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Transit use reduction following COVID-19: The effect of threat appraisal, proactive coping and institutional trust

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ABSTRACT

Transit systems suffered from a significant demand decrease during COVID-19. Understanding the psychological motivators underlying reduced transit use can help transit authorities and operators to take proactive action towards returning to the "new normal" and increasing their preparedness towards future pandemics. This study is based on the protection motivation theory to understand the effect of threat appraisal, and coping appraisal and denial mechanisms on transit use reduction for commuting. The behavioral framework is validated by a survey of 856 transit users in Israel during August 2020, three months after the end of the lockdown and before the vaccine administration. The results show that: i) Skepticism, risk ubiquity, and personal immunity beliefs lead to maladaptive threat appraisal; ii) wearing masks and social distancing are antecedents of fear of infection while using transit and reduced transit use; iii) higher perceived threat deters transit use, while trust in transit operators motivates transit use; and iv) in a franchised transit system, trust in transit operators depends on the perceived level-of-service and trust in the ability of government authorities to regulate, monitor and enforce transit operators' preventive and protective actions.

1. Introduction

The COVID-19 pandemic and the subsequent lockdown created a sudden and unprecedented change in the population's working habits and travel behavior. The induced changes include air traffic reduction, minimal transport use, working online from home, fewer activities, and more e-commerce. The pandemic induced the deepest global recession in eight decades, impacting employment patterns, population purchase power parities (PPP), and international trade. The pandemic induced average decreases of 5.2% in GDP, 13.6% in trade, and 4.1% in PPP estimates worldwide. The shutdown of entire industries resulted in the collapse of businesses and increased unemployment. During the first quarter of 2020, an estimated 5.4% of global working hours (equivalent to 155 million full-time jobs) were lost relative to the previous year. During the second quarter of 2020, the estimated loss rose to 14% (World Bank, 2020).

Due to social distancing and government recommendations to avoid transit use in Europe and the United States, COVID-19 led to a

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significant decrease in transit supply and demand (Tirachini & Cats, 2020). Recent studies focused on quantifying the effect of the lockdown on transit use during or after the lockdown. Daily transit operations under social distancing restrictions across regions included reduced transit capacity by 50% (Arellana et al., 2020; Wang et al., 2020) and the wearing of masks on public transport (Hadjidemetriou et al., 2020). In a survey conducted in India by Pawar et al. (2020), 75% of the respondents considered public transportation as unsafe in terms of health risks during the pandemic, 41.7% stopped traveling, and 5.3% shifted from transit use to other modes. Wang et al. (2020) showed by simulation that limiting transit capacity in New York to 50% would decrease transit ridership to 64%, and full capacity would correspond to 73% of the ridership. In New York, subway ridership dropped by 90% during the pandemic and remained low until the beginning of May, while traffic volumes in May showed a 31% decrease after a 67% decrease in April (Teixeira and Lopes, 2020; Zuo et al., 2020). In Spain and the Netherlands, transit use suffered a 70–90% reduction (Arellana et al., 2020). The transit ridership in Britain by the end of May was 60% of the ridership the previous year (Hadjidemetriou et al., 2020). In Colombia, two months post-lockdown, ridership remained at only 40% (Arellana et al., 2020). In A Coruña, Spain, upon restoring the supply after the lockdown, the ridership was 80–85% of the previous year (Orro et al., 2020). Wilbur et al. (2020) and Brough et al. (2020) found that the decrease in ridership varies across income groups, with reductions of 60–70% and 40% for high- and low-income groups, respectively. Tan and Ma (2020) found in Mexico City that the assessed risk of infection significantly influence commuters' choice of rail transport. Nevertheless, there is evidence that ridership could be restored if appropriate actions are taken by governments and transport authorities. Cho et al. (2020) present a data-driven view that public transport ridership can be restored. They investigated travel behavior in the 27 weeks after the emergence of COVID-19 in South Korea. Towards the end of the period, 80–85% of the commuting demand and 70–75% of the weekend demand were restored. These data, combined with the rate of mask use (60%) and considering that 70% of the population perceived the risk of infection to be very high (Cho et al., 2020), provide unique evidence of being able to manage transit use under COVID-19 conditions. While the effect of COVID-19 on transit ridership can be quantified, the behavioral mechanism underlying transit use reduction and retention remains unexplored.

Since fighting the pandemic is a marathon, not a sprint, and since pandemics can occur more than once, it is essential to understand the impact of COVID-19 on transit behavior to increase the preparedness for future pandemics. People should perform their daily routine under COVID-19 conditions while taking precautions to protect themselves and others. Transit use poses a particular challenge because design standards (for example, four people per square meter; Li & Hensher, 2013) do not conform to social distancing recommendations. Due to the massive fall in ridership, there is concern that the public will favor private vehicles due to fear (Honey-Rosés et al., 2020). Researchers view the possibility of transit bankruptcy depending on the duration of the crisis (Honey-Rosés et al., 2020; Tirachini & Cats, 2020). While government efforts to contain the pandemic are essential for effective public transport policy measures, policy measures to increases the preparedness of transit authorities are an essential part of fighting the pandemic. Zhou et al. (2020) propose to dynamically adjust the transit system to the spread of the pandemic based on a case study from Ningbo, China. Tirachini and Cats (2020) propose various policy measures for the post-COVID-19 crisis period, including applying new design standards, assessing the actual risk of infection in public transportation, and understanding passengers' behavioral adaptations to avoid infection. Nevertheless, studies do not discuss the mutual effect of government policy and actions taken by transit authorities, nor do they examine the relationship between trust in the government's ability to manage and monitor COVID-19 on public transport, and trust in transit operators.

This study adds to the current knowledge on coping with pandemics in public transport by providing a rigorous behavioral framework, namely the protection motivation theory, originally designed for coping with health hazards. The contribution of the study is fourfold. First, previous studies have only focused on the effects of COVID-19 on transit ridership; the underlying causes have not been explored. The current study focuses on the psychological motivators underlying the behavior and reveals the general behavioral mechanism of threat and coping appraisal as explaining passengers' choice to use or avoid public transportation. Second, while other behavioral theories, such as the Theory of Planned Behavior have been applied to understand transit ridership (e.g., Spears et al., 2013), these theories assume a "business as usual" scenario. Thus, they are limited in predicting behavioral changes during an abrupt system shock, as in the case of the COVID-19 pandemic. We apply the Protection Motivation Theory (PMT, Rogers, 1975), which was designed to represent behavioral change under abrupt system shock and the need to protect oneself in light of a threatening situation. PMT has been extensively applied to explain behavioral intentions in numerous countries and several contexts, including health (Milne et al., 2000), disaster management (McCaughey et al., 2017), physical activity (Bui et al., 2013), and eco-friendly behavior (Bockarjova & Steg, 2014; Kothe, 2019; Shafiei & Maleksaeidi, 2020). In the context of COVID-19, PMT has recently been applied to model the effect of COVID-19 on pro-environmental behavior (Tchetchik et al., 2021) and to model the effect of trust in government actions and information on protective behavior during the COVID-19 crisis (Al-Rasheed, 2020). Nevertheless, PMT has not been applied in the context of transportation research. Third, we add to the PMT possible denial mechanisms underlying behavioral reactions during a system shock. While denial mechanisms are associated with habitual risky health behaviors (Oakes et al., 2004), the studied denial mechanisms have not embedded in the original PMT. Moreover, while the costs and consequences of denial have been explored in the context of COVID-19 from the perspective of government responses (e.g., Weidner & Nelson, 2020; Buguzi, 2021), studies on the prevalence of denial beliefs and their effects on activities are scarce (e.g., Piton Hakim et al., 2021). The current study is the first to explore the effect of denial mechanisms on daily routine travel after the COVID-19 lockdown. Finally, restoring transit demand during the pandemic is the shared responsibility of government authorities, transit providers, and passengers. Previous studies have not investigated the effect of trust in government authorities and transit operators on passengers' reactions during the pandemic. This study closes the gap by looking at coping appraisal from the perspective of personal responsibility and institutional trust, namely trust in government authorities and transit operators.

The paper is organized as follows. Section 2 presents the behavioral framework and the mathematical model. Section 3 details the data collection. Section 4 elaborates on the results, and Section 5 offers policy discussion and conclusions.

2. Methods

2.1. Behavioral framework

The behavioral framework is based on the Rogers' (1975) PMT, explaining fear and belief in coping efficiency as a motivators of behavioral change towards risk avoidance. The appraised severity of the threat, the assessed occurrence and exposure probability, and beliefs regarding the expected efficacy of the coping response lead to a protection motivation and intent to take protective action (Rogers, 1975). Rippetoe and Rogers (1987) added perceived vulnerability and the possibility of maladaptive responses for both threat appraisal and coping. In this study we investigate whether the mechanism of threat and coping appraisal can explain transit reduction after the lockdown release towards returning to the 'new normal' after the pandemic. Fig. 1 presents the behavioral framework. The main components of the framework are presented in the following paragraphs.Fig. 2C.

Maladaptive denial beliefs involve three commonly expressed self-exemption beliefs associated with habitual risky health behaviors (Oakes et al., 2004): personal immunity to health effects ("bulletproof"), skepticism regarding potential health consequences ("skeptic"), and normalizing the risk because of the ubiquity of risks ("life's a jungle"). While the PMT formulation incorporates the possibility of maladaptive beliefs, it does not specify the nature of the maladaptive beliefs for consideration. The maladaptive strategies considered in the current study were first formulated within the context of smoking cessation (Oakes et al., 2004), and are hypothesized in the current study to affect human threat and coping appraisal following the COVID-19 outbreak.

Threat appraisal refers to personal vulnerability to COVID-19, the general fear exposure to COVID-19, COVID-19, risk expectancy in public transport and the specific fear of being infected with COVID-19 while travelling by public transport (Rippetoe & Rogers, 1987; Rogers, 1975). **Personal vulnerability** refers to personal health and economic risk factors as a result of COVID-19. An individual's personal vulnerability depends only on their characteristics and is not affected by activity or travel patterns. In the context of COVID-19, health risk factors include perceived risk to oneself and family members on the basis of being in a risk group that is related to existing health preconditions (e.g., elderly, obesity, and chronic illnesses such as cardio-vascular disease, cancer, diabetes, chronic kidney and liver diseases). Economic risk results from actual or expected employment or income loss. **General fear of exposure to COVID-19** encapsulates the general fear of being infected or infecting others, regardless of public transport use. Since public transport

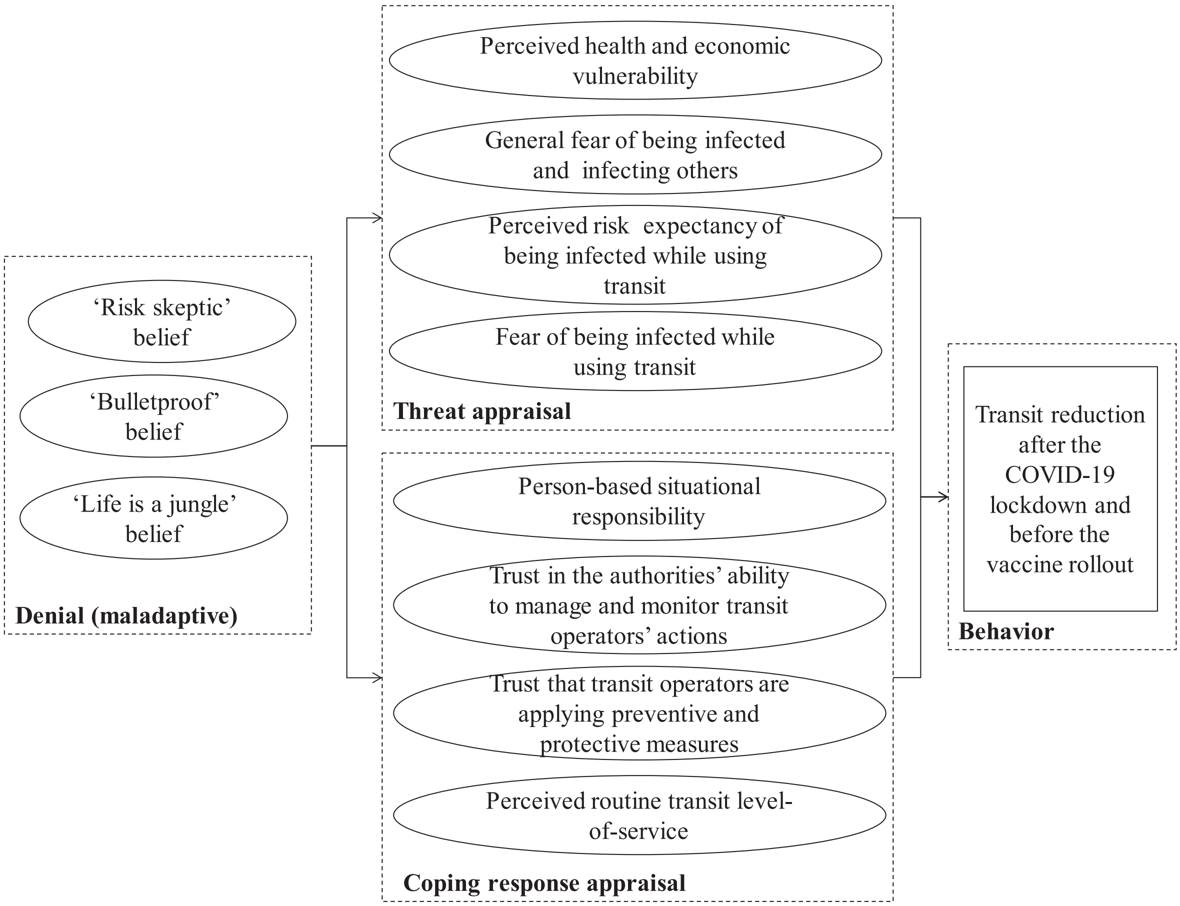

Fig. 1. Behavioral framework for transit use reduction after the COVID-19 lockdown and prior to the vaccine rollout.

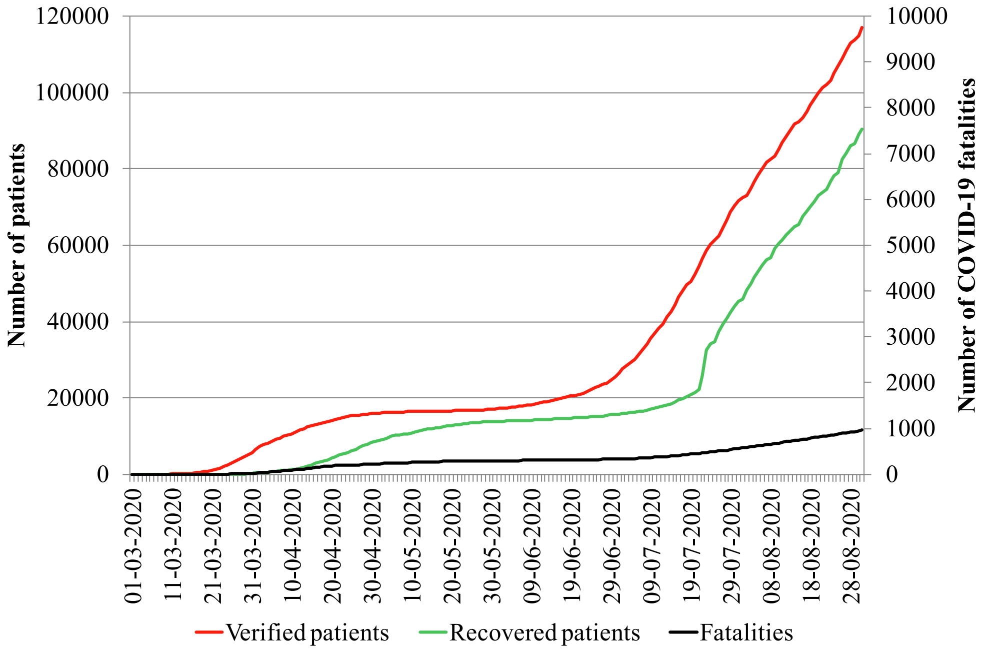

Fig. 2. Confirmed COVID-19 cases, recoveries, and fatalities in Israel, March–August 2020 (data source: Israel Ministry of Health).

and other activities were shut down during the first lockdown and reopened after the lockdown, general fear of exposure was conceptualized as the general fear of being infected or infecting others through close contact with a COVID-19 patient, independently of the conducted activities. **The risk expectancy in public transport** is the perceived likelihood of COVID-19 infection on public transport. Unlike the general fear of exposure, the risk expectancy is activity specific and only relates to the perceived risk of being infected on public transport. **Fear of being infected while traveling by public transport** is the specific fear associated with being infected while using public transport. Unlike the general fear, it is activity specific and only refers to transit use.

Coping appraisal includes personal responsibility, derived from taking protective and preventive actions at the individual level, and trust in organizational responsibility for community-wide actions. In the context of COVID-19, **personal responsibility** includes protective measures (i.e., wearing masks and gloves, hand washing and sanitizing) and preventive measures (maintaining social distance and avoiding crowded places). Notably, while both protective and preventive measures could be mandatory and defined by government or municipal regulations, compliance with these regulations is a matter of individual discretion. A study conducted on public transport in Mexico City during the influenza A (H1N1) outbreak shows no significant difference in compliance between mandatory and voluntary public health measures, and the highest mask wearing rates were 55% for men and 76% for women (Condon & Sinha, 2010). A series of related studies investigated compliance with the COVID-19 regulations in various countries, including the United Kingdom (Kooistra et al., 2020), the United States (van Rooij et al., 2020), the Netherlands (Kuiper et al., 2020), and Israel (de Bruijn et al., 2020). Although these studies only investigated compliance with social distancing and family visitation rules, rather than other protective and preventive measures, they show that compliance rates differed across countries. In the studied countries, the compliance rates were related to the capacity to comply with the rules, the normative obligation to obey the law, opportunities to break the rules, social norms, self-control, and general obedience of the law. The studies did not find that fear of punishment (deterrence) was significantly associated with compliance. Thus, compliance depended on people's intrinsic rather than extrinsic motivations. **Preventive measures** are a double-edged sword: they allow one to maintain a daily routine while taking precautionary steps, but they can also lead to self-isolation and a loss of daily routine and social activities. While threat appraisal and coping are independent processes in the original PMT formulation (Floyd et al., 2000; Rogers, 1975), in empirical models, coping appraisal (in particular coping self-efficacy) was found to be an antecedent reducing threat appraisal (McGinty et al., 2012; Rippetoe & Rogers, 1987). **Institutional trust**, namely, trust in the organizational responsibility for community-wide disaster management and preparedness, is an important aspect of regional resilience. Because trust is a key component of making decisions in uncertain conditions, higher trust in disaster management actions and information by civic agencies is associated with improved readiness to make decisions, public preparedness, and personal coping behavior (Paton et al., 2010), as well as civic participation in community-based disaster management programs (Peng et al., 2020). In the context of COVID-19, trust in government actions and information related to the pandemic was found to be positively correlated with personal protective behavior (Al-Rasheed, 2020). In this study, we focus on civic agencies that are responsible for implementing community-wide COVID-19 protective and preventive measures in the study region. The relevant civic agencies in the case study context are government agencies (i.e., the Ministry of Transport and the Ministry of Health) and transit operators. Thus, in this study, institutional trust is defined as trust in the preventive and protective measures implemented by the transit operators and trust in the ability of government authorities to manage, regulate, and monitor protective and preventive measures on public transport. In franchised transit systems, such as in the study region, transit planning is conducted by regional or national transit authorities and transit operators are bound by quality bids. Hence, there is a shared responsibility for planning and operations during both routine and emergency operation.

The research hypotheses deriving from the conceptual and theoretical framework are as follows:.

H1: Maladaptive denial strategies hamper threat appraisal.

H2: Personal vulnerability motivates the general fear of exposure to COVID-19.

H3: Personal vulnerability motivates the risk expectancy on public transport.

H4: The general fear of exposure to COVID-19 motivates general person-based preventive and protective coping strategies.

H5: Maladaptive denial strategies hinder coping appraisal.

H6: The risk expectancy on public transport motivates the fear of being infected while traveling by public transport.

H7: The fear of being infected while traveling by public transport motivates transit use reduction.

H8: General person-based protective measures (e.g., mask wearing and hand sanitizing) impede transit use reduction.

H9: General person-based preventive measures (i.e., avoidance) motivate transit use reduction.

H10: Organizational trust in government authorities and transit operators impedes transit use reduction.

H11: Satisfaction with the transit level of service during routine operation impedes transit use reduction.

2.2. Mathematical model

To validate the behavioral framework, we applied an ordinal Probit structural equation model with multiple indicators and multiple causes (SEM-MIMIC), similar to the approach taken by Allen et al. (2020) and Vallejo-Borda et al. (2020). The MIMIC model consists of two parts: the measurement model and the structural equation model.

The sample population consists of N individuals $n = 1,\ldots,N$. The measurement model relates the measured survey items to the hypothesized latent factors. Consider a questionnaire consisting of q items w_i, $i = 1,\ldots, q$, to be rated using a scale with m response categories. The response categories are successive integers $k = 0,1\ldots\ldots, k\text{-}1$. The ordinal measurement model assumes that a set of q latent response variables w^* underlies the q observed categorical responses w. An individual will choose response alternative k when his latent response value w_i^* is between the thresholds $\tau_{i,k}$ and $\tau_{i,k+1}$. The thresholds are assumed to vary between $\tau_{i,k}$ = -∞ and $\tau_{i,k+1} = \infty$ and are estimated in the model estimation process. For individual n, the latent response variables w^* are related to the observed categorical responses via the threshold relationship in equation (1):.

$$w_{ni} = k \quad if \quad \tau_{i,k} < w_i^* \leqslant \tau_{i,k+1} \tag{1}$$

The latent factors are linked to the latent response variables by means of a factor analytic model represented in equation (2):.

$$w_n^* = \Lambda z_n^* + \xi_n \tag{2}$$

where for each individual n, z^* is a p vector of factors, Λ is a $q \times p$ matrix of factor loadings to be estimated, and ξ is a vector of q measurement errors. Following Forero et al. (2009), four assumptions are generally accepted: (i) The factors pertaining to vector z^* and the ξ measurement errors are normally distributed; (ii) the mean of the factors and measurement errors is zero; (iii) the factors and measurement errors are uncorrelated; and (iv) the measurement errors are mutually uncorrelated, so that their covariance matrix is diagonal.

The structural equation model relates the latent constructs to socioeconomic variables, the extrinsic to the intrinsic latent constructs, and the latent constructs to the dependent variable. For individual n, the relationship between intrinsic latent variables, extrinsic latent variables, and socioeconomic characteristics is described in equation (3):.

$$z_{ns}^* = \gamma z_{nr}^* + \beta x_n + \varepsilon_n \tag{3}$$

where for individual n, z_{ns}^* is an intrinsic factor from a vector of t intrinsic factors in the model, and z_{nr}^* is a vector of r extrinsic factors from a set of u extrinsic factors, where $r \neq s$ and $p = t + u$. x_n is a vector of socioeconomic characteristics that describe individual n. The error term ε is assumed to be independent and normally distributed with a mean of 0 and a variance of 1. Since the factor scores are continuous variables, the relationship can be represented by a linear regression. The vectors γ and β are parameter vectors to be estimated.

Equation (4) describes the relationship between the dependent variable and explanatory variables, including the latent factors and the socioeconomic characteristics. The dependent variable is a binary variable; thus, the model is a binary Probit model. Probit models can be derived from an underlying latent variable model that satisfies the classical linear model assumptions. Let y^* be an unobserved (or latent) variable, determined as follows:.

$$y_n^* = \delta z_{ns}^* + \lambda x_n + \upsilon_n \quad y_n = 1[y_n^* > \alpha_0] \tag{4}$$

The function 1[•] is an indicator function, which takes on the value one if the event in brackets is true, and zero otherwise. Therefore, y is one if y^* is larger than a threshold parameter α_0 and zero otherwise. For individual n, y_n^* is the latent variable associated with the observed choice y_n (i.e., to reduce or to maintain transit use frequency), z^*_{ns} is the set of intrinsic (i.e., mediator and moderator) latent factors that explain the dependent variable, and x_n is a vector containing the socioeconomic characteristics that serve as control variables. In the Probit model, the error term υ is assumed to be independent and normally distributed with a mean of 0 and a variance of 1. The vectors δ and λ are parameter vectors to be estimated.

The response probability for the observed outcome y is provided in equation (5) as follows:.

$$P\left(y_n \middle| z_{ns}^*, x_n\right) = \Phi\left(\alpha_0 + \delta z_{ns}^* + \lambda x_n\right) \tag{5}$$

Similar to Allen et al. (2020) and Vallejo-Borda et al. (2020), the parameters were simultaneously estimated using diagonal weighted least squares with mean and variance adjustment (WLSMV), which is robust to skewness and kurtosis of items (e.g., Flora and Curran, 2004). Standardized parameters and robust standard errors were calculated using the open-code R-packages Lavaan version 0.6–6.1525 (Rosseel, 2012) and SemTools version 0.5–2.920 (Jorgensen et al., 2019).

3. Data collection

3.1. COVID-19 in the study region

The first case of COVID-19 in Israel was confirmed at the end of February and the government imposed a lockdown from March 12, which shut down the education system, prohibited culture, shopping, and leisure activities, implemented social distancing, and maintained 30% of the workforce. By March 25, a complete lockdown restricted movement to 100 m from home until the end of April.

Figure 2 shows the number of COVID-19 cases, deaths, and recoveries in Israel according to official data (Ministry of Health, 2021). In the middle of August, when we conducted our study, there were 1,000 cases and 7.45 deaths per 100,000 inhabitants. The fatality rates from the total number of verified cases were 0.08% for people in their forties, 0.3% for people in their fifties, 1.11% for people in their sixties, and 5.31% for people in their seventies (Broitman, 2020).

During the lockdown in April, 19% of the workforce worked from home, 27% were on unpaid leave, and 2% lost their employment. In August, 87% of the workforce worked in their workplace, 6% were on unpaid leave, and 12% reported unemployment (Central Bureau of Statistics, 2020). A national survey conducted in July 2020 reveals that 64.7% of the respondents were afraid of COVID-19 infection, 54.8% were worried about being unable to cover their expenses, and 28.2% expected their economic condition to worsen (Central Bureau of Statistics, 2020). In terms of institutional trust, 46.7% reported that they trust the government, and 68.6% positively evaluated the municipal authority in their residential location.

According to the Israeli Central Bureau of Statistics (2020), the rate of compliance with protective and preventive measures in Israel was high, with 82% maintaining social distancing, 92% wearing masks, and 91% washing hands and using disinfectant. An academic survey conducted in Israel found that the rate of compliance with maintaining a safe distance from others was much lower, at 47.7%, and compliance with the requirement to stay at home during the first lockdown was 60.3% (de Bruijn et al., 2020). During the period relevant to this study, between the beginning of March and the end of July 2020, 141,605 non-compliance fines were administered by the police, of which 58.8% were administered for not wearing masks and another 31.4% for being in public places in contravention of the regulations (Benita & Kain, 2020).

Regarding restrictions on public transport, during the first lockdown starting from March 2020, the Israel Public Transport Authority reduced scheduled train departures by 50%, closed low-demand train lines, shortened the operating hours, and stopped the weekend services. Towards the end of March, the Israel Public Transport Authority stopped all train services until June (Benita & Spector, 2020). At the beginning of March, the Israel Public Transport Authority instructed bus operators to reduce their capacity to the seated capacity, and to create a buffer between driver and passengers by keeping the first row of seats empty and accepting only electronic payment. From the end of March, the bus frequency was reduced to 2–3 arrivals per hour and the activity was reduced to 25% of the scheduled lines. Most of the direct inter-urban services were canceled and the urban service operated with low frequency and a reduced network. The bus operating hours were significantly shortened and weekend operation came to a halt (Benita & Spector, 2020). In terms of the demand for public transport, the reduction in the number of passengers during March 2020 was 44% compared to both January 2020 and March 2019. During the lockdown (including April 2020), there was an 88% reduction in passenger demand (Benita & Spector, 2020).

Upon returning to the new routine towards the end of June, the train services were restored with pre-registration required, a capacity restriction of 500 passengers per train, mandatory mask wearing, and restrictions on eating onboard (Ravid et al., 2020). In August, three months after the lockdown, while the service coverage had been restored, the maximum passenger capacity on buses remained at 50% during off-peak hours and 75% during peak hours, although there were no clear instructions regarding the authority of operators and drivers to enforce the restrictions. As a result, passengers complained of crowding and long waiting times (Zagrizak, 2020a). The instructions provided by the Ministry of Transport after the first lockdown stipulated mandatory mask wearing, passenger responsibility to board public transport with a healthy body temperature with enforcement only at main terminals, mandatory electronic payment instead of cash payment, and restrictions on eating during bus rides unless necessary for health reasons. The enforcement of mask wearing was defined as the responsibility of the police and the local authorities rather than the public transport operators (Ministry of Justice, 2020). While the Ministry of Transport instructed bus operators to drive without air conditioning and with open windows in July, this instruction was canceled one day after it was issued due to public criticism; the public raised the issues of health hazards due to high temperatures and inability to open the windows on the new buses operating in Israel (Barsky, 2020). Regarding public transport cleaning and disinfection, the Ministry of Transport advised bus operators to disinfect their buses daily in line with the recommendations of the Ministry of Health. However, passengers and drivers claimed that buses were not properly cleaned and disinfected, the disinfection process was not monitored by government authorities, and leading bus companies did not share detailed information regarding vehicle cleaning and disinfection (Zagrizak, 2020b; Zagrizak, 2020c). Hence, publicly available information regarding preventive and protective measures on public transport was vague.

During August, passenger demand was 36% of the normal demand for the railway system. The precautions taken were mandatory mask-wearing on public transport, restricting passenger seats, allowing only electronic payment, imposing geographical restrictions, and setting disinfection requirements for transit vehicles.

3.2. Survey design and administration

Based on PMT, we designed an online survey to elicit transit user motivation to reduce transit use post-lockdown. The survey included 40 questions eliciting socioeconomic characteristics, habitual travel habits before and after the first lockdown, risk and vulnerability assessment, and attitudes regarding situational awareness, denial mechanisms, perceived threat, and coping appraisal.

The questions about habitual travel habits included transit use frequency by transit mode (i.e., bus, train, taxi) and by travel purpose (i.e., work, education, leisure, shopping and errands) before COVID-19 and during the survey period after the first wave of COVID-19; payment type and the use of smart cards; and average transit trip travel time. The respondents were also asked about their frequency of use of other modes (i.e., private car, ride-sharing, bicycle, scooter) by mode and travel purpose before COVID-19 and during the survey period. The survey also asked whether respondents had purchased a new personal travel mode since the outbreak of COVID-19. Finally, the respondents rated their satisfaction with the level of service on public transport in terms of line coverage, frequency, travel time, reliability, crowding, and cleanliness.

The questions related to risk and vulnerability assessment included health and economic risk and vulnerability. The questions about health risk and vulnerability ascertained whether respondents were in a group at higher risk of COVID-19, had a household member in a group at higher risk of COVID-19, or were personal acquainted with hospitalized and non-hospitalized COVID-19 patients. The variables were elicited as observed measures since they are based on objective health conditions. In addition, the respondents were provided with an anchor for influenza risk on public transport, which is 5–20 cases per 100,000 (0.005–0.02%) inhabitants, according to a study from Britain (Goscé & Johansson, 2018), and were asked to estimate the risk of COVID-19 infection on public transport. The assessment scale provided ranged between 0.005% and 30%. This was in accordance with the findings of Goscé and Johansson (2018) and Zhu et al. (2012), who developed a micro-simulation model for the airborne transmission of influenza and found that the risk of infection could range between 0.05% and 27%, depending on the verified patient's location and the bus's micro-environment conditions. For comparison, the respondents were asked to assess the risk of being injured in a traffic accident while using a private mode of transport (i.e., car, bicycle/scooter, or motorbike) in Israel. The questions regarding economic risk were observed measures of working from home, income sources, the possibility of being fired in the event of needing to quarantine at home due to possible exposure to COVID-19, income loss during COVID-19, the perceived time frame for regaining the suffered income loss, and the perceived time frame for ending the economic crisis generated by COVID-19 in Israel.

The attitudinal questions focused on situational awareness, denial and self-exemption, fear of being infected on public transport, and coping appraisal. The attitudinal items were measured using a 5-point Likert scale. Table 1 details the attitudinal items of the questionnaire.

Elicited socioeconomic variables were age, gender, net household income, education, family status, children in the household by age group, driving license, and car availability. The observed socioeconomic variables were elicited as categorical variables. During the modeling stage, each of the observed variables was transformed to a set of binary variables before being included in the model.

Table 1
Awareness, denial, threat, and coping appraisal scale items.

Domain	Scale	Number of items	Content
Denial (self-exemption)	"Bulletproof" beliefs	5 items	Self-immunity due to good health condition, healthy life habits, influenza vaccines, and short exposure times
	"Skeptic" beliefs	4 items	Risk probability underestimation, lack of scientific evidence, short exposure times, disbelief regarding potential harmful consequences
	"Life's a jungle" beliefs	4 items	Everything is dangerous, no more risky than other activities, people do risky things
Threat appraisal	General fear of exposure	8 items	Being infected with and without symptoms, being hospitalized, staying in isolation, infecting family, friends, colleagues, and other people
	Fear of being infected while using transit	2 items	Fear of being infected while traveling or waiting for public transport
Coping appraisal	Personal responsibility	11 items	Wearing masks or gloves, hand washing for 30 s, using hand sanitizers and disinfectants, maintaining distance, avoiding crowded places, touch, supermarkets, shops, and indoor leisure activities
	Trust in the government authorities' ability to manage and monitor COVID-19 on public transport	5 items	Trust concerning health regulation enforcement, monitoring preventive and protective measures by transit operators, collecting information regarding COVID-19 infection rates on public transport, monitoring vehicle cleaning and disinfection, asking for regular progress reports from transit operators on COVID-19 related actions
	Trust in the operators	5 items	Trust concerning vehicle disinfection, mask-wearing enforcement, caring that passengers will avoid risk, health monitoring of drivers and other employees
	Level of service	6 items	Perceived satisfaction with service frequency, travel time, line reliability, crowding, cleaning, and maintenance

We administered the survey in August 2020, three months after the end of the first lockdown, to allow time for commercial and work activities to recover. The survey took place four months before the administration of the vaccine in Israel. Although a second lockdown began near the end of September 2020 and a third lockdown began in January 2021, these lockdowns were not foreseen in August 2020. We administered through 'Panel4all,' one of the leading survey companies in Israel, which has an online panel community of tens of thousands of participants across all population strata. The sample is geographically representative and gender balanced. Adults aged 21–67 (working age) split into three age groups (21–36, 37–52, 53–67) were chosen to represent the COVID-19 risk group. The survey targeted transit users, regardless of their transit use frequency, to include both captive and non-captive users, frequent and occasional users, as well as multi-modal passengers.

4. Descriptive statistics

4.1. Sample socioeconomic characteristics

The online survey yielded 856 complete and valid responses from transit passengers. We compared the respondents' characteristics to a publicly available onboard survey conducted by a non-governmental organization in 2014 (Transport Today and Tomorrow, 2014). Table 2 presents the sample socioeconomic characteristics compared to the on-board survey when available (in parenthesis). Both surveys were randomly drawn from a representative geographical distribution, albeit with different methods. The surveys also differ in terms of the target population. The current survey included the working population (21–67 year olds), while the 2014 onboard survey included high-school students and people at the retirement age. Regarding the gender distribution on public transport, according to the Central Bureau of Statistics, 51% of the men and 61% of the women in Israel used buses in 2015, and equal shares of men and women used rail transport (Central Bureau of Statistics, 2016). Because gender balance was a sampling criterion in our survey, our sample represents the gender distribution in the general population, similarly to the results of the Central Bureau of Statistics, and substantially differs from the 2014 onboard survey. The samples are reasonably similar in terms of car ownership, employment status, family types, and income level. The difference in high-school education and the number of people receiving allowance could be explained by the age range difference, since the 2014 survey include also high-school students and pensioners.

4.2. Sample COVID-19 risk appraisal

Table 3 details the perceived health and economic risks resulting from the COVID-19 pandemic and the time needed for crisis recovery. 30% of the respondents perceive themselves as being in a health risk group for COVID-19, and 26.62% perceive a family member to be at high health risk. 56.4% of the respondents are acquainted with COVID-19 patients. 21.5% have an infected family member, and 15.4% know hospitalized COVID-19 patients; hence, the health risk is substantially prevalent. 67.7% of the respondents reported some income loss and 21.4% reported a substantial income loss. 30.8% of the respondents believed there was a moderate to high risk of losing their job, with only 38.1% perceiving no such risk. Only 12.7% stated the ability to work from home, and 22.9% stated that they are unemployed because of the crisis. Most respondents work either partially from home or at shared workspaces. Most respondents (66.6%) think that the crisis will last at least one year, and two-thirds of the respondents believe that it will last more than 18 months.

Fig. 3 presents the perceived risk of being infected on public transport. At the time of the survey, statistics were published in the national media and popular newspapers regarding the number of confirmed cases and deaths per 100,000 inhabitants. As detailed in section 3.2, the survey elicited the perceived COVID-19 infection risk per 100,000 travelers. Notably, 80% of the respondents

Table 2
Sample socioeconomic characteristics.

Variable	Categories (%)				
Gender	Male	Female	No answer		
	49.8 (36.0)	50.0 (64.0)	0.2		
Age	21–30	31–40	41–50	51–60	60–65
	19.6	26.9	19.6	21.1	12.7
Family status	Single no children	Couple no children	Parents with children		
	20.7 (8.0)	13.2 (22.0)	66.1 (70.0)		
Education	High school	Tertiary education	University degree		
	22.3 (41.0)	22.8 (19.0)	55.0 (29.0)		
Income level	Lower than average	Average	Higher than average		
	45.5 (44.1)	29.6 (43.0)	25.0 (14.0)		
Income source	Employee	Independent	Allowance	Property	
	83.9 (74.6)	11.9 (4.8)	0.1 (20.6)	4.1	
Household car ownership	None	1 + car			
	26.2 (26.0)	73.8 (74.0)			
Smart card use	No smart card	Monthly zone card (discount)	Per-travel value card (discount)	Monthly zone card (adult)	Per-travel value card (adult)
	9.70	6.43	10.63	25.23	48.01

Note: The numbers in parentheses are the passenger characteristics from the 2014 onboard survey.

Table 3
Perceived health and economic risk and recovery time.

Variable	Categories (%)				
Perception of being in a risk group for COVID-19	No	Yes			
	69.28	30.72			
A family member in a risk group	Very low	Low	Moderate	High	Very high
	20.91	15.65	36.80	16.12	10.51
Knows COVID-19 patients	None	Family	Friends	Colleagues	Neighbors
	43.6	21.5	24.8	20.2	8.6
Knows hospitalized COVID-19 patients	None	Non-hospitalized	Hospitalized		
	43.6	15.4	41.0		
Income loss	None	Low	Moderate	High	Total loss
	32.24	26.05	20.33	17.52	3.86
Perceived job loss likelihood following COVID-19	No risk	Low risk	Medium risk	High risk	Very high risk
	38.08	31.07	17.29	8.18	5.37
Belief in the ability to recover income	Until December 2021	Until December 2022	No recovery		
	57.1	23.0	19.9		
Time until the end of the COVID-19 crisis (starting August 2020)	Three months	4–6 months	7–12 months	12–18 months	More than 18 months
	2.22	9.58	21.61	25.93	40.65
Ability to work from home following the lockdown release	Work only at home	Work at home partially	Work at a shared working space	Work at the workplace	Currently do not work
	12.73	21.14	42.52	0.70	22.90

estimated the COVID-19 infection risk as higher than the provided anchor point for the influenza infection risk on public transport. 27.3% considered the risk of infection on public transport to be higher than 5%, which is the influenza infection rate on public transport found by Cooley et al. (2011). The distribution of responses almost evenly across the whole scale indicates a general lack of knowledge about the actual infection risk. While the perceived infection risk seems high, Cho et al. (2020) documented that in South Korea, more than 40% of the respondents perceived the risk of infection while using public transport to be higher than 50%.

4.3. Taking preventive and protective measures

Fig. 4 presents the rate of compliance with protective and preventive measures. About 60% always comply with proper mask wearing (covering the mouth and nose). Another 20% usually comply with proper mask wearing outdoors in their residential neighborhood, which is a bit lower than the official statistics (Central Bureau of Statistics, 2020). Only 55% replace or wash their masks daily. 67% use alcohol-based hand sanitizers, which is a bit lower than the official statistics (Central Bureau of Statistics, 2020), but only 17% wash their hands in line with the regulations. The results regarding maintaining a safe distance from others and avoiding crowding are much lower than the official statistics: Only 18% maintain the required two-meter distance and only 26% avoid

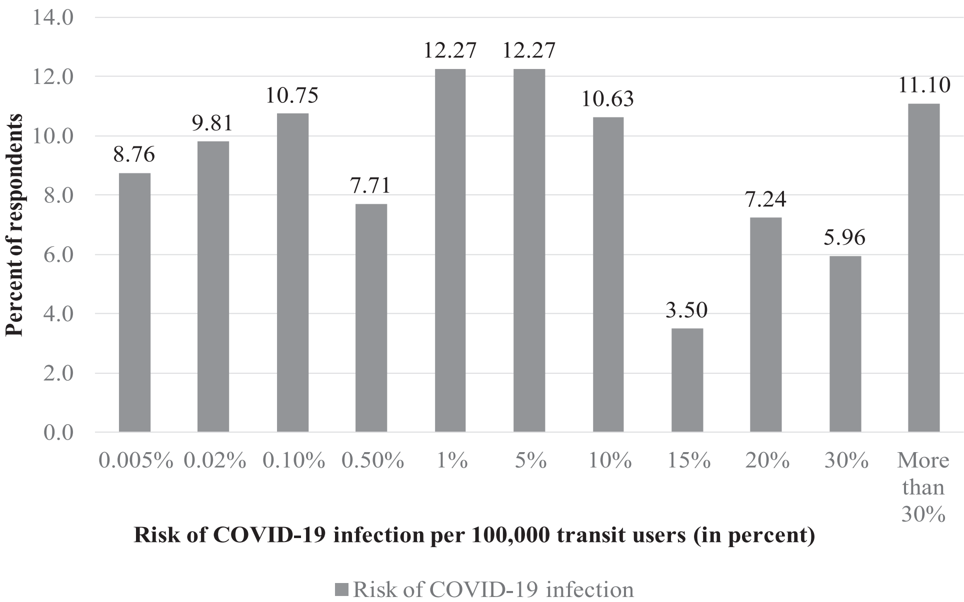

Fig. 3. Perceived risk of transit users being infected with COVID-19.

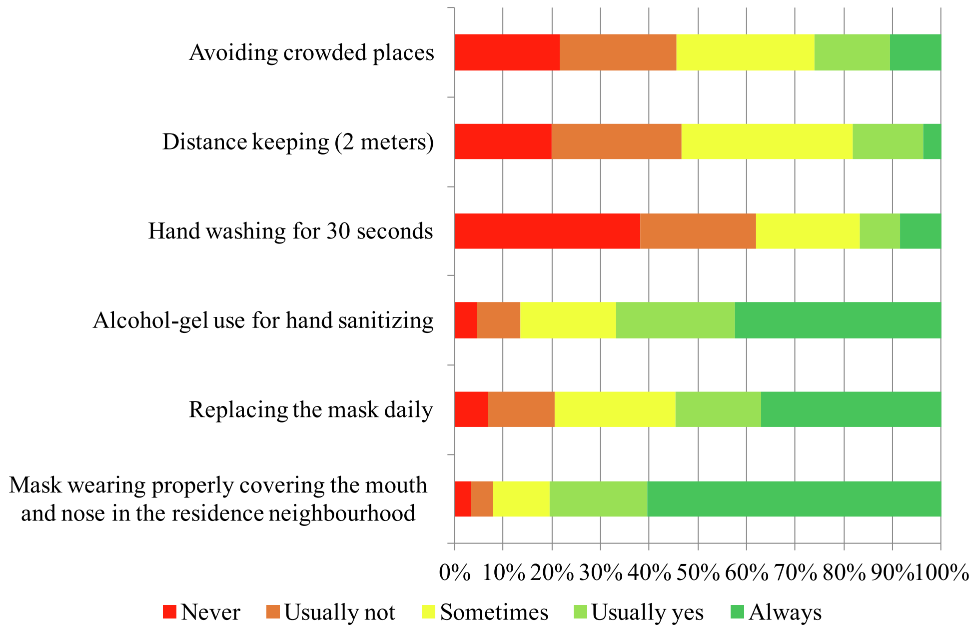

Fig. 4. Frequency of protective and preventive measures.

crowding.

4.4. Sample transit use before and after the lockdown

Fig. 5 and Fig. 6 show the transit use frequency by transit mode and trip purpose before COVID-19 and in August after the second wave of COVID-19. The bus was the respondents' primary transit mode, in agreement with the general modal share. In 2017, there were 184 million bus passenger trips, compared to 15.8 million train passenger trips. Shared-ride services are in their nascent stage. Before COVID-19, 57.71% of the bus riders were frequent, while 35.86% were occasional riders. These proportions match the 2014 passenger survey in which the proportions of frequent and occasional riders were 63% and 37%, respectively (Transport Today and

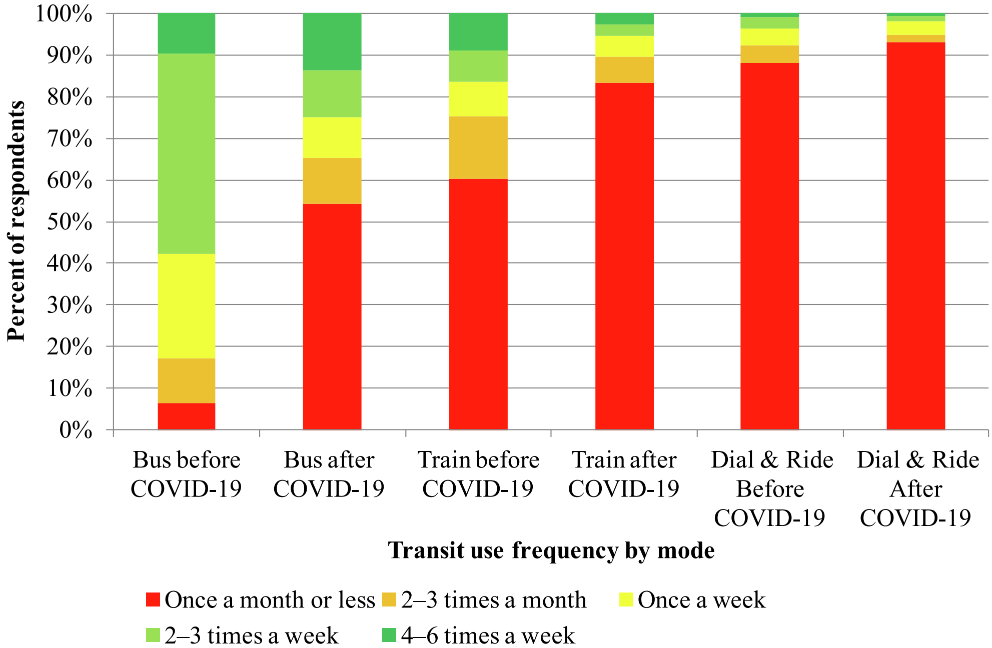

Fig. 5. Transit use frequency by mode pre- and post-lockdown.

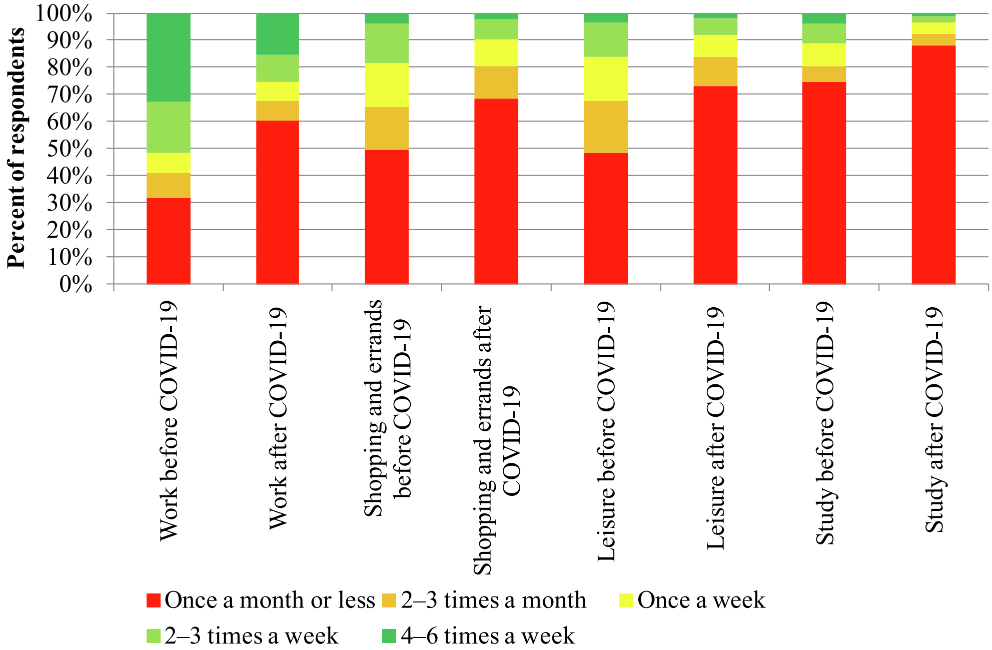

Fig. 6. Transit use frequency by purpose pre- and post-lockdown.

Tomorrow, 2014).

Post-lockdown, frequent bus trips dropped by **56**%. The results match a recent survey conducted in several regions showing that 43–57% of respondents reduced their transit use (Yosef, 2020). The proportion of people who travel by bus once a month or less rose to 54.32% compared to 6.43% pre-COVID-19. The proportion of people who take the train at least once a week dropped from 24.4% to 10.51%. The number of people who rarely use the train increased from 60.16% to 83.29%. The number of passengers using dial-and-ride services did not change significantly.

Before COVID-19, the proportion of mandatory trips for work (51.64%) and education (19.62%) in our survey are comparable to the 2014 survey in which 46.5% were trips to work, and 18.3% were for education. Frequent shopping and errand trips are also comparable: 30.85% in the current sample and 32.4% in the 2014 survey (Transport Today and Tomorrow, 2014). Mandatory frequent

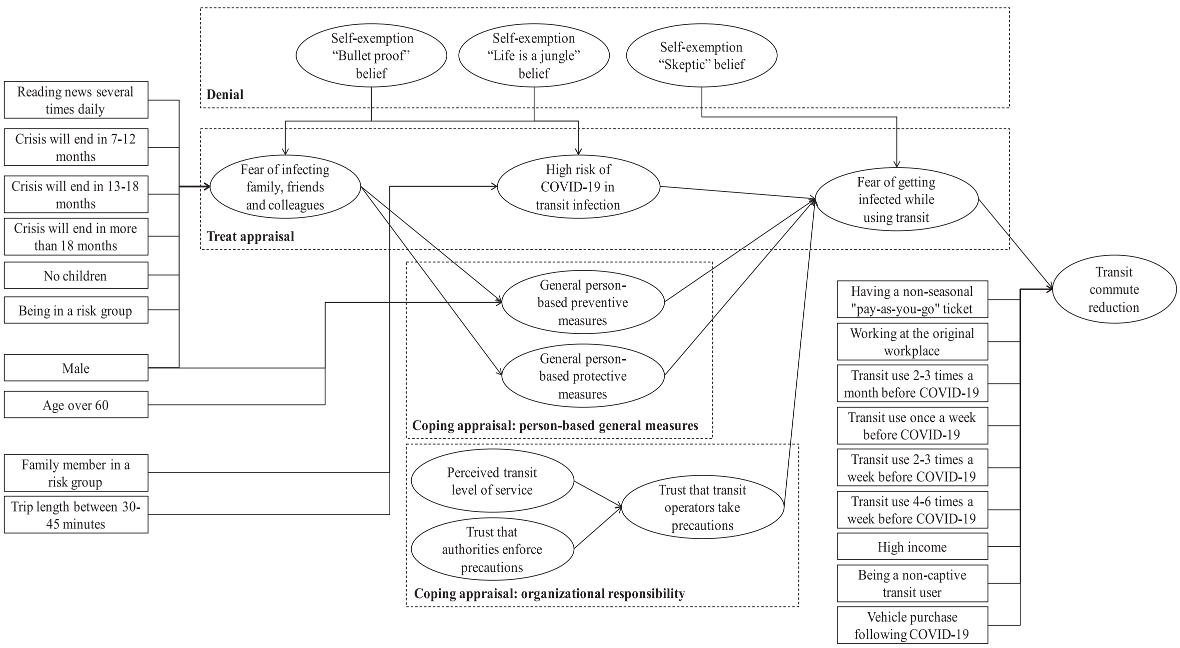

Fig. 7. Empirical structural relationships identified in the model.

trips to work dropped by 50%. The number of transit riders who conducted shopping and errand trips at least once a week dropped by 43%. The number of transit riders who took leisure trips dropped by 50%. Since the education system was closed at the time of the survey, trips for education came to a halt.

In this study, we focused on the reduction in the frequency of transit trips to work. The respondents were asked about their commuting trips before and after the first COVID-19 lockdown. The reduction in transit use was defined as a binary variable with a value of 1 when the transit use frequency after the lockdown was lower than before the lockdown and zero otherwise. 59.9% reduced their overall transit use frequency, and 43.3% reduced their transit frequency for commuting purposes.

Table 4
Measurement equations.

Item	Std. Est	Z	P-Value
Denial			
Self-exemption: “Skeptics” beliefs			
The odds of being infected with COVID-19 by a verified patient on public transport are negligible	0.805	47.4	0.000
There is no scientific evidence that COVID-19 infections on public transport are more common than in other places	0.776	49.4	0.000
The exposure time to other people on public transport is relatively short, so the likelihood of infection is low	0.844	65.7	0.000
Claims regarding the possibility of being infected on public transport are exaggerated	0.917	83.6	0.000
Self-exemption: “Bulletproof” beliefs			
I am healthy, so it is reasonable to assume that nothing will happen to me	0.842	49.0	0.000
I lead a healthy lifestyle that can help me overcome a possible COVID-19 infection	0.730	37.3	0.000
I already receive influenza and pneumonia vaccines, so nothing will happen to me	0.557	19.1	0.000
I can make sure my exposure times are short, so nothing will happen to me	0.760	33.5	0.000
Self-exemption: “Life is a jungle” beliefs			
Transit use is no more dangerous than other things people do during COVID-19	0.850	38.9	0.000
In the modern era, almost anything is a risk factor; this is life	0.807	43.8	0.000
Many things are harmful, and yet people do them	0.747	36.9	0.000
Threat appraisal			
General fear of infection			
I am afraid that I will become a symptomatic COVID-19 patient	0.900	56.6	0.000
I am afraid that I will become a hospitalized COVID-19 patient	0.856	55.3	0.000
I am afraid that if I am in close contact with a COVID-19 patient I could infect my friends	0.848	49.1	0.000
I am afraid that if I am in close contact with a COVID-19 patient I could infect my colleagues	0.890	58.0	0.000
that if I am in close contact with a COVID-19 patient I could infect other people	0.768	40.7	0.000
Fear of being infected on public transport			
I am afraid that I might be infected with COVID-19 during my travel time	0.980	12.5	0.000
I am afraid that I might be infected with COVID-19 during my waiting time	0.781	13.9	0.000
Coping appraisal			
Situational responsibility: protective measures			
Wearing a mask covering the mouth and nose while going out in your neighborhood	0.630	16.5	0.000
Wearing a mask covering the mouth and nose at the beach and at public pools	0.440	11.9	0.000
Replacing or washing the mask daily	0.641	18.5	0.000
Using alcohol-gel sanitizer after touching any surface	0.730	20.5	0.000
Situational responsibility: preventive measures			
Avoiding crowded places	0.787	34.9	0.000
Avoiding going to shops	0.642	24.9	0.000
Avoiding indoor leisure activities	0.827	37.0	0.000
Avoiding hand and elbow shakes	0.741	29.2	0.000
Maintaining a two-meter distance from other people on the street and while standing in line, for example at coffee shops	0.684	25.4	0.000
Trust in the authorities’ ability to manage & monitor transit operators’ actions related to COVID-19			
I trust the government authorities to enforce the health regulations on public transport	0.888	101.9	0.000
I trust the government authorities to enforce vehicle sanitizing and disinfection in public transport	0.887	107.8	0.000
I trust the government authorities to update the information regarding COVID-19 infections on public transport in other countries	0.859	87.7	0.000
I trust the government authorities to shut down public transport in the event of high COVID-19 infection rates	0.773	56.7	0.000
I trust the government authorities to demand regular reports from the transit operators detailing actions taken to prevent the spread of COVID-19	0.829	74.2	0.000
Trust that transit operators are applying preventive & protective measures against COVID-19			
I trust that transit operators disinfect their vehicles as needed	0.805	30.0	0.000
I trust that transit operators do their best to help passengers avoid unnecessary risk	0.868	31.9	0.000
I trust the transit operators to monitor the health of drivers and other employees wearing masks	0.761	31.5	0.000
I trust the transit operators monitor the health of drivers and other employees wearing masks	0.831	32.8	0.000
I trust the transit operators ensure that all passengers wear masks	0.773	29.9	0.000
Organizational trust: transit level-of-service satisfaction			
Geographical distribution of lines and stops	0.795	52.8	0.000
Line frequency	0.852	69.9	0.000
Travel time	0.771	52.6	0.000
Line reliability	0.840	65.4	0.000
Passenger crowding	0.708	36.7	0.000
Maintenance and cleanliness	0.649	28.8	0.000

The provided estimates of the latent and observed variables are standardized.

5. Model estimation results

We conducted exploratory factor analysis (EFA) before the model estimation. We tested for reliability (Cronbach's alpha = 0.871), sampling adequacy (KMO = 0.856), correlation structure (values between 0.3 and 0.7) and multicollinearity (Bartlett's sphericity p-value = 0.000). Principal axis factoring with subsequent orthogonal rotation (varimax rotation with Kaiser normalization) led to eleven factors. We applied a CFA to determine the factorial validity of our instruments. We estimated CFA parameters using WLSMV with R-packages 'Lavaan' and 'SemTools.' The CFA demonstrated a good fit for the pre-specified measurement structure following the literature's recommended values: ($\chi2$ [784] = 2480.0, P < 0.000, CFI = 0.953, TLI = 0.947, RMSEA = 0.053, SRMR = 0.051). We calculated coefficient alpha, the average variance extracted (AVE), and composite reliability, all were sufficiently high.

Figure 7 presents the structural relationships that were identified in the estimation process. Table 4 presents the measurement

Table 5
Structural equations.

Description	Std. Est.	Z	P-value
Threat appraisal			
General fear of being infected and infecting others			
Self-exemption "Bulletproof" belief	−0.236	−6.2	0.000
Being in a risk group for COVID-19	0.117	3.1	0.002
The belief that COVID-19 will end in<7 months (reference)	–	–	–
The belief that COVID-19 will end in 7–12 months	0.128	2.4	0.018
The belief that COVID-19 will end in 12–18 months	0.189	3.5	0.001
The belief that COVID-19 will end in more than 18 months	0.215	3.7	0.000
No children (having children is the reference)	−0.083	−2.3	0.020
Male (female is the reference)	−0.227	−6.4	0.000
Reading COVID-19 news updates several times a day	0.142	4.0	0.000
Risk expectancy on public transport			
Self-exemption "Bulletproof" belief	−0.143	−2.5	0.013
Self-exemption "Life is a jungle" belief	−0.215	−3.7	0.000
Family members are at high risk of COVID-19 infection	0.112	2.4	0.016
Trip length<30 min or more than 45 min (reference)	–	–	–
Trip length of 30–45 min	0.132	2.9	0.004
Threshold	0.754	3.6	0.000
Coping appraisal			
General person-based protective measures			
General fear of being infected and infecting others	0.621	13.2	0.000
Being in a risk group for COVID-19	0.053	1.5	0.146
Family members are at high risk of COVID-19 infection	0.184	4.3	0.000
Reading COVID-19 news updates several times a day	0.105	3.0	0.003
General person-based preventive measures (avoidance)			
General fear of being infected and infecting others	0.466	12.3	0.000
Male (female is the reference)	−0.079	−2.3	0.024
Age over 60 years (age under 60 years is the reference)	0.065	1.6	0.116
Trust that transit operators are applying preventive & protective measures against COVID-19			
Satisfaction with transit level of service	0.126	5.4	0.000
Trust in the authorities' ability to manage and monitor transit operators' actions related to COVID-19	0.788	20.6	0.000
Specific fear of being infected while using transit			
Self-exemption "Skeptic" belief	−0.362	−8.9	0.000
Risk expectancy on public transport	0.121	2.9	0.004
General person-based preventive measures (avoidance)	0.280	6.7	0.000
General person-based protective measures	0.595	8.5	0.000
Trust in transit operators' ability to cope with COVID-19	0.102	3.0	0.002
Dependent variable			
Reduction in transit use to work post-lockdown			
Specific fear of being infected while using transit	0.161	3.3	0.001
Having a seasonal public transport ticket (reference)	–	–	–
Having a non-seasonal "pay-as-you-go" ticket	0.122	2.9	0.004
Working at home, at shared spaces, and not working (reference)	–	–	–
Working at the original workplace after the lockdown	−0.231	−5.7	0.000
Purchasing an individual travel mode after the outbreak of COVID-19	0.063	1.5	0.124
Transit use once a month or less before the pandemic (reference)	–	–	–
Transit use 2–3 times a months or more before COVID-19	0.100	2.2	0.030
Transit use once a week or more before COVID-19	0.159	3.9	0.000
Transit use 2–3 times a week or more before COVID-19	0.340	7.4	0.000
Transit use 4–6 times a week or more before COVID-19	0.408	7.9	0.000
Low and moderate income (reference)	–	–	–
High income	0.100	2.3	0.022
Captive transit user (reference)	–	–	–
Being a non-captive transit user	0.154	3.6	0.000
Threshold	1.086	5.8	0.000

equations. The thresholds associated with the items of the measurement equations are reported in Appendix A. Table 5 presents the model's structural equations that yielded the best fit to the data. Only the scale items with the highest loadings entered the model estimation. The provided estimates of the latent and observed variables are standardized. The MIMIC model presented very good goodness-of-fit (($CFI = 0.929 > 0.90$, $RMSEA = 0.044 < 0.05$, $SRMR = 0.079 < 1$, WRMR [Weighted Root Mean square error] $= 1.997 < 2$). The next sections present the model results by theme.

5.1. General threat appraisal

The results support hypotheses **H1–H3**. The general fear of being infected and infecting others increases with perceived health vulnerability (i.e., being in a group at higher risk of COVID-19), increased awareness reflected in reading the news several times a day, and the perception that the crisis will last longer. Fear decreases with the denial "Bulletproof" belief of self-immunity and is lower for men and people who do not have children. The perceived risk expectancy on public transport increases with the perceived health vulnerability of family members (i.e., a family member being in a group at higher risk of COVID-19) and with a trip length between 30 and 45 min, in comparison with both shorter and longer trips. The perceived risk expectancy on public transport decreases with the denial "Bulletproof" and "Life is a jungle" beliefs.

5.2. General person-based coping measures and trust in organizational coping actions

The results confirm **H4** and partially support **H5**. General person-based protective measures (e.g., mask wearing, hand sanitizing and washing) increase with the perception that family members are at high risk of COVID-19 infection, with increased awareness reflected in reading the news several times a day, and with increased general fear of being infected and infecting others. General person-based preventive measures (e.g., avoidance) increase with increased general fear of being infected and infecting others, are more common in people over 60 years of age, and are less common in men than in women. Notably, denial maladaptive beliefs do not directly affect personal coping behavior when fear is considered a motivator of general person-based preventive and protective measures. However, maladaptive beliefs indirectly hamper personal coping behavior by reducing the general fear of infection.

Trust that transit operators are applying preventive and protective measures is positively related to trust in the authorities' ability to manage and monitor transit operators' actions and to satisfaction with the transit level of service during routine operations before COVID-19.

5.3. The specific fear of being infected while using public transport

The results confirm **H6**. The fear of being infected while using public transport increases with the perceived risk expectancy on public transport and with both protective and preventive behaviors. Namely, general person-based preventive and protective measures serve as mediators between the general fear of being infected and infecting others and the specific fear of being infected while using transit. The result that general fear triggers avoidance and avoidance triggers the specific fear of being infected while using transit is in line with the vicious circle of fear and avoidance documented in the crime literature (Liska et al., 1988) and in the health literature (Pfingsten et al., 2020), which show that fear triggers avoidance and the latter induces greater fear. The result that general fear triggers protective behavior and protective behavior triggers the specific fear of being infected while using transit is in line with the results of Sadiković et al. (2020), who regressed worry and fear on protective behavior during COVID-19 and found that protective behavior was positively associated with increased fear and worry. The result is also compatible with the results of Zheng et al. (2021a), who found that protection motivation during COVID-19 increases touristic travel avoidance.

The fear of being infected while using public transport decreases with denial "Skeptic" beliefs regarding the potential harm of COVID-19. The fear of being infected while using public transport is also moderated by trust that transit operators take active measures to cope with COVID-19. This result is in line with the finding of Jørgensen et al. (2021) that worry related to COVID-19 is moderated by institutional trust, and the finding of Zheng et al. (2021b) that trust in the government reduces fear in the context of touristic travel during COVID-19.

5.4. Transit use reduction after the first lockdown

The results confirm **H7** and partially support **H9–*H*11.** The empirical results do not support hypothesis **H8.** Transit use reduction is positively affected by the fear of being infected while traveling by public transport. H9–*H*11 are confirmed, but the relationship between the dependent variable (i.e., transit use reduction) and the explanatory variables (i.e., general person-based preventive measures, organizational trust, and level of service) is indirect and mediated by the fear of infection while using transit. As detailed in section 5.2, satisfaction with the level of service and trust in the ability of government authorities to manage and monitor transit operators' actions directly affect trust in the ability of transit operators to apply protective and preventive measures. In line with the research hypotheses, the fear of infection while using transit increases with general person-based preventive measures (i.e., avoidance) and decreases with trust in the transit operators. H8 is rejected and the opposite relationship is established. General person-based protective measures neither mitigate the fear of infection on public transport nor encourage transit use. Instead, much like preventive measures, protective measures are positively associated with a greater fear of infection while using transit and with a greater reduction in transit use. While the rejection of H8 seems contrary to intuitive thinking, it is in line with the literature as detailed in section 5.3.

Socioeconomic variables and transit use frequency before the pandemic serve as control variables and affect transit use reduction after the lockdown. Returning to the workplace after the lockdown is associated with a lower reduction in transit trips to work. The survey elicited five working patterns after the lockdown: working from home full-time (12.7%), working from home part-time (21.1%), returning to work at the workplace (1%), working at a shared working space (42.5%), and currently not working (22.9%). Compared with flexible working patterns, working from home, and being unemployed, returning to the workplace after the lockdown is significantly associated with a lower reduction in transit trips to work. Compared to women, men perceive lower risk expectancy of COVID-19 infection on public transport. Having children in the household is associated with increased awareness. People who read daily news updates about the health and economic effects of COVID-19 have higher awareness. Beliefs regarding a longer crisis duration also contribute to increased awareness of its consequences. Having a higher income and being a non-captive transit user are associated with a greater reduction in transit trips to work. Nevertheless, purchasing an individual travel mode such as an e-scooter or a car as a result of COVID-19 is not significantly associated with transit use reduction. Having a pay-as-you-go smartcard is associated with a greater reduction in public transport use for work than pre-paid seasonal tickets. The model shows that travelers who used transit with a higher frequency before the pandemic are more likely to reduce their transit frequency to work during the pandemic. This result is reasonable considering that frequent transit users are at greater risk of exposure to COVID-19 and have more possibilities to reduce their transit use than those who use public transport with a low frequency of once a month or less both before and after COVID-19.

6. Discussion

The study sheds light on the psychological mechanisms underlying transit use reduction for commuting during the COVID-19 pandemic.

First, the study shows that transit use reduction is motivated by high infection risk perceptions. Almost one fifth of the survey population (17%) think that the risk of infection is higher than 30%. This result is not unique to our case study. For example, in a study in South Korea, about 70% of the respondents thought the risk was higher than 50% (Cho et al., 2020) and in Mexico City, 27% perceived the risk of infection while using transit as high (Tan & Ma, 2020). A comparison of the results of the current study with epidemiological evidence shows a clear gap between public knowledge about infection rates and epidemiological evidence. Studies are just beginning to assess the spread of COVID-19 on public transport using mathematical models of contagion rates and need to be validated with field data to test the efficiency of prevention measures (Chatterjee et al., 2016; Mo et al., 2020; Yang et al., 2012). Evidence regarding the spread of other respiratory diseases on public transport is scarce. Based on London and New York data, the estimated influenza contagion risk ranges between 0.02% (Goscé & Johansson, 2018) and 5% (Cooley et al., 2011). Using a micro-simulation model for airborne transmission of influenza Zhu et al. (2012) found that the risk of infection could range between 0.05% and 27% depending on the verified patient's location and the bus's micro-environment conditions.

Second, three denial beliefs were found relevant (personal immunity, skepticism, and ubiquity of risks) in hampering threat appraisal, indirectly decreasing healthy coping mechanisms and increasing transit use. While maladaptive coping forms part of the original PMT, the nature of maladaptive coping has not been clearly defined in the PMT model. our results show that personal immunity influences both general fear of infection and risk expectancy, ubiquity of risks influences risk expectancy, and skepticism is related to reduced fear in the specific contextual circumstances (i.e. the fear of being infected while using public transport). Moreover, we also reveal the prevalence of each denial mechanism. In the case of Israel, skepticism regarding the health consequences of the pandemic spreading through public transport was rare, beliefs regarding the ubiquity of risks were held by 45–60% of the survey population and personal immunity beliefs were held by 30% of the survey population. Thus, while the respondents did not underestimate the possible consequences of the pandemic, they believed that they should either simply live with the risks, and that they can control the infection by maintaining a healthy lifestyle.

Our results show seemingly counterintuitive correlation between exercising self-protective measures, increased threat appraisal, and transit avoidance behavior. Notably, multicollinearity between preventive and protective measures was not detected in this study and the results remained stable across various model specifications. Thus, the intuitive assumption that taking precautions would mitigate threat appraisal and encourage continued daily routines is not supported by this study's results. While this is seemingly counterintuitive, other studies show the same correlation. Sadiković et al. (2020) found that protective behavior during COVID-19 contributes to increased fear and worry. Zheng et al. (2021a) found that protection motivation during COVID-19 increases touristic travel avoidance. The results are in line with the security–fear of crime paradox, which shows that home security systems and environmental design elements can decrease or increase the fear of crime (Barberet & Fisher, 2009). The results may imply that people who already take general protective measures do not want to jeopardize their efforts by using transit, or that uncertainty regarding the efficacy of protective measures could trigger avoidance behavior. The proposed explanation and the geographical transferability of the results are beyond the scope of the current study and are recommended topics for future studies.

Our results show the mitigating effect of passengers' institutional trust in returning to the 'new normal.' In the study region, the public transport system is a franchised and subsidized system with quality bids, where transit planning is conducted by public entities, and the Ministry of Transport has a substantial role in system planning, regulating, and monitoring. During the COVID-19 outbreak, the Ministry of Transport took a central role in leading community-wide actions on public transport. In these conditions, trust in the ability of government authorities to update, regulate, manage, and monitor the actions of transit operators motivates trust in the ability of transit operators to implement preventive and protective measures.

Last, our results also show that perceived general level-of-service satisfaction is an antecedent of trust in transit operators. Thus, under conditions of uncertainty the perceived coping appraisal of transit operators during emergencies depends on their perceived routine operational performance. In Israel, while information regarding proper passenger behavior was available, information regarding preventive and protective strategies implemented by the transit operators was partial. Under conditions of uncertainty, the survey respondents possibly used level-of-service indicators as anchors to evaluate the transit operators' ability to handle crisis situations.

7. Limitations

While the study adds important insights regarding the psychological motivators for transit use reduction during COVID-19, it is not without limitations. First, the survey only included transit users that were still using transit at the time of the survey after the first lockdown. A limitation is that different risk assessments between users and non-users cannot be obtained. Moreover, the survey did not capture transit users who used public transport before COVID-19 but ceased to use it following the lockdown. Since this study concerns transit use reduction, non-users were not the target population. Nevertheless, the risk perceptions of non-users and users who ceased using transit following COVID-19 are important to consider to increase the resilience and preparedness of public transport for emergency situations and future pandemics. Second, the high percentage of people in the sample who perceived themselves as being in a risk group indicates that the question may capture subjective perceptions rather than objective measures. Future studies should explicitly ask about underlying conditions for increased COVID-19 risk. Third, the questionnaire only elicited the change in transit use pre- and post-lockdown and did not consider the change activities besides working at home. Future studies should explore whether transit use reduction is linked to activity reduction and whether driving replaces transit use. Fifth, this study did not explore the effect of passenger loyalty on transit use frequency following COVID-19. Future studies could consider loyalty as a motivating factor for maintaining ridership in emergency situations. Sixth, this study did not explore the effect of public figures or influencers, who can motivate or demotivate transit use and influence public perceptions. Future studies could explore the effect of the media, public figures, and media influencers on transit ridership in emergency situations. Last, the current study was conducted in a single country. Cross-country comparison will advance information exchange on successful strategies for encouraging passengers to take precautions while continuing to use public transport.

8. Conclusions

The results of the current study answer a substantial knowledge gap regarding transit avoidance following the first COVID-19 lockdown release and before the administration of the vaccine. The results are relevant both within the context of COVID-19 and future respiratory disease pandemics, because of the need to maintain a daily routine under conditions of a health crisis until vaccines are developed and administered at a wide scale. While airborne diseases are not new phenomena, until the COVID-19 outbreak only a few studies explored the rate of pandemic spread in public transport, and behavioral research regarding human motivation for using public transport following a pandemic outbreak is severely lacking. The current study is the first to reveal the psychological motivation for transit frequency reduction for daily use following a lockdown release under pandemic conditions. The study results can help transport authorities and transit operators to return to the 'new normal' in the current crisis and prepare a contingency plan for the next pandemic.

The results have several policy implications that could help in increasing the resilience of transit systems to the consequences of future pandemics.

Considering the gap between the passenger perceptions and epidemiological studies, data-driven research regarding the actual spread of respiratory diseases in public transport and the efficiency of personal protective measures for contagion prevention is needed. For better transit management and safer transit use during a pandemic spread, transport and health authorities need to disseminate reliable information to the public as an aid for informed decisions concerning transit use under conditions of a pandemic spread.

In view of the role of self-immunity and ubiquity of risks self-exemption beliefs in underestimating threat appraisal and indirectly facilitating transit use, denial mechanisms may encourage unsafe transit use. Reducing denial mechanisms is essential for maintaining daily routines and sufficiently high transit ridership while fighting the pandemic and avoiding the pandemic spread in public transport. Sarwar et al. (2020) urged the authorities to mobilize all forms of communication mediums to create awareness among the public, to launch large-scale interventions, and to design awareness campaigns to disseminate accurate information regarding the contagion risk efficiency of protective measures. Soofi et al. (2020) suggested using insights from behavioral economics, such as informational nudges. For example, providing peer comparison feedback or communicating risks accurately can address biases such as overconfidence. Priming an outcome by presenting what happened to individuals who are considered peers can also be effective (e.g., adolescents may feel less immune if they become aware that an adolescent celebrity contracted COVID-19). Nevertheless, recommending specific measures requires a more elaborated study and further analysis and is beyond the scope of the current study. We thus recommend further research on the effectiveness of awareness campaigns that are designed to reduce denial mechanisms and increase proactive coping.

The counterintuitive results regarding the correlation between taking protective measures, increased fear of infection while using transit, and transit avoidance indicate that transport authorities and operators should not assume that using personal protective measures will contribute to maintaining ridership. Because self-protective and preventive measures are necessary to establish a new routine during the pandemic while minimizing risk, there is a need to further explore the relationship between protective measures, fear, and transit avoidance, and understand under which conditions protective measures increase or decrease fear. While several policy solutions for coping with COVID-19 have been suggested, such as increasing transit supply to conform to social distancing requirements and disinfecting vehicles (Tirachini & Cats, 2020), such solutions may be costly and there is a lack of information about their cost-effectiveness. The estimated cost of maintaining hygienic conditions and social distancing in the Israeli bus system is 12 million euros (Benita & Spector, 2020). Research should also investigate which preventive and protective measures implemented by transit operators are cost-effective in reducing both the infection rates and passengers' fear of infection.

Finally, our results show that in a franchised transit system, satisfaction with the level of service during routine operations and trust in the ability of transport authorities and operators to devise efficient coping strategies are essential for maintaining transit ridership. Hence, transit operators and authorities should view the level of service in routine operations and crisis management as interrelated aspects of resilience. Retaining passengers' trust in preparation for the next pandemic, or crisis, starts with routine level-of-service improvements, quality bids, and crisis management standards that are enforced, monitored, and communicated to the general public.

CRediT authorship contribution statement

Sigal Kaplan: Conceptualization, Data curation, Formal Analysis, Methodology, Writing – original draft, writing – review & editing. **Anat Tchetchik:** Conceptualization, Data curation, Formal analysis, Methodology, writing – original draft. **Doron Greenberg:** Conceptualization, Methodology, Funding aquisition, Writing – review & editing. **Itsik Sapir:** Conceptualization, Methodology, Funding aquisition, Writing – review & editing.

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.

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