveling alone and traveling with companions

Traveling alone and traveling with companions are two distinct scenarios. As a result, Binary Logit (BL) can be used to fit date and calibrate parameters in order to estimate the impact of different levels of satisfaction on these two models. We code traveling alone as "0″ and traveling with companions as "1", and the last category of the independent variable is used as the reference variable. The Hosmer-Lemeshow test is used to assess goodness-of-fit.

3.3. Survey area and data collection

Taiyuan, the capital city of Shanxi Province, is an ancient city with a history of>2,500 years. Bordered by the Fenhe River and surrounded by mountains on three sides, the city covers a total area of 1,460 square kilometers, with a total of five municipal districts registering 5,304,100 permanent residents by 2020. At the end of 2020, its GDP reached 415.325 billion China Yuan and its per capita disposable income of residents was 35,473 China Yuan, while the national per capita disposable income of residents in the same period reached 32,189 China Yuan (the state council, government of the people's republic of China, 2021). Taiyuan is only slightly above the national average level in per capita disposable income and is at a medium–low level. Even so, the city still lags behind developed coastal areas such as Shanghai and Shenzhen in terms of development and permanent resident.

This survey is based on the ***Study on Travel Service Guarantee for Low-Mobility Individuals in the Case of Public Health Emergencies***, a philosophy and social science planning project in Shanxi Province. The survey is divided into two stages. The first stage was held from December 18, 2020 to December 30, 2020. The survey team of 11 students collected 462 data on low-income individuals, but they could not be used because questionnaire questions were not comprehensively designed. The second stage was held from May 18, 2021 to May 24, 2021. Fig. 1 shows a survey conducted by a team of 12 students in the residential areas, parks, squares and shopping malls of five municipal districts including Wanbolin District, Jiancaoping District, Yingze District, Xiaodian District and Jinyuan District. Low-income individuals who meet the needs of the survey were sought around these areas. Before asking them to fill out the questionnaire, show them investigator card and student card and explain to them the purpose of this questionnaire. A material reward will be given after the promise is filled in truthfully (5 China Yuan per person or black signed pens of the same value). The questionnaire is divided into three main sections: (i) questions on socioeconomic attributes, traveling attributes, and traveling alone and traveling with companions for low-income individuals; (ii) questions on risk concerns and risk perception concerns when taking the bus before and after COVID-19; and (iii) an evaluation of ten indicators for satisfaction with bus[d]. A total of 1,000 questionnaires were distributed, 12 of which were lost and 58 of the remaining 988 questionnaires are invalid, therefore a valid sample questionnaire was 930, with sampling rate of 94.1%. Two reasons can account for it. For one thing, respondents were interrupted while filling out questionnaires, resulting in incomplete data. For another, respondents paltered with questionnaires.

Table 2 shows the basic descriptive information of respondents. Male low-income individuals and those with rural household registration were overrepresented at 62.6% and 63.4%, respectively. Respondents can provide a useful overview of some characteristics of low-income individuals in terms of age, occupation, household income, education, and household size. For example, they have

Table 2
Basic descriptive information of the respondents.

Dimension	N = 930		Dimension	N = 930	
	Category	Amount/ Percentage (%)		Category	Amount/ Percentage (%)
Household registration	rural	590/63.4	Occupation	self-employed	13/1.4
	urban	340/36.6		unemployment	233/25.1
Gender	female	582/62.6		retirees	91/9.8
	male	348/37.4		students	188/20.2
Age (unit: years)	[0, 20]	53/5.7		office workers/workers	405/43.5
	(20, 30]	164/17.6	Education level	junior high school and below	510/54.8
	(30, 40]	168/18.1		high school/technical secondary school	188/20.2
	(40, 50]	126/13.5		undergraduate/junior college	190/20.4
	(50, 60]	194/20.9		graduate student	42/4.5
	>60	225/24.2	Marital status	married	815/87.6
Disability	yes	86/9.2		unmarried	115/12.4
	no	844/90.8	family car ownership	no	661/71.1
Degree of disability	none	844/90.7		yes	269/28.9
	mild	66/7.1	personal IC card ownership	no	221/23.8
	moderate/ severe	20/2.2		yes	709/76.2
Annual household income (unit: ten thousand China Yuan)	[0, 3.5]	211/22.7	Family size	two people	103/11.0
	(3.5, 5]	227/24.4		three people	288/31.0
	(5, 7]	446/48.0		four people	482/51.8
	(7, 8.5]	20/2.2		five people	24/2.6
	(8.5, 10]	26/2.8		six people	34/3.7

lower levels of education and employment, as well as lower household incomes. Most of them are physically healthy, married, and have IC cards but no cars.

3.4. Reliability and validity

Before using the model for fit analysis, the variables' reliability and validity must be tested. The term "reliability" refers to the results being reliable, consistent and stable. Accuracy of questionnaire results as measured by the estimation method is shown by validity. Cronbach's alpha reliability analysis and Kaiser-Meyer-Olkin (KMO) test in SPSS were sued to validate the reliability and validity of the three latent variables, including risk concern, risk perception, and satisfaction with bus traveling, as well as the 20 observed variables. As shown in Table 3, the values of latent variables are all>0.6, indicating that the results are consistent (Taber, 2018). The KMO values are all>0.7, indicating that the variables have good structural validity.

3.5. Satisfaction differences in bus traveling

The comparison of satisfaction before and after COVID-19 reveals a higher percentage of low-income individuals who feel "average" and "satisfied", but more details show differences between those groups who feel "dissatisfied" and "satisfied". Fig. 2 and Fig. 3 depict satisfaction with bus traveling indicators of low-income individuals before and after COVID-19. Before COVID-19, the top three indicators with "dissatisfied" are "road traffic conditions (20%), waiting time (17%), and interior temperature (14%)". After COVID-19, the top three indicators with "dissatisfied" are "social distance (17%), risk alerts (16%), and arrival time (14%)". This disparity demonstrates the significant impact of COVID-19 on satisfaction with bus traveling. The high rate of coronavirus transmission and the intensive use of public transportation put low-income individuals under pressure to travel by bus, but due to financial constraints (particularly no income due to the closure of most businesses during COVID-19), they have no choice but to do so. In this case, they are more concerned about some changes brought by the epidemic, such as keeping social distance and reducing contact. Before COVID-19, the top three indicators of feeling "satisfied" are "interior ventilation (57%), traveling cost (51%), and "easy to transfer and stability in driver's speed choice (49%)". After COVID-19, the top three indicators of feeling "satisfied" are "easy to transfer (68%), traveling cost (65%), and interior temperature (58%)". Low-income individuals feel "satisfied" with "easy to transfer" and "traveling cost" before and after COVID-19. However, it is clear that the number of people who are satisfied with these two indicators has increased slightly after COVID-19.

According to the data collected, low-income individuals hold positive attitudes towards the 10 satisfaction indicators before and after COVID-19, but differences exist on indicators with feeling "dissatisfied" and "satisfied". More low-income individuals are dissatisfied with the epidemic-related satisfaction indicators such as risk alerts and social distance after COVID-19.

4. Results

4.1. Impact of socioeconomic and traveling attributes on satisfaction with bus traveling

Tables 4 and 5 show the running results after applying the coded questionnaire data to fit the model by using SPSS. The Wald test P values for the models are all<0.05, and the Nagelkerke R^2 values are all within the acceptable range, indicating that the results are reliable and valid. For a better presentation, Tables 4 and 5 show the most significant factors on the satisfaction with bus traveling for low-income individuals before and after COVID-19. The distribution of significant factors reveals that, overall, a major change has taken place in the significant factors of socioeconomic attributes and traveling attributes. Before COVID-19, satisfaction with bus traveling among low-income individuals is primarily determined by traveling attributes. Low-income commuters are less satisfied with waiting time (-0.535), arrival time (-0.734), and interior temperature (-0.615), while low-income non-commuters (traveling for life shopping, visiting family and friends, and recreational activities) are more satisfied with most variables when compared to people traveling for other reasons. This disparity could be attributed to the different traveling times of low-income commuters and low-income non-commuters before COVID-19, with the latter having most traveling time for leisure. In terms of the impact of traveling time and traveling distance on low-income individuals' satisfaction, these two attributes have the same impacts. When compared to low-income individuals who travel a long distance and for a long-time, those who travel a shorter distance are relatively positive about bus traveling. However, as traveling distance and time increase, the group's satisfaction decreases. This finding is consistent with the findings of Higgins, Morris and Zhu's research (Higgins et al., 2018; Morris & Guerra, 2015a; Zhu & Fan, 2018a). Before COVID-19,

Table 3
Test of Reliability and validity.

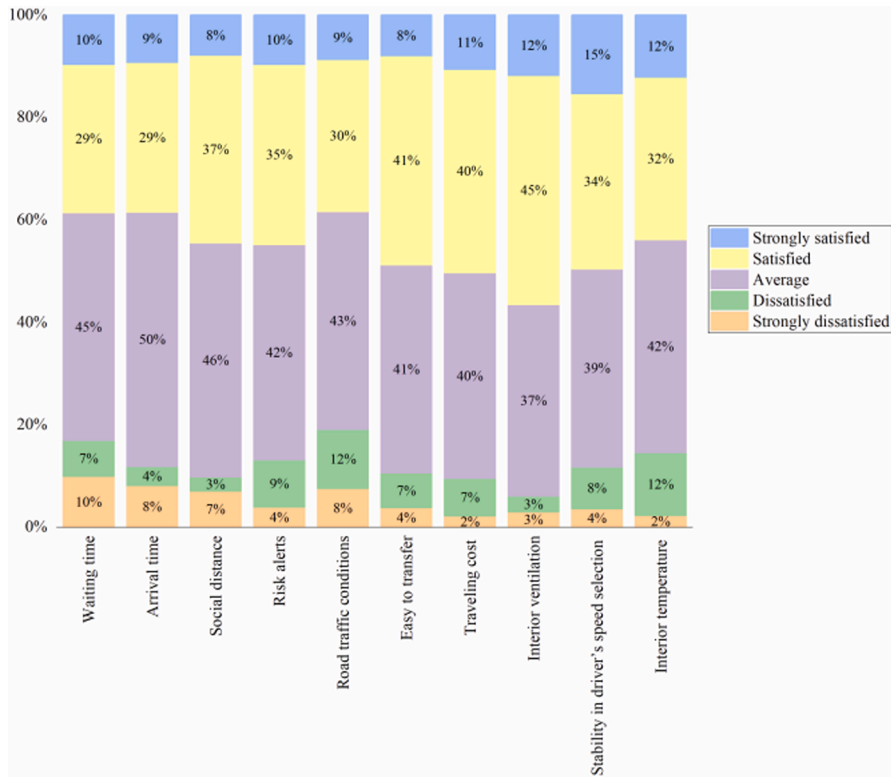| | Before COVID-19 | | | | | After COVID-19 | | | | |
| | Test of Kaiser-Meyer-Olkin | | | | Test of Reliability | Test of Kaiser-Meyer-Olkin | | | | Test of Reliability |
	KMO	χ^2	df	Sig.	α	KMO	χ^2	df	Sig.	α
Risk concern	0.894	3630.37	10	0.000	0.927	0.887	3236.34	10	0.000	0.916
Risk perception	0.876	2894.97	10	0.000	0.900	0.858	1944.89	10	0.000	0.856
Satisfaction	0.916	5037.66	45	0.000	0.909	0.903	6170.93	45	0.000	0.921

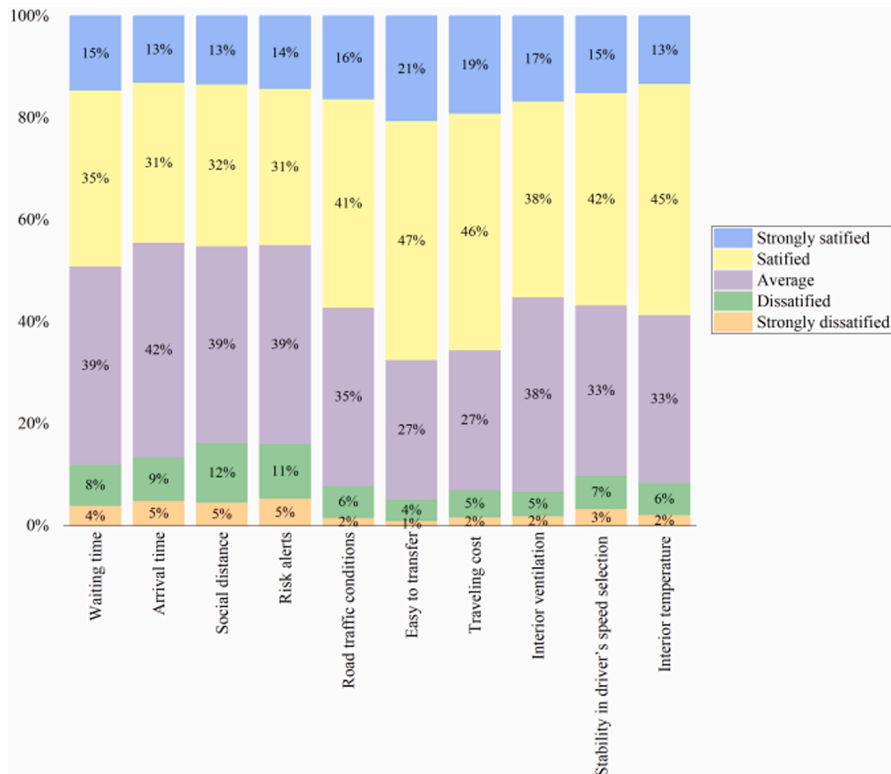**Fig. 2.** Distribution of different satisfaction indicators before COVID-19.

Fig. 3. Distribution of different satisfaction indicators after COVID-19.

Table 4
The impact of socioeconomic and travel attributes on satisfaction with bus traveling before COVID-19.

Socioeconomic / Travel attributes	Category	WT	AT	SD	RA	RTC	ET	TC	IV	SDSS	IT
household registration	rural	0.370*									
gender	female										
age (unit:years)	[0,20]										
	(20,30]								1.156*		
	(30,40]										
	(40,50]								0.722*		
	(50,60]	0.579**	0.408*	0.498*							
occupation	self-employed										
	unemployment										
	retirees										
	students										
education level	junior high school and below										
	high school / technical secondary school										
	undergraduate / junior college										
disability	no										
degree of disability	none										
	mild										
annual household income (unit: ten thousand China Yuan)	[0, 3.5]										
	(3.5, 5]										
	(5, 7]	−1.627*									
	(7, 8.5]										
family size	two people										
	three people										
	four people										
	five people										
marital status	married			−0.698*							
family car ownership	no									0.357*	
personal IC card ownership	no										
traveling purpose [a]	work	−0.535*	−0.734**		0.484*						−0.615*
	school				1.127***						
	life shopping	1.451***	1.075***	0.637**	1.629***	1.139***	1.056***	0.723***	0.626**	0.563**	0.606**
	visiting relatives and friends			0.574*	1.210***	0.586*					
	recreation activities	1.074***	0.883***	0.742***	1.499***	0.862***	0.549**	0.421*			
traveling distance [b] (unit: km)	[0,1]									−1.283**	
	(1,3]	2.536***	0.925*	1.039**	1.219***	1.058**	0.869*				
	(3,5]	1.069**									
	(5,7]	2.404***	0.673*	1.171***	1.161***	0.916**	0.856**	1.009**	0.756*		0.761*
	[7,10]	0.650*									
traveling time [c] (unit: min)	(0,5]	1.528***	1.284**	1.403**	1.392***	0.829*	1.076*			0.838*	
	(5,12]				0.790*						
	(12,20]	1.041**	1.078**	1.084**	1.036**					0.758*	0.783*
	(20,30]										
	(30,45]	−0.801**			0.556*			−0.663*			
−2 Log Likelihood		2009.65	2070.26	2049.37	2162.57	2319.23	2126.11	2187.38	2106.20	2384.56	2305.23
Sig.		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R^2		0.445	0.251	0.196	0.248	0.229	0.166	0.115	0.100	0.105	0.154

Note: *P < 0.05 ; **P < 0.01 ; ***P < 0.001; [a] Reference category: others (e.g., seeing a doctor); [b] Reference category: >10 km; [c] Reference category: >45 min.

Table 5
The impact of socioeconomic and travel attributes on satisfaction with bus traveling after COVID-19.

Socioeconomic / Travel attributes	Category	WT	AT	SD	RA	RTC	ET	TC	IV	SDSS	IT
household registration	rural	0.678***									
gender	female	−1.117***	−1.319***	−1.345***	−0.969***	−0.707***	−0.330*	−0.474***	−0.426**	−0.494***	−0.646***
age (unit:years)	[0,20]					−1.490*					
	(20,30]				−1.281*	−1.382**	−1.532**	−1.187*			−1.119*
	(30,40]										
	(40,50]				−0.895*	−1.052**	−1.011**	−0.867*		−0.690***	−1.215***
	(50,60]	−1.031***	−0.873***	−0.509*	−0.539**		−0.643***	−0.920***	−0.828***	−0.690***	−0.694***
occupation	self-employed					−1.502*					
	unemployment	0.665**	0.719**						0.486*		
	retirees	1.056***	0.966***	0.608*					0.925***		
	students		−0.985*								
education level	junior high school and below										
	high school / technical secondary school										
	undergraduate / junior college										
disability	no										
degree of disability	none										
	mild				−1.154*	−0.986*				−1.033*	−1.073*
annual household income (unit: ten thousand China Yuan)	[0, 3.5]										
	(3.5, 5]										
	(5, 7]										
	(7, 8.5]								−2.788*		
family size	two people										
	three people								1.833*		
	four people										
	five people								2.767*		
marital status	married	0.856**	0.868**	0.771*	0.650*			0.714*	0.914**	0.685*	0.668*
family car ownership	no	2.330***	0.669***	0.789***	0.724***	0.501**	0.401*	0.539***	0.701***	0.645***	0.844***
personal IC card ownership	no	−0.814***	−4.816***	−1.428***	−0.851***			−0.513**	−0.553***	−0.820***	−0.470**
traveling purpose [a]	work										
	school										
	Life shopping	1.484***		0.589*	0.987***				0.672*	0.693*	
	visiting relatives and friends	1.038**	0.672*	1.177***	1.441***				0.920**		
	recreation activities	1.492***	0.796*	0.838**	1.413***	0.864**	0.888**		0.877**		0.718*
traveling distance [b] (unit: km)	[0,1]			−2.112***	−1.243*			1.064*			
	(1,3]			−1.681**	−1.153*			1.346**			
	(3,5]			−1.199*	−1.135*		0.949*	1.380**			
	(5,7]	−0.790*						0.779*	0.786*		0.928**
	[7,10]	−1.005**									
traveling time [c] (unit: min)	(0,5]			1.421**	1.347*						
	(5,12]			1.608**	1.740***						
	(12,20]	1.181*		1.871***	2.077***				1.492**		
	(20,30]									−1.219**	
	(30,45]			−0.771*				0.786*			
−2 Log Likelihood		1721.59	1702.40	2082.15	2189.11	2105.21	2041.36	2064.47	2014.81	2101.36	2044.98
Sig.		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R^2		0.580	0.588	0.399	0.323	0.181	0.141	0.186	0.244	0.256	0.207

Note: *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$; [a] Reference category: others (e.g., seeing a doctor); [b] Reference category: >10 km; [c] Reference category: >45 min.

traveling attributes significantly affected satisfaction with bus traveling among low-income individuals, whereas socioeconomic attributes have little influence on the factors and impacts on them. First, the impacts of household registration on satisfaction with bus traveling are only reflected in waiting time (0.370), which favors rural household registration over low-income urban household registration. Only low-income individuals over the age of 40 are satisfied with variables such as waiting time and arrival time. However, low-income individuals with a household income of 50,000–70,000 China Yuan (compared to those with an annual household income of 85,000–100,000 China Yuan) and the married people (compared to the unmarried ones) are less satisfied with waiting time (-1.627) and social distance (-0.698), respectively. Low-income individuals without cars are satisfied with the "stability in driver's speed choice" (0.357). Furthermore, other socioeconomic attributes such as gender, occupation, education, disability, degree of disability, household size, and IC card ownership, have no significant impacts on low-income individuals' satisfaction with bus traveling.

After COVID-19, low-income individuals' satisfaction with bus traveling is determined by socioeconomic attributes rather than traveling attributes. The significant impact of traveling time on satisfaction among low-income individuals is greatly reduced. Low-income non-commuters express high satisfaction with bus traveling before and after COVID-19, although some differences in satisfaction variables exist. Low-income commuters who travel by bus have no significant impact on satisfaction, which could be attributed to work-from-home and online learning as a result of high viral infectivity. Traveling distance has a greater impact on satisfaction. Those traveling a medium distance are less satisfied with waiting time than those traveling a long distance (-0.790). Short-distance travelers are dissatisfied with social distance (-2.112) and risk alerts (-1.243), reflecting the epidemic's social pressure. The socioeconomic attributes have greatly increased the impact factors and effect forces on low-income individuals traveling by bus, which is consistent with the actual situation of low-income individuals after COVID-19. The group has been subjected to severe socio-economic pressure as a result of the epidemic, making them even more financially disadvantaged. The impact of household registration on satisfaction with bus traveling after COVID-19 is comparable to that before COVID-19. However, gender has a significant impact on satisfaction with bus traveling, with low-income females being more dissatisfied with bus traveling than low-income males. At the same time, low-income individuals of all ages, with the exception of those over 60, are dissatisfied with bus traveling. Occupation also has a significant impact on it as well, with low-income unemployed and retirees being more satisfied with bus traveling overall, while the self-employed and students being dissatisfied with it. Low-income individuals with mild disabilities are also dissatisfied with road traffic conditions (-1.154), easy to transfer (-0.986), stability in driver's speed choice (-1.033), and interior temperature (-1.073) when traveling by bus, possibly due to their difficulty in moving. Before COVID-19, factors such as marital status and family car and IC card ownership have varying degree of impact on satisfaction with bus traveling. factors such as education, disability, annual household income, and household size have no significant impact on satisfaction with bus traveling after COVID-19.

The analysis above demonstrates the difference in satisfaction with bus traveling before and after COVID-19. Satisfaction with bus traveling among low-income individuals is determined by traveling attributes before COVID-19 and by socioeconomic attributes after COVID-19. This shift reflects the variation in low-income individuals' satisfaction with bus traveling as a result of the epidemic.

Table 6
Composite reliability and convergence validity before COVID-19.

Dimensions	Items	Test of parameter significance					Reliability[a]	Composite Reliability	Convergent Validity[b]
		U-std.	S.E.	T-value	P-value	Std.	R^2	CR	AVE
Risk concern	Interior environment	1.000				0.866	0.750	0.928	0.721
	Physical condition of other passengers	1.054	0.028	37.372	***	0.891	0.794		
	Physical contact	1.034	0.027	38.579	***	0.906	0.821		
	Level of crowding	0.959	0.03	32.449	***	0.825	0.681		
	Mask wearing	0.849	0.031	27.533	***	0.747	0.558		
Risk perception	Non-disinfected and dirty bus	1.000				0.851	0.724	0.901	0.649
	Physical contact with other passengers	1.023	0.029	35.156	***	0.893	0.797		
	Coughing and sneezing on the bus	0.989	0.03	32.858	***	0.856	0.733		
	Bus congestion and depression	0.827	0.031	26.741	***	0.750	0.563		
	Not wearing masks	0.719	0.032	22.146	***	0.655	0.429		
Satisfaction	Waiting time	1.000				0.812	0.659	0.861	0.511
	Arrival time	0.892	0.036	25.002	***	0.781	0.610		
	Social distance	0.729	0.035	20.793	***	0.668	0.446		
	Road traffic conditions	0.916	0.037	24.671	***	0.772	0.596		
	Traveling cost	0.611	0.033	18.554	***	0.605	0.366		
	Interior temperature	0.680	0.035	19.183	***	0.623	0.388		

*** P < 0.001.
[a] R^2 refers to the ability of the dimension to interpret on items.
[b] AVE refers to the average ability of the dimension to interpret on items.

4.2. Impact of psychological attributes on satisfaction with bus traveling

4.2.1. Confirmatory factor analysis

  (i) Composite reliability and convergent validity

Confirmatory factor analysis (CFA) verifies the measurement model's fit to the survey data, so as to test the former one's composite reliability, convergent validity, and discriminant validity. After conducting CFA analysis of the three latent variables, which include risk concern, risk perception, and satisfaction with bus traveling before and after COVID-19, it was discovered factor loading<0.5, colinearity and non-dependent residuals among the observed variables such as risk alerts, easy to transfer, stability in driver's speed choice, and interior ventilation before COVID-19, as well as those such as waiting time, arrival time, road traffic conditions, and easy to transfer after COVID-19. As a result, we removed the corresponding observed variables by using Modification Index (MI) and re-estimated them, and the results are shown in Tables 6 and 7. The adjusted standard factor loading values are>0.5, meeting the acceptable criteria of Hair (1998). Composite Reliability (CR) refers to the reliability of the constructed indicators based on reliability of all observed variables. The higher the reliability, the more consistent the indicators. The acceptable reliability threshold is 0.7 (Hair, 1998). The CR values for all variables shown are>0.7, indicating that latent variables have a high internal consistency. The variation explanation of observed variables corresponding to latent variables is calculated by using Average Variation Extracted (AVE). Higher AVE values indicate that latent variables have a higher convergent validity. Fornell (1981) proposed that the AVE standard value should be>0.5. The test results show overall good convergent validity within each latent variable.

  (ii) Discriminant validity.

Discriminant validity refers to whether the overall correlation between latent variables and their corresponding multiple observed variables (i.e., AVE) is greater than correlation between latent variables and latent variables, and if so, latent variables have good discriminant validity. Tables 8 and 9 show, risk concern, risk perception, and satisfaction with bus traveling have good discriminant validity before and after COVID-19.

4.2.2. Standardized parameters

The calibrated standardized parameter results show (see Figs. 4 and 5) that risk concern can have a significant positive impact on risk perception before and after COVID-19, but the value of this impact decreases after the COVID-19 (-0.18). In contrast, risk concern before COVID-19 has a negative impact on satisfaction, which may indicate that low-income individuals who are actively concerned about situations such as wearing masks are a little dissatisfied with the current waiting time and arrival time of traveling by bus. However, low-income individuals generate an unusually high level of satisfaction with bus traveling in terms of risk perception, but the standardized coefficients for both cases have only a minor impact on satisfaction. Before and after COVID-19, risk concern has a minor negative impact on satisfaction with bus traveling, and risk perception has a minor negative impact on satisfaction with bus traveling among low-income individuals. At the same time, the increased emphasis on risk alerts and other satisfaction indicators related to the epidemic suggests that the low-income individuals after COVID-19 pay more attention to their own protection and the epidemic

Table 7
Composite reliability and convergence validity after COVID-19.

Dimensions	Items	Test of parameter significance					Reliability[a]	Composite Reliability	Convergent Validity[b]
		U-std.	S.E.	T-value	P-value	Std.	R^2	CR	AVE
Risk concern	Interior environment	1.000				0.846	0.716	0.917	0.690
	Physical condition of other passengers	1.001	0.030	33.202	***	0.865	0.748		
	Physical contact	1.072	0.032	33.734	***	0.874	0.764		
	Level of crowding	0.817	0.032	25.723	***	0.733	0.537		
	Mask wearing	1.076	0.035	30.927	***	0.828	0.686		
Risk perception	Non-disinfected and dirty bus	1.000				0.764	0.584	0.858	0.550
	Physical contact with other passengers	0.967	0.048	20.131	***	0.680	0.462		
	Coughing and sneezing on the bus	0.938	0.048	19.615	***	0.663	0.440		
	Bus congestion and depression	1.106	0.045	24.382	***	0.820	0.672		
	Not wearing masks	1.208	0.053	22.904	***	0.768	0.590		
Satisfaction	Risk alerts	1.000				0.661	0.437	0.892	0.582
	Social distance	0.987	0.055	18.031	***	0.666	0.444		
	Traveling cost	0.957	0.049	19.690	***	0.738	0.545		
	Interior ventilation	1.115	0.050	22.185	***	0.857	0.734		
	Stability in driver's speed selection	1.185	0.053	22.234	***	0.860	0.740		
	Interior temperature	0.986	0.048	20.371	***	0.769	0.591		

*** $P < 0.001$.
[a] R^2 refers to the ability of the dimension to interpret on items.
[b] AVE refers to the average ability of the dimension to interpret on items.

Table 8
Discriminate validity before COVID-19.

Dimensions		Composite Reliability	Convergent Validity	Test of discriminant validity		
	Std. loading	CR	AVE	Risk concern	Risk perception	Satisfaction
Risk concern	0.866 ~ 0.747	0.928	0.721	**0.849**		
Risk perception	0.851 ~ 0.655	0.901	0.649	0.594	**0.806**	
Satisfaction	0.812 ~ 0.623	0.861	0.511	−0.047	0.013	**0.715**

Table 9
Discriminate validity after COVID-19.

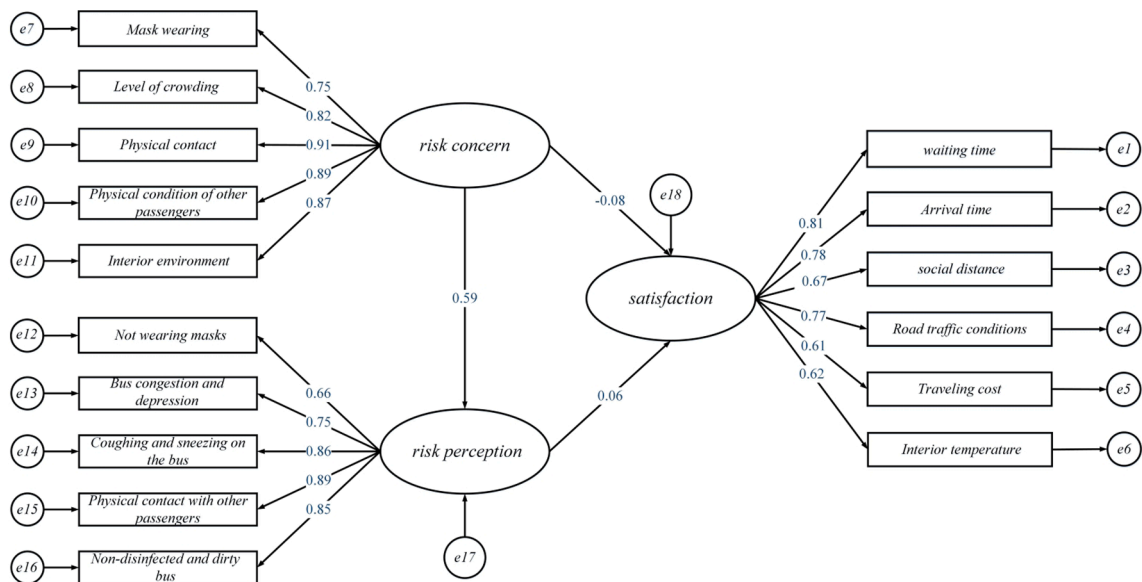| Dimensions		Composite Reliability	Convergent Validity	Test of discriminant validity		
	Std. loading	CR	AVE	Risk concern	Risk perception	Satisfaction
Risk concern	0.846 ~ 0.828	0.917	0.690	**0.831**		
Risk perception	0.764 ~ 0.768	0.858	0.550	0.407	**0.742**	
Satisfaction	0.661 ~ 0.769	0.892	0.582	−0.027	−0.028	**0.763**

Fig. 4. The relationships among risk concern, risk perception, and satisfaction with bus traveling before COVID-19.

prevention policies on public transportation rolled out by local authorities.

A set of fitting indicators is frequently used to determine the fitting of SEM model. Kline (2015) pointed out that the values displayed by fitting indicators only represent the average or overall fitting of SEM model. It includes positive and negative indicators. Therefore, different types of fitting indicators must be included as a complementary description. From Jackson's article summarizing the fitting frequency reported by 194 scholars (Jackson et al., 2009), we chose the most frequently reported fitting indicators to fit the accuracy and precision of SEM model. As shown in Table 10, all the indicator values satisfy the requirement of fitting, demonstrating the good fit between established structural equation model and the actual survey data.

4.2.3. Direct and indirect effects

The structural equation method allows for a quantitative analysis of the effects between latent variables (Maccallum and Austin, 2000), such as total effects (T), direct effects (D), and indirect effects (I). The presence or absence of a mediating variable between two variables can reflect the presence or absence of an indirect effect on final outcome variable. Table 11 shows the statistics of the effects of the epidemic on risk concern, risk perception, and satisfaction with bus traveling before and after COVID-19. The results show a significant positive direct effect of risk concern before COVID-19 on risk perception (D = 0.594), and a slight direct effect (D = -0.085) and a slight indirect effect (I = 0.038) on the total effect of satisfaction (T = -0.047). Similarly, risk concern still has a significant positive direct effect on risk perception (D = 0.407), and a slight effect directly(D = -0.019) and indirectly (I = -0.008) on satisfaction with bus traveling after COVID-19.
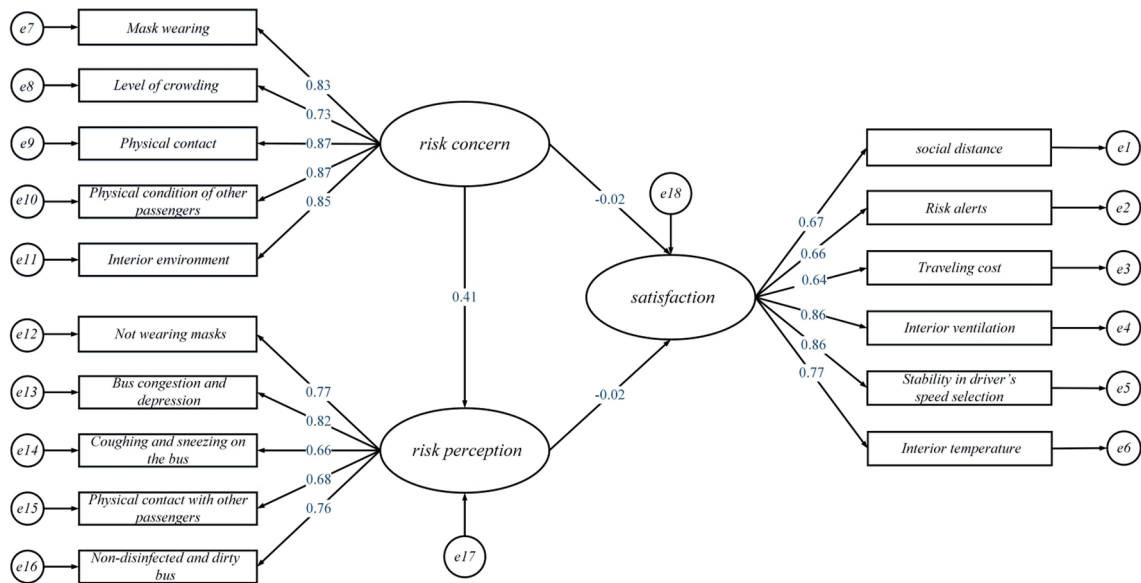
Fig. 5. The relationships among risk concern, risk perception, and satisfaction with bus traveling after COVID-19.

Table 10
Indicators of model fitting.

Fitting indicators	χ^2/df	GFI	AGFI	RMESA	CFI	IFI	TLI	NFI	SRMR
Standard range	1 ~ 5	>0.9	>0.9	<0.08	>0.9	>0.9	>0.9	>0.9	<0.08
Before COVID-19	4.602	0.940	0.919	0.062	0.961	0.961	0.954	0.951	0.0300
After COVID-19	4.552	0.942	0.922	0.062	0.958	0.958	0.950	0.947	0.0373

Table 11
Effect of latent variable.

Dimensions	Effect	Before COVID-19		After COVID-19	
		Risk concern	Risk perception	Risk concern	Risk perception
Risk perception	Standard Total Effect	0.594[***]	—	0.407[***]	—
	Standard Direct Effect	0.594[***]	—	0.372[***]	—
	Standard Indirect Effect	—	—	—	—
Satisfaction	Standard Total Effect	−0.047	0.064	−0.027	−0.021
	Standard Direct Effect	−0.085	0.064	−0.019	−0.021
	Standard Indirect Effect	0.038	—	−0.008	—

***P < 0.001.

4.3. Impact of satisfaction on traveling alone and traveling with companions

4.3.1. Descriptive features

The descriptive characteristics of the statistics in Fig. 6 and Fig. 7 show that before COVID-19, the different levels of satisfaction with the ten satisfaction indicators reflect the preference for traveling with companions by bus among low-income individuals, but the difference lies in those low-income individuals who are "strongly dissatisfied" with the ease to transfer have a slight preference for traveling alone. In terms of satisfaction, low-income individuals who may have a negative attitude toward satisfaction indicators of traveling by bus are more likely to travel with companions, as evidenced by waiting time (76%), traveling cost (74%), social distance (69%), road traffic conditions (68%), and arrival time (65%). After COVID-19, attitudes differ significantly in their preference for traveling alone and traveling with companions. Overall, low-income individuals with both satisfied and dissatisfied attitudes are more likely to travel alone. Those who dislike taking the bus may be more likely to travel alone after COVID-19. Only those with favorable attitudes toward most satisfaction indicators travel with companions. The descriptive results show significant differences in satisfaction levels and modes of traveling alone and traveling with companions by bus before and after COVID-19, but the validity of the results needs to be further verified.
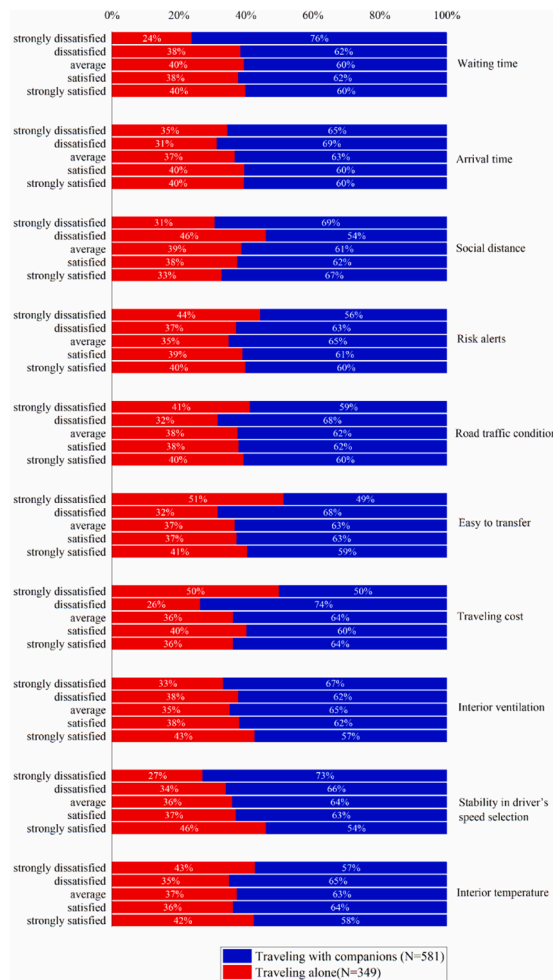
Fig. 6. The relationships between satisfaction levels and modes of traveling alone and traveling with companions by bus before COVID-19.

4.3.2. Statistical effects

Before COVID-19, the model's maximum likelihood estimation statistic was −2log likelihood = 1186.98 and Nagelkerke R^2 = 0.06, which were tested by Hosmer-Lemeshow and revealed that df = 8, and Sig. = 0.526 > 0.05. After COVID-19, the model's maximum likelihood estimation statistic was −2log likelihood = 973.59 and Nagelkerke R^2 = 0.08, which were tested by Hosmer-test Lemeshow and revealed that df = 8, and Sig. = 0.345 > 0.05. The Hosmer-Lemeshow test for the two models demonstrates that they fit the data well. The results (Table 12) indicate that before COVID-19, low-income individuals holding other attitudes towards three variables, including arrival time, risk alerts and stability in driver's speed choice, are more likely to travel with companions by bus than those who are "strongly satisfied with those three variables". Low-income individuals with other attitudes towards three variables, such as social distance, traveling cost and interior temperature, are more likely to travel alone by bus than those who are "strongly satisfied" with those three variables. These two scenarios imply that low-income individuals' satisfaction or dissatisfaction with arrival time, risk alerts, stability in driver's speed choice, social distance, traveling cost, and interior temperature have no impact on their traveling choices, and it is possible that the group is behavior-oriented (Kitamura, 2009; Etminani-Ghasrodashti et al., 2018). The group's different attitudes towards other variables have a minor impact on traveling choices. For example, low-income individuals who rate waiting time as "average" are more likely to travel alone by bus. In terms of the road conditions variable, low-income individuals who rate "average", "satisfied" or "strongly dissatisfied" with this variable are more likely to travel with companions by bus than those who are "strongly satisfied", while those who are "dissatisfied" with this variable are more likely to travel with companions by bus. It is possible that for low-income individuals, the level of satisfaction on this variable is not a deciding factor for traveling alone or traveling with companions by bus and the same is true for interior ventilation. Low-income individuals who are "strongly dissatisfied" with easy to transfer are more likely to travel alone by bus.

After COVID-19, low-income individuals who have different attitudes toward variables, such as waiting time, social distance, risk alerts, easy to transfer, stability in driver's speed choice and interior temperature, are more likely to travel alone by bus than those who are "strongly satisfied" with those six variables. This situation reveals two possibilities: (1) The level of satisfaction with these six variables may have no impact on traveling alone or traveling with companions by bus; (2) Due to COVID-19, low-income individuals
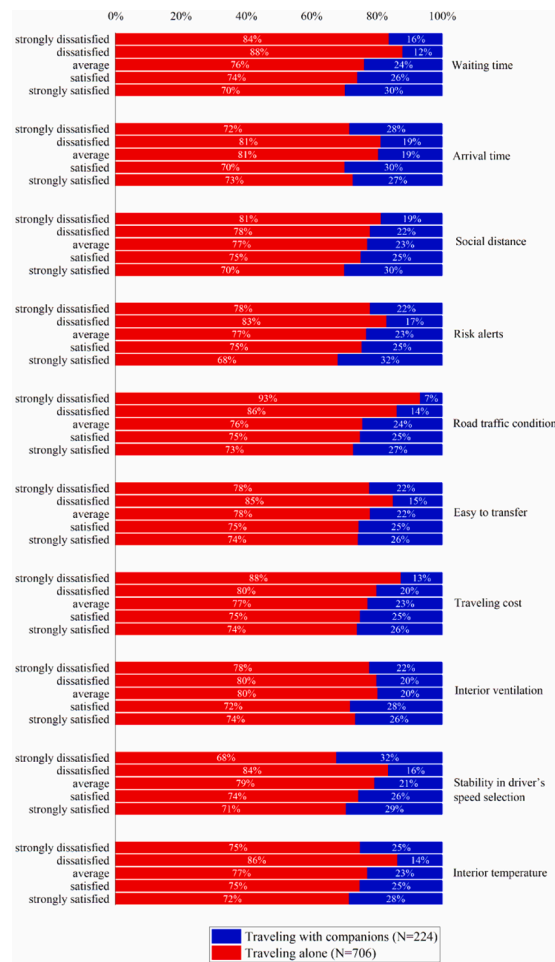
Fig. 7. The relationships between satisfaction levels and modes of traveling alone and traveling with companions by bus after COVID-19.

travel alone by bus to protect themselves by reducing contact with others. Low-income individuals who have different attitudes to-wards arrival time and interior ventilation are more likely to travel with companions by bus than those who are "strongly satisfied" with those two variables. Low-income individuals who are "strongly dissatisfied" with road traffic conditions and traveling cost are more likely to travel alone by bus.

5. Discussion and conclusions

Although it has discovered the tremendous destructive power of COVID-19 on public transport traveling (Kwok et al., 2020; De Vos, 2020), few papers revealed that satisfaction with bus traveling among low-income individuals was also affected by COVID-19. The low-income individuals whose economic status was initially at the bottom of society are even more unable to make ends meet due to the impact of COVID-19. We collected 930 data from Taiyuan City, China, to seriously study satisfaction differences under different so-cioeconomic attributes, travel attributes, and psychological attributes before and after COVID-19, and also to explain the impact and differences of satisfaction on traveling alone and traveling with companions.

Firstly, some surprising results were found in the study of different socioeconomic and travel attributes. The impact of traveling purpose, traveling distance, and traveling time on the satisfaction is far greater than socioeconomic factors before COVID-19, this result is similar to the results of previous studies (Campbell et al, 1976; Andrews and Withey 1976; Diener and Suh, 1997), and yet impact factors have transferred from travel attributes to socioeconomic on a large scale after COVID-19. This may be due to the impact of the epidemic on the living and economic conditions of low-income individuals. Secondly, the epidemic has shaped a more cautious attitude to bus traveling. Study on psychological attributes and satisfaction has found that similar results appear in before and after COVID-19: (i) risk concern have a significant positive impact on risk perception. (ii) risk concern and risk perception have a minor impact on satisfaction. Finally, it has some interesting findings about the relationship between satisfaction levels and modes of traveling alone and traveling with companions by bus. low-income individuals' satisfaction or dissatisfaction with arrival time, risk alerts, stability in driver's speed choice, social distance, traveling cost, and interior temperature have no impact on their traveling

Table 12

Differences in satisfaction levels and modes of traveling alone and traveling with companions by bus before and after COVID-19.

Variables	Degree	Before COVID-19 Traveling with companions(N = 581) Traveling alone(N = 349)				After COVID-19 Traveling with companions(N = 224) Traveling alone(N = 706)			
		Coef. (B)	Std.	Wald	Sig.	Coef. (B)	Std.	Wald	Sig.
Waiting time	strongly dissatisfied	0.846	0.546	2.398	0.121	−0.550	0.798	0.476	0.490
	dissatisfied	0.442	0.612	0.521	0.470	−1.059	0.597	3.146	**0.076**
	average	−0.073	0.435	0.028	0,866	−0.052	0.458	0.013	0.910
	satisfied	0.078	0.398	0.038	0.845	−0.063	0.436	0.021	0.885
Arrival time	strongly dissatisfied	0.272	0.570	0.228	0.633	1.244	0.689	3.258	**0.071**
	dissatisfied	0.801	0.692	1.340	0.247	0.957	0.650	2.172	0.141
	average	0.613	0.471	1.696	0.193	0.629	0.570	1.219	0.270
	satisfied	0.435	0.447	0.947	0.330	1.246	0.543	5.260	**0.022***
Social distance	strongly dissatisfied	−1.102	0.627	3.085	0.079	−0.292	0.738	0.157	0.692
	dissatisfied	−1.678	1.106	2.305	0.129	−0.460	0.599	0.589	0.443
	average	−1.386	0.539	6.606	**0.010****	−0.661	0.521	1.610	0.205
	satisfied	−1.343	0.530	6.421	**0.011***	−0.856	0.504	2.877	**0.090**
Risk alerts	strongly dissatisfied	0.480	0.779	0.380	0.538	−1.006	0.762	1.743	0.187
	dissatisfied	0.019	0.566	0.001	0.973	−1.586	0.718	4.879	**0.027***
	average	0.483	0.471	1.054	0.304	−1.228	0.621	3.914	**0.048***
	satisfied	0.414	0.461	0.806	0.369	−1.311	0.600	4.779	**0.029***
Road traffic conditions	strongly dissatisfied	−0.312	0.838	0.139	0.710	−2.583	1.988	1.661	0.197
	dissatisfied	0.010	0.781	0.000	0.990	0.440	0.725	0.369	0.544
	average	−0.232	0.732	0.100	0.751	0.940	0.586	2.576	0.109
	satisfied	−0.037	0.722	0.003	0.959	0.615	0.575	1.145	0.285
Easy to transfer	strongly dissatisfied	−0.214	1.015	0.044	0.833	1.632	1.708	0.913	0.339
	dissatisfied	0.465	0.869	0.287	0.592	−0.296	0.755	0.154	0.744
	average	0.722	0.817	0.780	0.377	−0.427	0.560	0.580	0.446
	satisfied	0.813	0.793	1.049	0.306	−0.231	0.525	0.193	0.660
Traveling cost	strongly dissatisfied	−1.292	0.906	2.031	0.154	−1.954	1.243	2.470	0.116
	dissatisfied	−0.401	0.624	0.414	0.520	0.105	0.696	0.023	0.880
	average	−0.849	0.523	2.632	0.105	0.300	0.538	0.310	0.577
	satisfied	−1.031	0.493	4.378	**0.036***	0.100	0.485	0.043	0.837
Interior ventilation	strongly dissatisfied	1.189	0.758	2.457	0.117	1.765	1.164	2.297	0.130
	dissatisfied	−0.524	0.610	0.739	0.390	0.952	0.749	1.617	0.204
	average	0.342	0.388	0.778	0.378	1.152	0.574	4.019	**0.045***
	satisfied	0.230	0.338	0.464	0.496	1.502	0.552	7.398	**0.007****
Stability in driver's speed selection	strongly dissatisfied	0.865	0.545	2.519	0.112	−0.180	0.851	0.044	0.833
	dissatisfied	0.609	0.436	1.955	0.162	−0.649	0.683	0.902	0.342
	average	0.634	0.333	3.617	**0.057**	−1.062	0.579	3.358	**0.067**
	satisfied	0.477	0.306	2.430	0.119	−1.016	0.539	3.557	**0.059**
Interior temperature	strongly dissatisfied	−0.305	0.633	0.232	0.630	−0.589	0.958	0.378	0.539
	dissatisfied	−0.129	0.410	0.099	0.753	−0.470	0.638	0.543	0.461
	average	−0.281	0.385	0.535	0.464	−0.001	0.418	0.000	0.998
	satisfied	−0.093	0.364	0.066	0.798	−0.091	0.395	0.054	0.817
constant	—	0.551	0.274	4.038	**0.044***	−0.834	0.228	13.347	**0.000*****

*P < 0.05.

**P < 0.01.

***P < 0.001.

choices before COVID-19. After COVID-19, low-income individuals who have different attitudes toward variables, such as waiting time, social distance, risk alerts, easy to transfer, stability in driver's speed choice and interior temperature, are more likely to travel alone by bus than those who are "strongly satisfied" with those six variables, this situation reveals low-income individuals travel alone by bus to protect themselves by reducing contact with others due to COVID-19.

This study implies a positive value of bus traveling, and could be used by urban planners and policy makers to improve low-income individuals' satisfaction in the late stages of a public health emergency, promote "Green travel", and even reduce single-person driving. More attention was paid to the experience of riding a bus before COVID-19, and it was shifted to the epidemic prevention policies and specific public transportation measures after COVID-19. This potentially suggests that the transport department should pay more attention to infrastructure construction, punctuality rate and reliability of the bus, passenger' comfort in normal daily life. This also indicates that taking good care of yourself and avoiding virus infection is a prerequisite for low-income individuals to travel by bus after COVID-19, and implies that public transportation companies should do a good job of in-vehicle protection, such as frequent disinfection, which is the key to improving the satisfaction and loyalty of low-income passengers after COVID-19. Moreover, these results show that in addition to the enormous psychological pressure that the epidemic has put on low-income individuals to travel by public transport, it also affects satisfaction in bus traveling. To eliminate these tremendous psychological pressures, the primary task of policy makers is to implement epidemic prevention policies on buses, reduce psychological stress, and improve the satisfaction between low-income individuals or other groups. In addition, policymakers can encourage multi-person bus traveling by increasing

satisfaction with bus traveling to improve the efficiency of residents' travel and reduce excessive single-person driving behaviors in cities, such as enhance the ventilation system in the bus, increase the number of transfer station facilities and warning signs, improve the professional quality of drivers.

The shortcomings of this paper are mainly reflected in three aspects: **(i)** design of satisfaction. The design of satisfaction usually involves multi-level indicators. The ten satisfaction indicators often do not comprehensively reflect the passengers' satisfaction with bus traveling. However, it may be representative. **(ii)** the impact of COVID-19 in each city and country is different, and the epidemic prevention policies formulated by each city may not be consistent, the results of this study may not be entirely applicable for all cities, but there is specific references value. **(iii)** As for the factors to be explored, there may be a lack of consideration of more objective data to express, such as the built environment (Ye and Titheridge. 2017). Typically, the built environment is a practical measurement of bus travel satisfaction, but the author cannot add these data to the model due to resource constraints. It is hoped that more factors such as built environment can be added to better understand the satisfaction with bus traveling between low-income individuals and other groups in future research.

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CRediT authorship contribution statement

Fan Sun: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Writing – original draft, Visualization. **Minjie Jin:** Writing – review & editing, Supervision, Project administration, Funding acquisition. **Tao Zhang:** Supervision, Project administration, Funding acquisition. **Wencheng Huang:** Writing – review & editing, Supervision, Project administration, Funding acquisition.

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.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tra.2022.04.015.

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