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Perceived risks of transit use during COVID-19: Correlates and strategies from a case study in El Paso, Texas

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ABSTRACT

Introduction: COVID-19 has led to public transportation ridership plummeting and thus created fiscal crises and operational difficulties for transit operators. Although transit services remain essential for people with limited access to alternative transportation modes, the unfavorable public view keeps potential riders from transit. The public transportation industry is in dire need of restoring trust and recovering ridership.

Methods: In July 2020, we conducted an online survey in El Paso, Texas, to investigate COVID-19 risk perceptions related to transit use. A total of 712 valid responses, consisting of 613 English and 99 Spanish responses, were included in the analyses.

Results and conclusions: Descriptive and bivariate analyses showed many choice transit riders changed their mobility patterns by abandoning public transportation. Survey participants reported that social distancing and cleaning services were very important in encouraging them to return to transit. The free fare policy was also a stimulus for the existing riders to continue their transit use during the pandemic. The multivariable analysis results highlighted that public knowledge plays a vital role in COVID-19 risk perceptions and transit use decisions. Major opportunities exist in terms of public awareness campaigns that inform the public about the COVID-19 related safety measures transit operators are implementing. We further suggest some practical strategies to enhance public communication and help transit operators recover from COVID-19. This study offers timely insights for public policy stakeholders, including transit agencies, to better utilize their resources to protect public health, regain public confidence, and bring passengers back.

1. Introduction

COVID-19 has brought numerous changes to the world, especially regarding human mobility. Compared to other travel modes such as private vehicles, ridehailing, walking, and biking, public transportation has been viewed by some as the least safe means of moving around during the infectious outbreak. A precipitous ridership decline has been observed across all types of public transit – buses, trains, ferries, and airlines – impacting many individuals, particularly those who rely on transit for their daily mobility needs.

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As the 22nd largest city in the U.S. and the sixth in Texas (United States Census Bureau, 2021), the City of El Paso became a COVID-19 hot spot with high rates of infection. By March 2022, the City of El Paso had seen more than 240,000 COVID-19 positive cases and about 3,400 death tolls (El Paso Strong, 2022).

Following the national emergency declaration for COVID-19 in March 2020, the state of Texas, El Paso County, and the City of El Paso declared a local disaster due to this public health emergency. Travel across the land border was restricted to essential travel only. On March 24, 2020, the City of El Paso issued the “Stay Home, Work Safe” order. In April and May 2020, the El Paso City Council extended a disaster declaration and emergency precautions, requiring face coverings in public spaces. In June 2020, businesses and parks partially reopened. At the end of June 2020, the governor of Texas ordered all bars to close again as coronavirus cases climbed to record highs and hospitals reached their capacity in Texas (El Paso Times, 2021).

Even prior to the pandemic, public transit in El Paso was not the most popular transportation mode, consistent with low engagement rates throughout southern states. According to the U.S. Census Bureau (2021), about 2% of workers in the south region of the U.S. commuted by transit in 2019, and the percentage of public transportation commuters is even lower in El Paso, at 1.2%. Yet, prior to the pandemic, El Paso had a budding public transit system. Sun Metro Mass Transit Department (Sun Metro) is the primary public transportation provider in El Paso, Texas. It operates fixed-route buses, Bus Rapid Transit or BRT (named Brio) lines, streetcars, and paratransit services. The total number of passenger boardings in 2019 was more than 12 million (Sun Metro, 2020c). Although operating in a small service capacity, several shared/on-demand programs (e.g. AndaleRide, SunCycle, and Glide E-scooters) are available to residents in El Paso.

Similar to most cities, public transportation ridership in El Paso dropped significantly in March 2020. In 2020 and 2021, Sun Metro received a total of more than $40 million in funding to continue providing services throughout the COVID-19 pandemic (Sun Metro, 2020a). In response to the outbreak, Sun Metro began to waive all bus fares on March 22, 2020, as well as implementing a variety of safety measures and reducing its service operations accordingly (The City of El Paso, 2020). To protect passengers and operators, Sun Metro increased its cleaning efforts for fleets and facilities. Furthermore, Sun Metro encouraged people not to ride if they felt sick, to practice social distancing, and to wear face coverings when riding the services (Sun Metro, 2020b). Passengers were required to board and exit from the rear doors. These COVID-19 response guidelines were published in the news/newspapers, the official agency website, and on social media. Sun Metro also put “Seat Closed” signs on every other seat to ensure passengers followed the social distancing protocol.

Despite various infection control measures taken by Sun Metro, as of the end of 2021, ridership continued to remain significantly lower than the pre-COVID-19 period in El Paso (Sun Metro, 2021). Low transit ridership could further lead to financial crises and operational difficulties. As many studies highlighted, fear of infection and unfavorable public views of transit services are the primary challenges for rebuilding transit riders’ confidence (Abdullah et al., 2021; Ashraf Javid et al., 2021; Hotle et al., 2020; Vichiensan et al., 2021). Given COVID-19 may remain a potential public health threat for a longer period of time than what might once have been expected, building trust and attracting riders back have become crucial priorities for Sun Metro and other transit providers. Previous studies discussed the importance of various safety measures and guidelines implemented by transit operators (Kamga and Eickemeyer, 2021; Shen et al., 2020; Tirachini and Cats, 2020). However, limited research investigated public awareness of these guidelines. Whether and how these COVID-19 related strategies could mitigate passengers’ safety concerns and build trust are largely unknown.

Using El Paso, Texas as a case study, this study addresses several critical issues related to transit use during COVID-19. It aims to understand public attitudes toward using public transportation and explore the relationship among public awareness of safety guidelines, risk perceptions, and transit use. Specific research questions are (a) Who continued riding transit during COVID-19? (b) Is the public informed of transit safety measures? (c) Do those measures and guidelines reduce public concerns of COVID-19 infection and help gain the confidence of riders in their ability to stay safe during the transit ride? and (d) What communication strategies can transit agencies consider to recover the ridership during the pandemic? The results of this study will provide insights for policymakers and other stakeholders in the public transportation sector to promote safe travel and regain passengers during the current pandemic, with the potential to provide some additional lessons for future pandemics.

2. Relevant literature

2.1. Benefits of public transportation

Public transportation provides many benefits to individuals, communities, and the environment (Brown and Werner, 2008; Frank et al., 2006). For example, by using public transit, riders increase their physical activity, which is known to bring many additional health benefits (Brown and Werner, 2008; Frank et al., 2006). For people with limited access to or ability to drive private vehicles, public transportation plays a critical role in increasing their mobility and independence (Boarnet et al., 2017; Foth et al., 2013; Hess, 2005). Furthermore, multiple studies demonstrate that public transportation attracts businesses and increases commercial and residential property values near transit facilities (Baum-Snow and Kahn, 2000; Perk et al., 2010). Public transit also contributes to environmental sustainability by moving people more efficiently and therefore helping to reduce traffic congestion and related costs (Anderson, 2014). Additionally, public transit burns less fossil fuel and produces significantly less air pollution per passenger mile than single-occupancy vehicles (U.S. Bureau of Transportation Statistics, 2018; Vincent and Jerram, 2006).

2.2. Transit use and the COVID-19 pandemic

As of April 2022, more than 498 million cases of COVID-19 infection have been reported worldwide (World Health Organization,
Governments around the world have imposed various mobility restrictions to prevent the spread of the virus, substantially impacting how people travel. Trip frequencies, distances traveled, and trip purposes have been significantly changed due to the stay-in-place rules, business restrictions, mask-wearing mandates, school closures, and social distancing guidelines. Many transit riders drastically changed their mobility patterns by switching from public transportation to private vehicles or other modes such as walking and bicycling (Abdullah et al., 2020; Jenelius and Cebeauer, 2020; Parker et al., 2021).

Transit ridership in many countries has plummeted since COVID-19. Aloi et al. (2020) estimated that transit use fell by 93% in Spain. Rasca et al. (2021) reported up to 80% of loss in transit patronage in Innsbruck, Austria. The number of transit passengers in Poland dropped by 77% from January to April in 2020 (Wielechowski et al., 2020). A study in Sweden showed a 40%–60% decrease in public transit ridership (Jenelius and Cebeauer, 2020). In Bangkok, Thailand, the railway ridership reduced by 79% during April 2020 (VichienSan, 2021). In Hong Kong, China, people reduced their Metro Transit Railway use by more than 40% from January to March 2020 (Zhang et al., 2021). Ahangari et al. (2020) compared the ridership of ten U.S. cities between April 2019 and April 2020 and found 62%–87% ridership declines. New York City witnessed up to a 94% ridership decline in peak hours in March 2020 compared to the same month in 2019 (Gao et al., 2020).

Although public transportation systems received financial support from governments, many transit agencies mentioned that the aid was only enough to temporarily keep them operating on a limited operational budget (EBP US, Inc., 2021). With the shrinking revenue collected from transit fares, the ridership reduction presented significant financial challenges to transit agencies. To reduce the transmission risks, some transit providers suspended their operations during the first surge of COVID-19 starting in March 2020. In 2020 and 2021, many transit agencies were forced to cut their services due to low ridership and limited financial resources (American Public Transportation Association, 2021).

While transit ridership decreased overall, studies showed that transit service reductions in the U.S. often disproportionately affected lower-income and vulnerable groups who mostly relied on the public transit system to get to work, food, or healthcare services (DeWeese et al., 2020; Hu and Chen, 2021; Wilbur et al., 2020). Abdullah et al. (2021) found that older people are less likely to use public transportation during the pandemic. Many historically marginalized groups have been encountering greater difficulties accessing the public transportation system since the service changes and experiencing greater challenges while avoiding transit use (Chen et al., 2021; Jiao and Azimian, 2021; Palm et al., 2021).

2.3. Public perceptions of transit and perceived risks of infection during the COVID-19 pandemic

Although some studies reported no robust links between transit use and COVID-19 transmission (Scannell Bryan et al., 2021; Schwartz, 2020), people’s perceived risk is significantly higher for public transit than other modes. The relatively high perceived risk of infection while riding transit has been consistently reported in studies worldwide, such as Ozbilen et al. (2021) in the U.S., Barbieri et al. (2021) in Europe, Kim et al. (2021) in South Korea, and Zafri et al. (2022) in Bangladesh.

Previous studies also revealed that fear of infection and perceived risks play critical roles in the mode shift from public transit to other modes perceived safer, such as driving, walking, and biking (Abdullah et al., 2020; Sánchez-Canizares et al., 2021). A survey conducted in Poland showed that fear of COVID-19 infection is one of the most prevalent reasons for discontinuing the use of public transportation (Przybylowski et al., 2021). In Australia, Beck and Hensher (2020) found 58% of their survey respondents were extremely concerned about the levels of hygiene on public transportation.

While transit as a shared transportation mode is associated with relatively higher risk perceptions than private vehicles in general, the risk perception of each individual is related to many other factors. Perceived risk is a complex, psychological, and social phenomenon. Studies indicated that various factors such as personal vulnerability (e.g. age, gender, education levels, health status), economic component (e.g. income, insurance), and awareness of the pandemic situation (e.g. media coverage) were all associated with perceptions of infection risks (Barbieri et al., 2021). Yıldırım and Güler (2020) and Yıldırım et al. (2021) analyzed COVID-19 perceptions and stated compared to males, females reported higher levels of perceived risks. Ozbilen et al. (2021) reported people without a bachelor’s degree were more likely to find traveling risky during the pandemic. The likelihood of a health threat was also a significant predictor of the risk perception. People were expected to have higher perceived risks if they believed an infection would lead to serious health consequences (de Zwart et al., 2009). Individuals with lower household incomes often expressed higher risk perceptions than those in the high income groups (Ozbilen et al., 2021). In addition, as Toanoglou et al. (2021) reported in a multinational study, media coverage, governments’ situation control, and crisis growth also affected perceptions of risks.

2.4. Transit agencies’ responses to COVID-19

Providing clean services and ensuring social distancing are among the key strategies for transit agencies to restore the public’s confidence and encourage them to return to transit. The public believes that transit operators have obligations to implement safety measures (Sánchez-Canizares et al., 2021). People placed a high priority on infection-related factors when asked, “which of the following measures would increase your use of transit.” Social distancing, cleanliness, and the use of face masks were among the top choices (Abdullah et al., 2020; Parker et al., 2021).

To attract riders and protect transit staff, transit operators have implemented numerous COVID-19 related safety measures and published guidelines for passengers. Kamga and Eickemeyer (2021) summarized commonly adopted protective measures in the U.S. and Canada, which included enhanced cleaning protocols, adding decals six feet apart to guide passengers, separating bus drivers from passengers, tapping off every other seat on buses, and enforcing rear door boarding. Based on the experience in China, Shen et al. (2020) identified strategies that could enhance the safety of public transportation, which included personnel management (e.g. passenger flow
control), personal protection (e.g. social distance, mask wearing), environmental cleaning and disinfection (e.g. ventilation enhancement, frequent disinfection), and health education (e.g. health protection training for staff and passengers). Tirachini and Cats (2020) discussed the importance of physical distancing, face masks, hygiene, sanitization, and ventilation in public transportation. However, there is insufficient empirical evidence that specifically focuses on the importance of communicating these safety precautions to passengers.

3. Methodology

3.1. Recruitment and data collection

The data used in this paper came from an online COVID-19 survey (i.e., survey specifically designed to address research questions comparing before and during COVID-19), which was part of a larger National Institutes of Health (NIH) funded project. The survey link was distributed to 2,915 El Paso residents who completed a prior survey about transit use in 2018–2019. The initial pool of participants was recruited through city-wide advertising efforts, including flyers, door hangers, home visits, information booths, posters at transit facilities, community events, social media, news on TV and newspapers, and websites. After sending individual invitations via email or text message, a total of 1,046 responses were received in July 2020. The eligibility criteria of the study participants were (a) living in the City of El Paso, Texas; (b) being aged 18 years or older; and (c) not being a full-time student. Up to two eligible participants from the same household were allowed to join the study. After excluding 303 incomplete responses and another 31 ineligible responses (27 who did not live in the City of El Paso and four duplicates), a total of 712 valid responses, consisting of 613 English and 99 Spanish responses, were included in the analysis (Fig. 1).

3.2. Key measures

One survey question was used to capture how many days per week the participants used private automobiles, the Brio, and the regular bus before and since COVID-19. Based on the responses to this question, participants were categorized into (a) continued transit riders – defined as those who used the Brio or regular bus at least once a week both before and since COVID-19, (b) previous transit riders – those who used the Brio or regular bus at least once a week before COVID-19 but stopped using any since COVID-19, and (c) drivers – those who used private vehicles and did not use the Brio or regular bus before and since COVID-19 (Appendix B).

The perceived risks of catching COVID-19 while traveling were captured for a variety of transportation modes using a four-point Likert scale: no risk, low risk, moderate risk, and high risk. Based on the distribution of the participant responses to this item, three binary variables (i.e. high vs. no-to-moderate risks) were generated, representing the perceived risk of catching COVID-19 while using (a) Brio, (b) regular bus, and (c) both Brio and regular bus. The third binary variable was coded as 1 if the participant chose high risk for both Brio and regular bus, and 0 if the participant chose no-to-moderate risks for either Brio or regular bus.

Another binary variable, awareness of the Sun Metro COVID-19 safety guidelines, captured whether the participants were aware of the safety measures Sun Metro has implemented in response to COVID-19. In the survey, we provided a brief description of these measures and asked the participant: “Are you aware of these changes made to public transportation in your area in response to COVID-19?” with response options for “Yes” and “No”.

![Fig. 1. Survey data screening process.](http://example.com/fig1.png)
3.3. Statistical analyses

First, we summarized the descriptive characteristics of participants regarding their home locations, socioeconomic status, awareness, and perceptions. Second, we compared their transportation mode choices before and since COVID-19 to examine the mode shift phenomenon. Chi-squared or ANOVA analyses were performed to compare the continued transit riders, previous transit riders, and drivers in terms of socioeconomic status, awareness, and perceptions. Third, chi-squared tests were used to examine the associations between COVID-19 safety guideline awareness and perceived risks. A series of bivariate analyses were conducted to compare the “no-to-moderate risk perception” group and “high risk perception” group. Lastly, three multivariable binary logistic regression models were carried out using the perceived risk of catching COVID-19 while riding the regular bus, Brio, and transit as the dependent variables, respectively. Six sociodemographic variables (i.e., age, sex, ethnicity, employment status, household income, and education level) were included as confounding variables. Perceived risks while riding an automobile and walking and perceived vulnerability of catching COVID-19 were included in the model as the bivariate analyses showed statistically significant correlations (p < 0.01). We used Stata SE 15 for all statistical analyses carried out for this paper.

![Fig. 2. Participants by ZIP Code Tabulation Areas (ZCTAs).]
4. Results

4.1. Participant profile

The participants were residents from 19 different ZIP Code Tabulation Areas (ZCTAs) in El Paso, Texas (Fig. 2). Participants’ age ranged from 19 to 85 years (mean = 45, SD = 14), with 54.7% being younger than 45 years. About 81.9% of the respondents were of Hispanic origin, which was close to the city’s average of 81.4% (U.S. Census Bureau, 2019). Participants were 67.1% female, 38.3% with a bachelor’s degree or above, and 65.3% with less than $50,000 annual household income. Most respondents’ households (83.5%) owned at least one private vehicle per person with a driver’s license. Since COVID-19, approximately 63.3% of the participants were employed compared to 69.8% before COVID-19, and 32.9% traveled outside of their homes for work compared to 61.4% before COVID-19 (Appendix A).

Participants perceived higher risks of catching COVID-19 from using transit than driving alone. Overall, 1.3% thought driving alone was of high risk, while 65.2% and 59.6% thought the risk was high while riding the regular bus and Brio, respectively. About 45.7% of our study participants were aware of the Sun Metro COVID-19 safety measures. The majority of the participants indicated that social distancing (69.6%) and cleaning services (64.4%) were very important to encourage them to use public transportation, and 41.2% considered free services during the pandemic as being very important.

4.2. Mode shift during the COVID-19 pandemic

Most participants (395 out of 712) were considered “drivers” in this study. A total of 31 were grouped as “continued transit riders.” Among the continued riders, 17 did not own a private vehicle, including six who did not use private automobiles at all. Of the 56 “previous transit riders”, 45 switched to private automobiles, and the remaining 11 either switched to other modes such as biking and walking or stopped traveling (Appendix B).

Compared to drivers, continued and previous transit riders had less income, owned fewer vehicles, and obtained lower educational attainment. Half of the continued transit riders had less than one vehicle per driver in the household, while this proportion was significantly lower (21.3%) among the previous transit riders (Appendix C).

Compared to drivers, both continued and previous transit riders were more likely to report that COVID-19 related safety measures were very important for them to use transit. Social distancing and cleaning services were placed as high priorities across all three groups. Free services were particularly important for continued transit riders (Appendix C).

4.3. COVID-19 safety guideline awareness and perceived risks

Bivariate analysis results indicated that for the group who noticed the Sun Metro COVID-19 safety measures, their perceived risks of catching COVID-19 were much lower than the group who did not. Chi-squared tests showed statistically significant (p < 0.05) results for both the regular bus and Brio (Table 1).

Appendix D compares the characteristics of the participants who viewed transit riding as "no-to-moderate risk" and "high risk". People of Hispanic origin and people who were unemployed since COVID-19 were more likely to perceive transit use to be associated with a high risk of catching COVID-19. In general, people who thought other transportation modes were risky were more likely to perceive taking transit as being risky too. For example, the perceived risk of catching COVID-19 while riding transit was positively associated with the perceived risk while riding in a private vehicle as a passenger (x² = 29.71, p < 0.001) and walking (x² = 43.87, p < 0.001). People were more likely to perceive a high risk of COVID-19 infection if they reported the infection would lead to serious health consequences (x² = 39.01, p < 0.001).

As stated in section 3.3, we built three multivariable binary logistic regression models. Since the results of the three models were similar, only the logistic regression estimating predictors of the transit use perceived risk is displayed below (Table 2). The results showed that people with a bachelor’s degree or higher were less likely to report riding transit as being of high risk (Table 2). Employment status was also associated with risk perceptions at the 0.1 alpha level, as people who were not employed since COVID-19 were more likely to perceive riding transit as being of high risk. In terms of awareness and perception-related confounding variables, the results of the logistic regression were consistent with the bivariate analysis results. After controlling for the variances of inherent

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**Table 1**

Guideline awareness and perceived risks of riding transit.

| Perceived risks of catching COVID-19 while riding: | Brio Aware | Brio Not aware | Brio Total | Regular Bus Aware | Regular Bus Not aware | Regular Bus Total |
|---------------------------------------------------|------------|---------------|------------|-------------------|-----------------------|------------------|
| No risk                                           | 7          | 3             | 10         | 6                 | 1                      | 7                |
| Low risk                                          | 25         | 12            | 37         | 23                | 11                     | 34               |
| Moderate risk                                     | 93         | 114           | 207        | 90                | 94                     | 184              |
| High risk                                         | 157        | 205           | 362        | 171               | 238                    | 409              |
| Total                                             | 282        | 334           | 616        | 290               | 344                    | 634              |

Brio: Pearson chi2(3) = 10.347, p = 0.016.

Regular Bus: Pearson chi2(3) = 14.374, p = 0.002.
risk perceptions, awareness of the COVID-19 safety measures implemented by Sun Metro was associated with a lower perceived risk of catching COVID-19 while riding transit (OR = 0.608, p = 0.017).

5. Discussion

5.1. Major result discussion

Descriptive analyses provided evidence that the study participants perceived a much higher risk of catching COVID-19 from using transit than driving alone, which is consistent with existing studies (Kim et al., 2021; Ozbilen et al., 2021; Zafri et al., 2022). More than half of the participants thought riding the regular bus and Brio were of high risk. This perception may be sustained over a longer period of time than once expected, due to the continued impact of COVID-19, making this a major concern for public transit agencies.

Although public transportation services remain essential for people who have limited access to personal vehicles, many people have changed their transportation mode choices since the start of the COVID-19 pandemic. Our study showed a significant shift from public transportation to other modes, especially private automobiles, reflecting the view among our participants that public transportation might be among the least safe way of traveling during an infectious disease pandemic. This mode shift phenomenon was captured by previous studies in many countries (Abdullah et al., 2020; Hadjidemetriou et al., 2020; Harris and Branion-Calles, 2021; Parker et al., 2021). The reduction in transit use was reflected by Sun Metro’s ridership. Compared to the same months in 2019, Sun Metro’s regular bus ridership dropped by 82.7%, 78.9%, and 71.5% in April 2020, May 2020, and June 2020, respectively. Ridership of the Mesa Brio line also decreased from about 27,000 in April 2019 to 16,000 in April 2020 (Sun Metro, 2021). To regain ridership, efforts are needed to restore passengers’ confidence and trust in safety protocols.

Similar to other transit operators, Sun Metro in El Paso, Texas has implemented many measures to improve safety in operations. Survey respondents said that social distancing and cleaning services were very important for them in using transit during the pandemic. This finding is consistent with existing studies (Labonté-LeMoyne et al., 2020; Parker et al., 2021; Tirachini and Cats, 2020) and suggests implementing and adhering to COVID-19 related safety measures are essential to regain riders. The free fare policy was also an incentive for existing riders to continue using transit during the pandemic, reflecting the characteristics of the “continued transit rider” group that tended to be of lower-income and with limited access to private automobiles. The positive ridership impacts of the free fare policy during the COVID-19 pandemic were demonstrated by Dai et al. (2021). These results implied the importance for transit providers to utilize customized strategies when trying to retain and attract riders of different socioeconomic status.

Our survey results showed more than half of our study participants and more than half of the previous transit riders were not aware of the COVID-19 related safety measures implemented by Sun Metro. Both bivariate and multivariable analyses indicated that participants’ perceived risks were significantly lower among people who were aware of the safety guidelines. This suggested that enhancement of information dissemination and public education could help people build trust towards transit during the pandemic. Transit agencies have realized maintaining safety precautions and cleanliness is critical when resuming services. However, actions to better inform passengers of these safety measurements are often limited. Our survey results highlighted that there is a large room for improvement in terms of passenger communication about the implemented safety measures. As Ashraf Javid et al. (2021) pointed out, public transportation providers and passengers need to better recognize the associated benefits of following the safety guideline. To attract passengers back, it is critical for transit providers to explore innovative and effective methods to increase public awareness about their ongoing safety and preventive measures. Based on these findings, practical strategies to enhance the pandemic-related
passenger communication system are suggested in the following section.

5.2. Recommendations for COVID-19 recovery

As of the writing of this article, many countries have been opening up the economy with many residents returning to their places of work, and yet cases of COVID-19 have continued to rise or remain high. The World Health Organization (2020) summarized the measures that can be implemented by transport providers, such as providing public hand-hygiene stations, encouraging the use of online booking systems, and controlling pedestrian traffic. The Association for European Transport (2022) also provided and kept updating the technical best practices for transit systems to recover from COVID-19 (FTA, 2021). Physical distancing and cleaning services will remain the recommended protocol for some time. As riders return gradually, public transit agencies are expected to face many challenges. This study highlights the importance of information communication by transit agencies to the public. Some practical recommendations for COVID-19 recovery follow. The choice of implementation would depend on the agency’s operational context and available resources.

Diverse communication channels are needed to inform passengers about safety measures and service changes. Floor and seat stickers, large decals, posters, and banners can be printed and displayed throughout the system. In addition to static signage, electronic communications need to play an important role. Websites, social media, radio, TV, smartphone apps, virtual bulletin boards, and emails should be used for notifications whenever possible (Cluett et al., 2003).

An adequate provision of real-time passenger information should be ensured. To help riders plan their trips safely and comfortably, transit providers need to alert passengers about seat availability and overcrowding through smartphone apps, text messages, or LED dynamic displays. For instance, Long Island Rail Road allowed its passengers to access real-time train crowding information through the official LIRR app (Metropolitan Transportation Authority, 2022). East Japan Railway provided real-time congestion level information to customers via websites, smartphones, and on-site screens (East Japan Railway Company, 2020). During the COVID-19 pandemic, some agencies also allowed bus operators to bypass stops to enforce physical distancing rules (FEMA, 2020), while a backup bus was requested when needed. Such strategies will need continuous real-time information sharing and will need to be flexible to react to and be informed by evidence-driven public health data.

Marketing campaigns are one of the most prevalent strategies to disseminate information to passengers and the wider public. Many transit agencies hosted welcome back campaigns focusing on the steps the agencies will take to ensure the safe restoration of their services. For example, Bay Area Rapid Transit (BART) published its “BART 15-step plan” underlining the efforts to keep passengers safe (BART, 2021). Transport for London (TfL) encouraged riders to use transit systems by running the “Welcome back. Tube it. Bus it. Train it” campaign (VCCP London, 2021).

Effective management cannot be achieved without two-way communication. New technologies and innovations are often adopted to keep passengers engaged. Dallas Area Rapid Transit (DART) used the “DART Say Something” app to allow passengers to report unhygienic surfaces (DART, 2021). California Transit Association (2022) recommended that transit agencies utilize social media to disseminate facts or information. In China, the Beijing subway operators encouraged passengers to make seat reservations online in advance to avoid overcrowding (China Daily, 2020).

5.3. Limitations and future directions

As a cross-sectional online survey carried out in a single city, this study is subject to some limitations. First, online survey participants tend to be more technology savvy and active internet users. For example, respondents who were uncomfortable with online survey instruments might drop out of the study. Although the online survey gave participants more safety assurance and flexibility, especially during the COVID-19 pandemic, it brought selection bias and limited the study’s generalizability. Second, study participants may not represent the city-wide population, given we only delivered recruitment information to our baseline participants who live in 85 census block groups in the City of El Paso. Also, this study took place in a single U.S. city, which might limit its generalizability to other regions. Third, measures were limited as some participants skipped questions, and not all answers could be ascertained fully.

A total of 712 responses were included in this study. While the sample size was still adequate for statistical analyses, it was limited for more detailed sub-group level analyses. Thus, larger and more representative samples would be needed in future work to delve into the more nuanced experience of diverse sub-groups with different characteristics experiencing different barriers to transit use. Furthermore, this study underscored passenger communication as an essential step to restore transit ridership during the pandemic. However, it is unclear which communication channels were more cost-effective. Future research is needed to assess diverse communication and education programs and systems and how those can be tailored to be most effective for the specific local contexts and populations.

6. Conclusions

This study focused on the practical challenges faced by transit providers during the COVID-19 pandemic and the related public health concerns among potential and actual transit users. Furthermore, we provided evidence concerning public perceptions and risk concerns related to transit use, which are critical to key stakeholders in public policy and other sectors, including public transit. Our study findings suggest that public awareness of COVID-19 related safety measures plays an essential role in alleviating concerns
of infection while riding public transportation. There is a major opportunity for improvement in terms of marketing and public communication that can and should be targeted at informing people about the efforts transit operators are undertaking to maintain a safer operating environment among transit operators and users alike. Bridging the knowledge gap is the key to restoring the confidence of the general public. As transit operators strive to provide a safe, secure, and healthy environment for the users, they must also better inform current and potential passengers about what is being done to maintain a safer operating environment. These findings are critical for key stakeholders who can take action now and at the same time may also provide lessons learned, to the extent possible, for future disaster emergency management plans in similar contexts.

CRediT author statement

**Jiahe Bian:** conceptualization, methodology, software, original draft preparation. **Sinan Zhong:** project administration, data curation, writing-reviewing and editing. **Samuel D. Towne Jr.:** writing-reviewing and editing. **Chanam Lee:** conceptualization, funding acquisition, supervision, writing-reviewing and editing. **Marcia G. Ory:** funding acquisition, supervision, writing-reviewing and editing. **Wei Li:** conceptualization, funding acquisition, supervision, writing-reviewing.

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Data availability

Data will be made available on request.

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All study procedures were performed in compliance with relevant regulations and institutional guidelines. The study protocol was reviewed and approved by TAMU IRB (IRB2017-0848D).

Appendix A. Participant characteristics

| Socioeconomic status                                      | N   | Frequency | Percent |
|-----------------------------------------------------------|-----|-----------|---------|
| Employment status since COVID-19                          |     |           |         |
| Employed                                                  | 632 | 400       | 63.29   |
| Unemployed                                                | 232 | 36.71     |         |
| Employment status since COVID-19                          |     |           |         |
| Not work outside of the home                              | 632 | 424       | 67.09   |
| Work outside of the home                                  | 208 |           | 32.91   |
| Household income                                          |     |           |         |
| <$50,000                                                  | 645 | 421       | 65.27   |
| ≥$50,000                                                  | 224 |           | 34.73   |
| Vehicles per driver in the household                      |     |           |         |
| Less than one                                             | 658 | 111       | 16.87   |
| One or more                                               | 547 |           | 83.13   |
| Age                                                       |     |           |         |
| Younger than 45                                           | 693 | 379       | 54.69   |
| 45+                                                       | 314 |           | 45.31   |
| Sex                                                       |     |           |         |
| Male                                                      | 697 | 229       | 32.86   |
| Female                                                    | 468 |           | 67.14   |
| Ethnicity                                                  |     |           |         |
| Hispanic                                                  | 697 | 571       | 81.92   |
| Non-Hispanic                                              | 126 |           | 18.08   |
| Education                                                 |     |           |         |
| No bachelor’s degree                                      | 694 | 428       | 61.67   |
| Bachelor’s degree or higher                               | 266 |           | 38.33   |

Awareness and perceptions

| Awareness of the Sun Metro COVID-19 safety guidelines     |     |           |         |
| Yes                                                      | 678 | 310       | 45.72   |
| No                                                       | 368 |           | 54.28   |

Importance of “clean services” COVID-19 safety measures  
Not at all important                                      | 700 | 132       | 18.86   |
Somewhat important                                        | 177 | 117       | 16.71   |
Very important                                             | 451 |           | 64.43   |

Importance of “free services” COVID-19 safety measures    
Not at all important                                       | 680 | 177       | 26.03   |
Somewhat important                                        | 223 |           | 32.79   |
Very important                                             | 280 |           | 41.18   |

Importance of “social distancing” COVID-19 safety measures 
Not at all important                                       | 683 | 103       | 15.08   |
Somewhat important                                        | 105 |           | 15.37   |
Very important                                             | 475 |           | 69.55   |

(continued on next page)
Appendix B. Continued transit riders, previous transit riders, and drivers

| Before COVID-19 | Since COVID-19 | Number | Group |
|-----------------|----------------|--------|-------|
| Use both transit and private automobiles (PV) (N = 85) | Use both transit and PV | 20 | Continued transit riders |
| Use transit only | 4 | Continued transit riders |
| Use PV only | 42 | Previous transit riders |
| Do not use either | 6 | Previous transit riders |
| Unclear | 13 | Others |
| Use transit only (N = 22) | Use both transit and PV | 1 | Continued transit riders |
| Use transit only | 6 | Continued transit riders |
| Use PV only | 3 | Previous transit riders |
| Do not use either | 5 | Previous transit riders |
| Unclear | 6 | Others |
| Use PV only (N = 529) | Use both transit and PV | 5 | Others |
| Use transit only | 0 | Others |
| Use PV only | 395 | Drivers |
| Do not use either | 20 | Others |
| Unclear | 99 | Others |
| Do not use either (N = 24) | Use both transit and PV | 0 | Others |
| Use transit only | 0 | Others |
| Use PV only | 1 | Others |
| Do not use either | 14 | Others |
| Unclear | 9 | Others |
| Unclear (N = 65) | Any | 63 | Others |

Note: Due to the small sample size and missing data, responses in the group “others” are not discussed in this paper.

Appendix C. Characteristics of continued transit riders, previous transit riders, and drivers

| Socioeconomic status | Continued transit riders | Previous transit riders | Drivers | Total | P-value (Chi2/ANOVA) |
|----------------------|--------------------------|-------------------------|---------|-------|---------------------|
| **Employment status since COVID-19** | Employed | 13 | 28 | 239 | 280 | 0.170 |
| | Unemployed | 15 | 20 | 137 | 172 | |
| **Worked outside of the home since COVID-19** | No | 22 | 39 | 259 | 319 | 0.134 |
| | Yes | 6 | 9 | 117 | 132 | |
| **Household income** | <$50,000 | 29 | 43 | 203 | 275 | 0.000** |
| | ≥$50,000 | 2 | 8 | 160 | 170 | |
| **Vehicles per driver in the household** | Less than one | 8 | 10 | 51 | 69 | 0.000** |
| | One or more | 8 | 37 | 336 | 381 | |
| **Age** | Younger than 45 | 11 | 33 | 218 | 262 | 0.073 |
| | 45+ | 20 | 23 | 172 | 215 | |
| **Sex** | Male | 14 | 20 | 122 | 156 | 0.218 |
| | Female | 17 | 34 | 269 | 320 | |
| **Ethnicity** | Hispanic | 25 | 47 | 305 | 377 | 0.474 |
| | Non-Hispanic | 6 | 8 | 84 | 98 | |
| **Education** | No bachelor’s degree | 22 | 41 | 208 | 271 | 0.004** |
| | Bachelor’s degree or higher | 9 | 14 | 179 | 202 | |

| Awareness and perceptions | Continued transit riders | Previous transit riders | Drivers | Total | P-value (Chi2/ANOVA) |
|---------------------------|--------------------------|-------------------------|---------|-------|---------------------|
| Awareness of the Sun Metro COVID-19 safety guidelines | Yes | 24 | 32 | 159 | 215 | 0.000** |
| | No | 4 | 22 | 225 | 251 | |
| Importance of “clean services” COVID-19 safety measures | Not at all or somewhat important | 4 | 6 | 159 | 169 | 0.000** |
| | Very important | 27 | 50 | 231 | 308 | |

(continued on next page)
### Continued transit riders

| Importance of “free services” COVID-19 safety measures | Not at all or somewhat important | Very important | Total | P-value (Chi2/ANOVA) |
|------------------------------------------------------|----------------------------------|---------------|-------|---------------------|
| Continued transit riders                             | 5                                | 24            | 256   | 282                 | 0.000** |
| Previous transit riders                               | 21                               | 34            | 128   | 186                 |         |
| Drivers                                               | 256                              | 128           | 444   |                     |         |
| Total P-value (Chi2/ANOVA)                            | 0.000**                          |               |       |                     |         |

| Importance of “social distancing” COVID-19 safety measures | Not at all or somewhat important | Very important | Total | P-value (Chi2/ANOVA) |
|----------------------------------------------------------|----------------------------------|---------------|-------|---------------------|
| Continued transit riders                                 | 1                                | 30            | 50    | 241                 | 0.000** |
| Previous transit riders                                  | 4                                |               | 144   | 149                 |         |
| Drivers                                                  | 144                              | 241           | 385   |                     |         |
| Total P-value (Chi2/ANOVA)                               | 0.000**                          |               |       |                     |         |

*p < 0.05. **p < 0.01.

### Appendix D. Characteristics of the low-risk versus high-risk perception groups

#### Perceived risk of catching COVID-19 while riding transit

| Socioeconomic status | No-to-moderate risk | High risk | Total | P-value (Chi2/t-test) |
|----------------------|---------------------|-----------|-------|----------------------|
| Employment status since COVID-19                          |                    |           |       |                      |
| Employed            | 170                 | 210       | 380   | 0.002**              |
| Unemployed          | 69                  | 148       | 217   |                      |
| Household income    |                     |           |       |                      |
| < $50,000           | 159                 | 240       | 399   | 0.956                |
| $50,000+            | 84                  | 128       | 212   |                      |
| Age                 |                     |           |       |                      |
| Younger than 45     | 149                 | 216       | 365   | 0.579                |
| 45+                 | 111                 | 176       | 287   |                      |
| Sex                 |                     |           |       |                      |
| Male                | 92                  | 120       | 212   | 0.237                |
| Female              | 170                 | 271       | 441   |                      |
| Ethnicity           |                     |           |       |                      |
| Hispanic            | 205                 | 337       | 542   | 0.008**              |
| Non-Hispanic        | 57                  | 54        | 111   |                      |
| Education           |                     |           |       |                      |
| No bachelor’s degree | 148             | 252       | 400   | 0.067                |
| Bachelor’s degree or higher | 111       | 140       | 251   |                      |

#### Awareness and perceptions

| Importance of “clean services” COVID-19 safety measures | Not at all or somewhat important | Very important | Total | P-value (Chi2/t-test) |
|-------------------------------------------------------|----------------------------------|---------------|-------|----------------------|
| Continued transit riders                                | 98                               | 129           | 227   | 0.277                |
| Previous transit riders                                 | 168                              | 265           | 433   |                      |
| Drivers                                                | 158                              | 219           | 377   | 0.345                |
| Total P-value (Chi2/t-test)                            | 0.218                            |               |       |                      |

| Importance of “free services” COVID-19 safety measures | Not at all or somewhat important | Very important | Total | P-value (Chi2/t-test) |
|-------------------------------------------------------|----------------------------------|---------------|-------|----------------------|
| Continued transit riders                                | 85                               | 109           | 194   | 0.234                |
| Previous transit riders                                 | 152                              | 249           | 393   |                      |
| Drivers                                                | 135                              | 203           | 338   | 0.234                |
| Total P-value (Chi2/t-test)                            | 0.345                            |               |       |                      |

| Importance of “social distancing” COVID-19 safety measures | Not at all or somewhat important | Very important | Total | P-value (Chi2/t-test) |
|----------------------------------------------------------|----------------------------------|---------------|-------|----------------------|
| Continued transit riders                                 | 196                              | 278           | 453   | 0.234                |
| Previous transit riders                                  | 184                              | 249           | 433   |                      |
| Drivers                                                  | 175                              | 278           | 453   |                      |
| Total P-value (Chi2/t-test)                              | 0.234                            |               |       |                      |

| Perceived risk of catching COVID-19 while driving alone  | No risk                          | Low risk       | Moderate and high risk | Total | P-value (Chi2/t-test) |
|--------------------------------------------------------|----------------------------------|---------------|------------------------|-------|----------------------|
| Continued transit riders                                | 184                              | 249           | 433                    | 23    | 0.234                |
| Previous transit riders                                 | 175                              | 278           | 453                    | 35    |                      |
| Drivers                                                | 171                              | 273           | 444                    | 70    |                      |
| Total P-value (Chi2/t-test)                              | 0.234                            |               |                        |       |                      |

| Perceived risk of catching COVID-19 while riding in an automobile as a passenger | No risk                          | Low risk       | Moderate and high risk | Total | P-value (Chi2/t-test) |
|----------------------------------------------------------------------------------|----------------------------------|---------------|------------------------|-------|----------------------|
| Continued transit riders                                                        | 165                              | 194           | 359                    | 210   |                      |
| Previous transit riders                                                          | 165                              | 194           | 359                    | 210   |                      |
| Drivers                                                                          | 165                              | 194           | 359                    | 210   |                      |
| Total P-value (Chi2/t-test)                                                       | 0.234                            |               |                        |       |                      |

| Perceived risk of catching COVID-19 while walking                                 | No risk                          | Low risk       | Moderate and high risk | Total | P-value (Chi2/t-test) |
|----------------------------------------------------------------------------------|----------------------------------|---------------|------------------------|-------|----------------------|
| Continued transit riders                                                        | 146                              | 117           | 263                    | 83    | 0.000**              |
| Previous transit riders                                                          | 146                              | 117           | 263                    | 83    |                      |
| Drivers                                                                          | 146                              | 117           | 263                    | 83    |                      |
| Total P-value (Chi2/t-test)                                                       | 0.000**                          |               |                        |       |                      |

| Perceived vulnerability of catching COVID-19                                   | No symptoms                      | Have minor symptoms | Become seriously ill | Be hospitalized or die from it | Total | P-value (Chi2/t-test) |
|-------------------------------------------------------------------------------|----------------------------------|---------------------|----------------------|-------------------------------|-------|----------------------|
| Continued transit riders                                                        | 34                               | 22                  | 56                   | 20                            | 95    |                      |
| Previous transit riders                                                          | 168                              | 193                 | 361                  | 43                            | 151   | 0.000**              |
| Drivers                                                                          | 191                              | 216                 | 431                  | 53                            | 60    |                      |

*p < 0.05. **p < 0.01.

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