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Public transport strategy and epidemic prevention framework in the Context of Covid-19

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ABSTRACT

As countries across the world modify their travel in the face of the Covid-19 pandemic, the first casualty becomes the public transport sector. Transport authorities across the world have reported about 95% reduction in users during peak COVID-19, decrease of fare box revenues and additional costs for disinfecting and implementing physical distancing measures. The public transport companies in India face a larger crisis as nearly 85% people travelling intercity use public road transport in normal times. In this paper we drawpassenger clusters based on their travel dynamics and develop two frameworks, namely, passenger driven transportation strategy framework and epidemic prevention strategy framework to deal with the COVID-19 induced travel changes. The frameworks use three tenets of mobility, namely, agility, integrated movement, and public based partnership. The strategies aim to enable the transport enterprises to open new windows of travel and efficiencies for the passengers rather than restricting access and choices. However, security remains fundamental to making these new and innovative service changes possible.

1. Introduction

India ranks third in terms of motor vehicles with average fleet held at 140,497, average fleet operated at 127,814, passenger kms performed at 5,244,265 lakhs and 125 vehicles available per 100,000 inhabitants (ILO, 2015). Intercity public transport represents around 10% of the total trips, occupying about 45% of global passenger kilometers (Bak et al., 2012; Hayashi et al., 2014). However, the novel corona virus has brought a significant change in the travel pattern and behavior. Since the COVID-19 outbreak, travel demand has fallen globally and changed the patterns as well (Transformative Urban Mobility Initiative (TUMI), 2020). A longer-term impact on transportation behaviorbecomes inevitable (Verma et al., 2020). Public transport has been hard-hit since the outbreak, with dramatic reductions in ridership. The impact has resulted in the decrease of fare box revenues (in some cities the reduction in patronage surpasses 90%) and brought along additional costs for disinfecting and implementing physical distancing measures (UITPa, 2020; Verma et al., 2020). Major transport authorities around the world have reported up to a 95% reduction in users which not only shows the magnitude of the problem we face today but puts the future of these businesses and services in uncertainty (AlexKreetzer, 2020).

The crisisshows significant severity for the Indian public transport companies as 85% of people travel intercity by road in normal times (Kaushik, 2015). Around 477.5 billion pkm of service gets provided by the state-run transport buses in the nonurban sector, with about 37.6% households in urban India and 47% of households in rural India being dependent on public transport such as bus (India Census, 2011). Despite the risk of coronavirus, public transport stays the only commuting choice for many people, especially lower-income citizens (Prassenji-tLahiri, 2020). A need to bring in coordinated efforts in terms of tools and methods from policy makers, public transport service providers and passengers to mitigate risk of virus spread in the current and post-crisis becomes an urgent imperative (Tirachine and Cats, 2020; Junyi Zhang, 2020; Gao et al., 2021).

This article explores possible transport strategies and epidemic prevention strategy induced by COVID-19, drawing insights from passenger typesbased on travel demographics. A sample survey of 605 passengers draws out service travel demographics using the K-means clustering method. The emerging three clusters are used to develop two frameworks, namely, public transport strategy and epidemic preventionframework.

The large dependence on bus transport in India motivates the study

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to explore new strategies and segmentation. First, the lock down and restrictions have created significant impacts on individual psychology, community, global business and the general economics order (Barman, 2020). The return to 'normality' in public transport systems, hence, needs to be explored. The new normal requires newer policies. The new normal has implications for the decisions by relevant authorities and their capacity to manage the change (Verma et al., 2020; UITPb, 2020). For example, contamination issues will be a key factor in people using public transport (AlexKreetzer, 2020). States must find a way to make the transit safe and favorable for the people who have no choice but to use them.

Second, the restrictions on public transport may lead to passenger commute by overcrowding in smaller vehicles like cars, maxi cabs, goods tempos as well, and requires preventive measures (Transport Department, GOK, 2020; Verma et al., 2020). Intercity buses are more environmentally friendly, with passenger miles per gallon being twice more than the intercity rail and four time higher than domestic air carriers (Woldeamanuel, 2012). To meet 1 km of passenger travel demand, a car consumes five times higher energy than a 52-seater bus (Namboodiri, 2007). People resort to use private cars for transportation due to inadequate public transport network (Badami and Haider, 2007; Irtema et al., 2018; Sam et al., 2018). A return to the personal car will create an impossibly large number of trips, with the associated congestion and pollution (Qrius, 2020).

Thirdly, the biggest challenge Post COVID-19requires active promotion of public transport usage. Group travel has shrunk, and leisure travel has dwindled as well, due to safety fears. With high uncertainty to continue for some time, travel behavioral changes are a clear post covid-19 response (Qrius, 2020). Furthermore, measures taken on public transport services such as restrictions should be customized based on the intensity and phase of the outbreak (Tirachine and Cats, 2020). For operations and revenues to reach its previous demand and supply pattern, a socio-cultural change in the public transport itself becomes imperative.

All these concerns form the trigger to understand passenger behaviorand frame appropriate framework to keep transport services live during and post COVID-19. The paper contributes to the literature as follows: First, the paper explores the various challenges posed by different types of passengers to the COVID outbreak and the strategies to tackle the pandemic effectively. The study hasidentified different customer segments, their travel behavior and their perceptions, and framedappropriate transport response systems. The frameworks help efficient and effective redesigning of services with the restrictive capacity. Second, we develop a comprehensive and dynamic epidemic prevention strategy framework at three levels namely red, yellow and green modes as per the infection prevalence in the regions. The levels ensure availability of public transport services for the ongoing COVID crisis and future health pandemics from the perspective of transport operators and passengers. These strategies are built from the three core tenets of mobility, namely, agility (collection and organization of information for various mobility offerings), integrated movement (combinations of offerings including user input and customization), and public based partnership. Third, and most critically, the study addresses public transport provisions to essential and low-income passenger groups even during the health pandemic crisis. Passenger driven design thinking approach gets adopted to re-design, re-allocate and re-distribute public transport services for the health pandemic crisis.

2. Literature review

2.1. COVID-19 and transport

COVID-19 pandemic has forced us to adapt to the "new normal" lifestyle (Albani, 2020; Pantuliano, 2020; Park, 2020; Tzannatos, 2020). Public transport forms an essential service to provide mobility and must respond to the emergencies in the times of pandemics (ZHOU et al., 2020). As countries across the world adopted "stay at home" approach to reduce the spread of the Covid-19 pandemic, the first casualty becomes the public transport sector (Molloy et al., 2020; Astroza et al., 2020). COVID-19 pandemic has disrupted public transport services, witnessing 80–90 percent drop in ridership (Gkiotsalitis and Cats, 2021). The COVID-19 pandemic has made passengers more concerned about hygiene and cleanliness of public transport systems (Beck and Hensher, 2020; Qiu et al., 2020). Consequently, the transport demand has reduced drastically (Qrius, 2020). The transport organizations have incurred huge financial losses worldwide and will take atleast six to eight months to get back to the previous demand and supply patterns. For instance, Karnataka transport undertakings alone have incurred a loss of INR 16 billion due to the lockdown (hindustantimes, 17 May 2020). Significantly, public transport systems are predominantly used by people with lower incomes and making these services available to them becomes an urgent imperative and a matter of social equity (Tirachine and Cats, 2020).

Public transport worldwide has adopted a number of epidemic prevention measures, such as reduced bus frequency, decreased passengers capacity, passengers' wearing masks and gloves, reduction in number of touch points, providing personal protective equipment (PPE) to staff, dispersal of passengers inside the cars, regular deep cleaning and disinfection of public transport vehicles, workplaces, stations and assets coming into contact by users include ticketing devices, poles and seats, installing disinfectant dispensers, to actively respond to the COVID-19 epidemic (ZHOU et al., 2020; UITPa, 2020; Verma et al., 2020).

2.2. Safety, cleanliness and service provision attributes

2.2.1. Ventilation

According to UITPa (2020), public transport systems forms a high-risk environment as high number of people are put into a confined space with limited ventilation, no access or control to identify potentially sick persons, and numerous common surfaces to touch (ticket machines, handrails, door knobs, etc.). COVID-19 contagion risk increases with passenger occupancy level in public transport systems and presence of touch surfaces such as doors, seats, handrails and ticketing machines (UITP, 2020; Fa-Chun et al., 2020; van Doremalen et al., 2020). Research studies indicate infectious aerosols can accumulate and remain in indoor air for hours, hence, closed environments such as public transport vehicles are riskier. With proper usage of face masksthe probability of virus spread can be reduced (Tirachine and Cats, 2020; Nishiura et al., 2020; Qiu et al., 2020; Prather et al., 2020).

The risk becomes higher in long trips than short trips and becomes relevant for intercity bus transport (Tirachine and Cats, 2020). Public transportation can be a potential virus transmission medium without the proper ventilation, face masks and frequent cleaning (Tirachine and Cats, 2020; Shen et al., 2020b). Therefore frequent ventilation of public transport vehicles gets recommended which helps both onboard staff and passengers in reducing the risk of contagion spread especially in the long trips (Buonanno et al., 2020; CDC 2020c; SAGE 2020; Qiu et al., 2020; Morawska and Milton, 2020). Further, rear-door boarding avoids contact between drivers and passengers (Tirachine and Cats, 2020).

2.2.2. Social distancing

To avoid COVID-19 transmission, the social distancing of at least 1 m is found to be an effective non-pharmaceutical measure (Tirachine and Cats, 2020; Chu et al., 2020). A 12-m-long bus should be carried with a maximum capacity of 18–20 passengers to practice the current social distancing (GIZ 2020). The social distancing should be practiced in vehicles, station walkways and platforms to reduce crowding of passengers in their journey cycle. Relevant and adequate information should be made available to passengers on safety measures, hygiene, correct use of face masks and spacing (GIZ 2020).

2.2.3. Frequency

Given the present situation of restrictive capacity, the public transport can be made efficient and effective by redesigning services. The redesign includes adjusting the bus frequency to accommodate maximum possible passengers with physical distancing, leveraging the technology by optimizing the reservation systems based on the demand and travel trend, dynamic station skipping, reducing waiting time, speed controland timely information sharing (Muñoz et al., 2013; Hickman 2001; Tirachine and Cats, 2020; Junyi Zhang, 2020; Gao et al., 2021; Dong et al., 2020; Chen and Pan, 2020). With proper planning, all the stops can be served during off-peak hours which has low demand. Further, alternate stop skipping from trip to trip results in lesser stop closure and reduce inconvenience to passengers (K. Gkiotsalitis, 2021).

2.2.4. Technology

Corona has triggered accelerated usage of technological interface to avoid overcrowding, waiting and ensure contact less transactions. Some of the measures to be practiced in public transport post COVID-19 to ensure safety includes online booking, limiting the interactions of drivers and passengersbyno cash ticket sales onboard, allowing rear-door boarding only, covering the drivers area with a plastic sheet, and cancelling in-person ticket inspections (UITPb, 2020). Contact tracing methods such as log entries, smart card data validations helps in minimizing the exposure period of passengers and infection spread (Krishnakumari and Cats, 2020).

2.2.5. Limited occupancy and service provisions

During the pandemic compromise becomes inevitable with the public transportation services such as decreased accessibility, reduced service level, less robustness, decreased efficiency, service denial, closing selected stations, limiting service span, prolonged travel time and cancelling certain services affecting the overall service quality (Tirachine and Cats, 2020; Gkiotsalitis and Cats, 2021; K. Gkiotsalitis, 2021; Tikkaja and Viri, 2021; Basso et al., 2020; Meng et al., 2018). Public transport invites challenges of maintaining adequate service levels during the pandemic specifically for high-risk users group despite reduced demand (UITP, 2020a). However, governments and public transport service providers are trying best to instill confidence in passengers and making public transport available through frequent cleaning of vehicle systems, improved ventilation of vehicles, temperature checks for staff and passengers, mandatory face masks and sanitization (Gkiotsalitis and Cats, 2021; Tirachini and Cats, 2020; Musselwhite et al., 2020). All these adjustments are devised and implemented in an ad hoc manner by service providers (UITP, 2020b).

In India, transport authorities have issued travel restrictions to contain the spread of virus, including modified seating arrangement allowing only half the capacity. A 54 seats capacity bus allows only 26–30 passengers with alternate seating arrangement and considerable gap between two people (KSRTC, 19 May 2020; Transport Department, GOK, 17 May 2020). Masks for the crew and passengers are made mandatory. Each passenger gets hand sanitized with thermal screening before boarding. Passengers detail such as name, address, source and destination and contact number gets recorded for the purpose of contact tracing in case of any positive cases (KSRTC, 19 May 2020; Ministry of Road Transport and Highways, GOI, May 17, 2020).

2.2.6. Examples of pandemic prevention strategies

According to World Conference on Transport Research Society (WCTRS) COVID-19 Task Force, policy decisions to address COVID-19 and future public health pandemics lack of suitable scientifically sound methodologies (Junyi Zhang, 2020). Findings of Zhang et al. (2020) indicates higher infection cases and deaths of outbreak occurring in those countries and regions where contingency plans and guidelines for transport systems are less. Coordinated efforts become an urgent need, in terms of tools and methods from policy makers, public transport service providers and passengers to mitigate risk of virus spread in the current and post-crisis (Tirachine and Cats, 2020; Junyi Zhang, 2020; Gao et al., 2021). Re-designing services, re-allocating resources and re-distributing passenger flows should be part of strategies in tailoring public transport services during COVID-19 crisis and post crisis (Gkiotsalitis and Cats, 2021). Disease outbreak situations need contingency planning involving risk analysis, risk mitigation, preparedness, scenario based response plan, testing and monitoring (Dickson, 1992; WHO, 2018). The community or region with high diseaseprevalence at a given time greatly influences the risk of virus spread. Hence measures taken on public transport services such as restrictions should be customized based on the intensity and phase of the outbreak (Tirachine and Cats, 2020).

Effective measures to manage public transport during the pandemic and post-COVID crisis by some of the cities and countries are listed by C40 Knowledge Hub (2020). Namely, only sitting passengers are allowed to travel in cities like Rio de Janeiro, Lagos and Lima. Bus stops are made more spacious to ensure physical distancing among passengers in London. To make disinfection activities easier, prone to virus elements such as seat covers and carpets are removed in Bogota. Sanitizers are placed at stations and vehicles in Paris and Cape Town cities. Passengers who are not wearing face masks while using public transport are imposed fines in Germany. Shanghai and Nanjing cities make use of QR codes on public transport to identify people who are exposed to COVID-19. Auckland makes use of mobile app to inform travelers on the presence of 2 m social distancing in the nearing public transport vehicles. Barcelona has made provisions for temporary lanes to improve the response during public transport. In Washington DC metro, Krishnakumari and Cats (2020) has demonstrated the Smart card data validations for contact tracing in public transport. The central and state governments in India have taken measures to contain virus spread through public transport such as restricted public transport services, sanitization of vehicles and stations, contact tracing and social distancing.

2.2.7. Case studies

Gkiotsalitis and Cats (2021) has proposed the three level of planning to manage public transport during COVID-19 pandemic, including 1. strategic planning focusing on public transport network such as stations and route determination. 2. Tactical planning focuses on dimensioning of service capacity such as vehicle schedules, service variants and service frequencies. 3. Operational Planning deploy strategies to mitigate crowding, crowd management at stations, boarding limits, real time vehicle control and crowding information. Accurate, timely and relevant information sharing with the public in an interactive manner becomes crucial and digital epidemiology can be used for the purpose (Junyi Zhang, 2020; Gao et al., 2021; Dong et al., 2020).

C40 Knowledge Hub has listed the measures to be practiced during crisis and post-crisis such as extending the ticket duration, marking 2 m spots at stations for social distancing, increasing the service frequency during peak hours to reduce crowding in vehicles, minimizing the contact between staff and passengers, frequent cleaning of vehicles and stations, face masks, placing sanitizer dispensers, creating temporary bus lanes, customizing traffic signals in favour of public transport vehicles, leveraging technology to optimize demand, service supply, monitor ridership, crowd management and prioritize transit dependent passengers. All these measures will greatly reduce risk of virus transmission and bring back people to use public transport.

Junyi Zhang (2020) has proposed PASS (P: Prepare–Protect–Provide; A: Avoid–Adjust; S: Shift–Share; S: Substitute–Stop) approach for policymaking during COVID-19 and future public health pandemic since the public transport is associated with multi-faceted infection risks. Governments should take above measures to safeguard transport users and operators when pandemic occurs and specifically vulnerable groups such as low income people and essential workers (Junyi Zhang, 2020; Zhang et al., 2020). Lower income groups and essential workers cannot avoid travel during the outbreak since they may not have alternate means of travel or lack of opportunity to work remotely (Iio et al., 2020). Complete shutdownof the public transport, hence, may not be possible

even in pandemic situations (Tikkaja and Viri, 2021). Therefore, ensuring availability of transport services, though with reduced service levels, becomes a challenge. Zhou et al. (2020) has proposed unconventional epidemic prevention strategies for COVID-19 taking China's Ningbo UPT system case. The Gridding operating strategy divides the bus system operating areas within a city into a grid with towns (streets) as units, for better access and control. The demand-response operating strategy specifically gears to meeting inelastic demands from people who travel for work. An emergency bus bridging strategy chiefly takes advantage of the rapidity and large capacity of urban rail transit to connect the main journey routes.

Post COVID-19, potentially high travel demand and bus transportation capacity face a mismatch. From research studies demonstrate service quality factors such as reliability, assurance, tangibility, empathy and responsiveness are affected. But we also see scientific methodologies and proper implementation can maintain service quality up to certain levels given the pandemic situation. During the pandemic period, boosting the capacity of buses in a scientific, rational manner without alleviating the risk of virus transmission among the passengers along with satisfying the inelastic travel demand becomes the need of the hour (ZHOU et al., 2020). To address thesechallenges, we draw upon various fields to develop transportation frameworks for a safer, agile response to travel.

3. Research methodology

We conducted a) literature review of transport service quality, safety, cleanliness and service provision attributes for COVID19 b) sample case study is conducted to understand the categories of passengers and their service level perceptions, and c) content analysis to identify the practices and methods adopted to address covid19 in passenger transportation.

3.1. Literature review

The literature review was conducted between August 2019 and December 2020. An initial search of literature started with relevant key words. Some examples of key search terms used during extensive literature were service quality, intercity bus transport, COVID-19 and transport strategies, safety measures during COVID-19. After screening of titles, abstracts, introductions, conclusions, and type of publications, we selected papers focusing on transport safety measures during covid pandemic and their impact on service quality. After in-depth analysis we divided the literature into three broad themes: service quality of intercity bus transport, covid-19 impact on transport operations and important transport attributes during covid-19 to ensure its operation, and case studies which have adopted pandemic prevention and transport strategies.

3.2. Sample case study

Perceptions of service quality for intercity bus transport are captured from around 605 passengers travelling between the city of Bangalore to other cities/towns/villages like Mysore, Tumkur, Mangalore and Hubli. As per K-means clustering, passengers are clustered into three groups based on their perception of service quality factors. Cluster 1 has mean values of service quality factors more than 3 and hence named as high-ranking service quality passengers (HSQP). The cluster 2 has mean values less than 3 for most of the service quality factors and hence named as low-ranking service quality passengers (LSQP). The cluster 3 has mean values around 3 for most of the service quality factors and hence named as moderate-ranking service quality passengers (MSQP). Table 1 gives the distribution of demographics in each cluster.

The cluster characteristics with respect to demographic and transport attributes are as follows:

Table 1
Distribution of clusters.

Variables	HSQP (%) (n = 225)	LSQP (%) (n = 238)	MSQP (%) (n = 142)
Demographics			
Gender:			
Male	69.8	58.4	57.7
Female	30.2	41.6	42.3
Age group (years):			
15–30	69.3	89.1	88
Above 31	30.7	10.9	12
Education:			
Illiterate	5.8	3.4	0
UG	28.0	32.8	30.3
PG	47.6	59.2	59.9
Above PG	18.7	4.9	9.9
Occupation:			
Student	40.4	68.9	70.4
Employed	59.6	31.1	29.6
Income per month:			
No income	16.4	24.8	26.1
Below 5000	6.7	9.7	7
5000–10000	20.4	25.6	23.9
10,000-25000	24.4	16.4	17.6
25,000-50000	20.4	14.3	17.6
Above 50,000	11.6	9.2	7.7
Transport characteristics			
Service Provider:			
Government	65.3	64.3	57
Private	34.7	35.7	43
Bus type:			
Non-AC normal	35.1	55	31.7
Non-AC semi sleeper	14.2	13	25.4
Non-AC sleeper	8.0	13	7.0
AC Semi sleeper	32.0	14.3	29.6
AC sleeper	10.7	4.6	6.3
Distance Travelled (kms):			
Below 50	14.7	33.6	21.8
50–150	19.6	28.2	23.2
150–250	19.6	9.7	7.7
250–350	12.4	6.7	13.4
Above 350	33.8	21.8	33.8
Time taken:			
1–2 h	11.1	35.3	15.5
2–4 h	22.2	22.3	12.0
4–6 h	15.1	12.2	16.2
6–8 h	21.3	13.9	14.1
>8 h	30.2	16.4	42.3
Route Type:			
Plain route	52.9	65.5	57.7
Hilly route	15.6	8.8	2.8
Both route	31.6	25.6	39.4
Journey Type:			
Day Journey	40.9	54.2	43.7
Night Journey	44.4	30.7	33.8
Both Journey	14.7	15.1	22.5

- The HSQP cluster shows a relatively older population, with significantly more uneducated and highly educated passengers, thereby falling into two travel extremes, namely, using non-AC normal bus or AC sleeper bus.
- The LSQP cluster, has a younger population, with higher concentration of undergraduate and post graduate passengers (nearly 70% students) and higher level of unemployed (nearly 25%).
- The MSQP cluster stands out with no uneducated person in the group. The cluster also has higher number of students in the group and relatively more women than the other 2 groups. However, the group also stands put for having many middle-income passengers.

3.2.1. Content analysis

Based on the passenger and travel type, the two frameworks are discussed through content analysis of literature, appropriate websites,

newspaper articles, blogs and official notifications issued by transport authorities. The multiple keywords are identified from the literature to identify, extract and categorize relevant text from the covid19 and passenger transport literature. The various risk mitigation measures undertaken to reduce covid-19 transmission during the travel are identified, organized and structured to prepare the framework. Logical flow of operations based on the challenges and appropriate measures are drawn in the epidemic prevention framework by taking the clue from passenger types. The framework is divided into three modes namely, red, yellow and green based on the risk perception and challenge type posed by different categories of passengers. The risks associate with each passenger type is identified and appropriate mitigation strategies are outlined.

This study aims to develop two frameworks to effectively manage the transport service during pandemic situation. This include, transportation strategy framework that helps to understand the different passenger types, their service preferences, challenges faced and respective strategies to effectively manage the service. The epidemic prevention framework helps to address the challenges arising from covid19 systematically to ensure safer and agile response to travel.

4. Strategies in the context of COVID-19

Using the emerging cluster dynamics and extensive use of literature, we develop a multi-level epidemic prevention strategy and a multi-dimension passenger driven public transport strategy. First, we detail three initiatives to meet the COVID-19 challenge. Second, we align the three initiatives to the passenger cluster types for specific pandemic response strategies. Fig. 1 details the various passenger driven transportation strategies Third, we develop a transportation framework for the different passenger types. Fig. 2 details the three-level epidemic prevention strategy.

Evidence from other empirical studies indicates most of the factors studies above being influenced due to the COVID pandemic measures. For example, 'assurance'gets affected due to decreased accessibility, service level, service denial and fear of infection; 'reliability'gets affected due to the prolonged waiting times, decreased frequency of buses, lack of information, decreased efficiency; tangibles factor improved because of better hygiene, cleanliness, sanitization, physical distancing; responsiveness factor gets affected due denial of services to sick passengers, no direct response from staff, decreased seat availability; economic factor gets affected due to increased ticket prices of the bus service (Tirachine and Cats, 2020; Gkiotsalitis and Cats, 2021; K. Gkiotsalitis, 2021; Tikkaja and Viri, 2021; Basso et al., 2020; Meng et al., 2018). Passenger clusters based on the service quality factors provides an understanding of planning appropriate services. Further, integrating the analysis with findings of literature review in the COVID and post-COVID times contributed for devising appropriate strategies for public transport service customization and epidemic prevention. As an outcome, a comprehensive public transport framework and epidemic

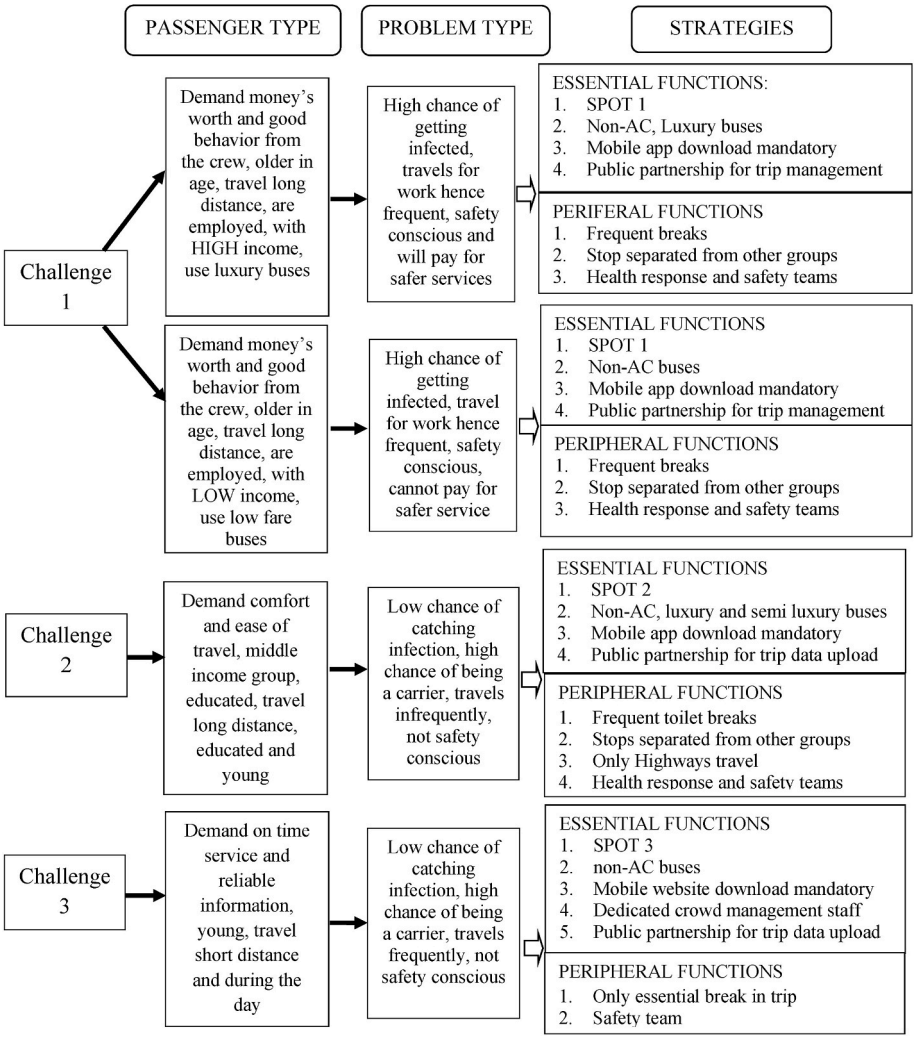

Fig. 1. Transportation strategy for companies.

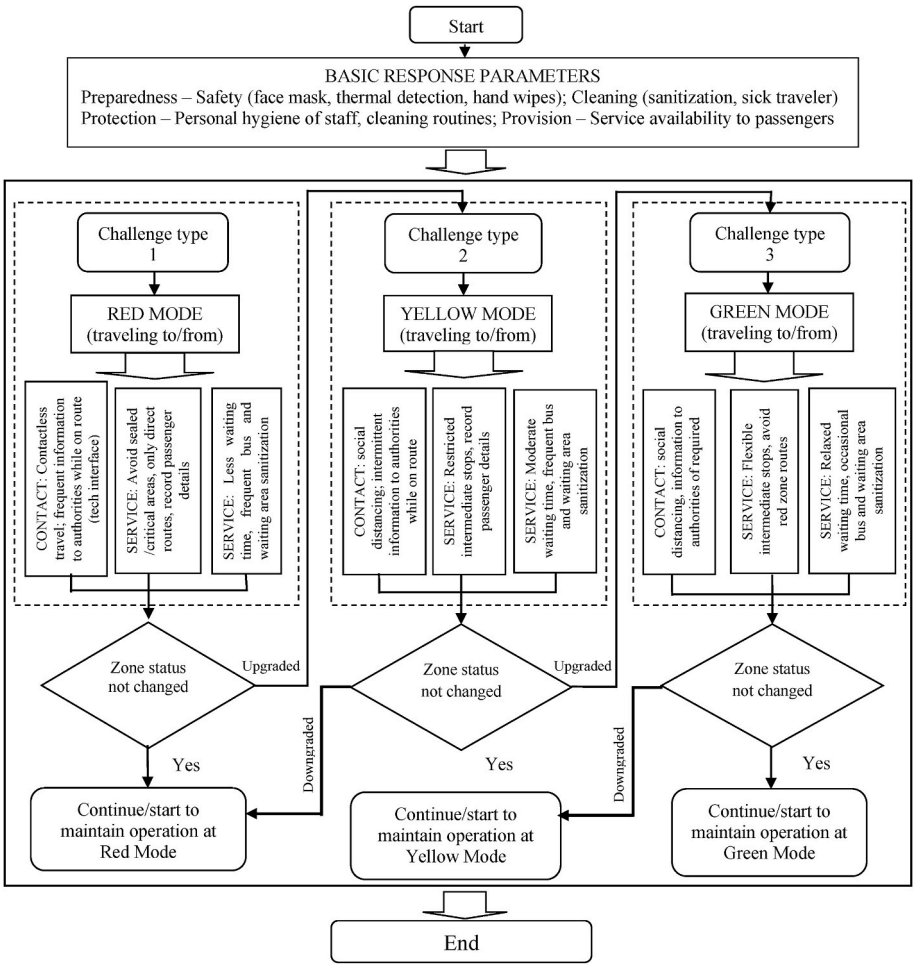

Fig. 2. Three level epidemic prevention strategy.

prevention framework for service providers is presented in the following sections.

4.1. Transport strategy

The cluster analysis brought forth three types of travel challenges for the transport companies, namely, passenger demanding money's worth and good behavior from the crew, being older in age, travel long distance, being employed, with both low and high income profile; passengers demanding comfort and ease of travel, belonging to the middle income group, educated, travel long distance, and young in age; and passengers demanding on time service and reliable information, young, travelling short distance and during the day. Transportation strategy framework helps to understand the different passenger types, their service preferences, challenges faced and respective strategies to effectively manage the service.

Different strategies, hence, need to be employed for the different passenger types (Tirachine and Cats, 2020). Taking help from the three core tenets of mobility, namely, agility (collection and organization of information for various mobility offerings), integrated movement (combinations of offerings including user input and customization), and public based partnershipthe strategies for different passenger types are developed (Mulley et al., 2018; Hirschhorn et al., 2019; Junyi Zhang, 2020; Gao et al., 2021; Dong et al., 2020; Tirachine and Cats, 2020). The core principle is 'enabling the transport enterprises to open new windows of travel and efficiencies rather than restricting access and choices' (Gkiotsalitis and Cats, 2021; Tikkaja and Viri, 2021; K. Gkiotsalitis, 2021). The following questions are asked: how can customers interface seamlessly and successfully with the transport companies for the core services? What abilities do the transport companies require to engage with the customers in the COVID-19 era? What new applications or interfaces are required to aid seamless safe travel? And finally, what processes need to be re-engineered or infrastructure upgraded and better-managed in order to deliver the right experience for the customers?However, COVID-19 based security remains fundamental to making these new and innovative service changes possible.

Fig. 1 details the different strategy points. For example, for the elder passengers travelling long distance and can afford to pay for safety a separate substation 'spot 1' is recommended with Non-AC, luxury buses as the fleet. Non-AC bus with open windows form less risky travel in the pandemic situation. The mobile app will be very useful for these passengers, and they can also partner with the bus staff for trip management like any health emergency or following safety procedures. Conversely, the 'spot 2' substation is recommended for the infrequent long-distance traveler who can partner with the bus staff for frequent trip data upload and safety management.

In the framework, strategies are divided into two functions, namely essential and peripheral for each of the passenger types. Essential functions refer to mandatory actions which must be implemented without compromise. These are the combinations of agile mobility, integrated movement and public partnership aspects at various degrees based on the passenger types. These includes camps relevant to kind of passengers, bus type as per their preferences, mobile app or mobile website to access the required information and update the real time data, public partnership to help transport authorities to manage the transport needs with the reduced risk of virus spread.

Periphery functions are the auxiliary services offered in the transportation strategy and these services varies as per the passenger types. This includes breaks during the journey such as toilet or refreshment and frequency of breaks depends on the passenger type. Bus stops are separated or isolated from the stops of other camps to ensure safety. Health response teams are formed to identify the critical health issues and respond to immediately. Furthermore, safety teams are formed to monitor the safety standards implementation at the bus stations and buses. The passenger driven transport strategy is complimented with the three-level epidemic prevention strategy to create service framework based on the passenger type and their risk level.

4.1.1. Main tenets

The transport strategy is based on the tenets of agility, integrated movement, and public based partnership. Specific travel needs and passenger types are merged as 'spots'. For example.

SPOT 1: for older age passengers, who travel long distance and are employed. The group has a high chance of getting infected. The group travels for work hence frequently and are safety conscious. These include both, high income, and low-income people.

SPOT 2: SPOT 2 can be further sub divided into 'family group' and 'unrelated group' and is for the young travelers, who travel infrequently, and have a high chance of being carriers. The space should be kept distinctly separate from the SPOT 1 and separate fleet identified for the group to ensure safe travel.

SPOT 3: for the younger traveler, travelling for short distance, frequently, for a formal activity, namely, work, education, or any other service. This group also has high chance of beingcarriers. The space will require separate crowd management staff to ensure proper following of procedures, due to nature of the group, namely, being frequent and short distance traveler.

The role of technology for integrated movement stands uniquely significant in the current times. Technology can put incredible power in the hands of the users to take informed, planned travel decisions without fear and with confidence of safety. Some examples and options used in the strategy include:

- Mobile App with custom application build for specific type of service: Mobile apps work as central touch points and offer greater control over the user experience. This gives the user confidence of safety and security during the travel, and also encourage people to plan a travel, book online tickets, track the vehicles and interact with service providers. Digital epidemiology (COVID App) can be used for accurate, timely and relevant information sharing with public in an interactive manner (Junyi Zhang, 2020; Gao et al., 2021; Dong et al., 2020).
- Data platform: A separate data platform to manage the exponential complexity of real time information, collection as well as dissemination. The growing use of mobile phones will add to the complexity. Hence, a thought on managing the volume of data becomes critical. Elements as diverse as traffic lights, movement of vehicle to each customer's health (temperature, critical disease status etc) can be shared if required.
- Website: While institutively people assumed travel websites to show reduced traffic during the pandemic times, however, we see otherwise (UITPa, 2020). Traffic surges are seen for real time information about transport movement, procedures, and change in rules (UITPb, 2020). A website beyond focus on cancellation, reschedule and refund can manage the new demand in information.

While standard operating procedures and precautionary measures will help to contain the spread of virus, ensuring uninterrupted public transport service with less risk of virus contamination requires more. Partnering with the passengers can meet the additional safety requirements. Furthermore, passengers can also support real time data support (Junyi Zhang, 2020; Gao et al., 2021; Dong et al., 2020). The following teams can be made from the passengers while the bus is in transit:

- Health emergency response teams, in each bus journey, to immediately respond to health emergencies.
- Transmission of real time data of the journey through the mobile app.

Passenger led control of end-to-end security while in transit, to monitor safety standards focused on improving the process, reducing errors, and the vulnerabilities resulting from inconsistent and non-standard approaches.

4.2. Epidemic prevention framework

Further, a three-level epidemic prevention strategy framework for companies is developed taking support from Zhou et al. (2020). Fig. 2 details the framework. Parameters such as sanitization, wearing masks, ensuring social distancing and thermal screening are important to ensure safety of passengers during the pandemic irrespective of passenger types and are considered the Basic Response Parameters. Basic Response Parameters broadly cover three aspects of the safety namely preparedness, cleaning and protection. Preparedness involves foreseeing the risks of pandemic and equipping with all necessary precautions such as mandatory face masks, thermal screening and detection, and hand wipes for both staff and passengers. With adequate preparedness, virus spread can be effectively contained. The epidemic prevention framework is developed to address the challenges arising from covid19 systematically to ensure safer and agile response to travel.

Transport staff gets most exposed to the contamination areas posing the risk of getting infected or even becoming the carriers of virus. Therefore, ensuring their safety by strictly following the hygiene protocols with routine health checkups, cleaning and screening, becomes critical. Creating separate transparent shield at the driver side protects driver and passengers as well. Under the pandemic situation driver and conductor role can be merged since passengers and their seating is already fixed. Staff's risk exposal gets reduced and ensures smooth transport services at the same time. Basic response parameters should be mandatory irrespective of modes or challenge types before proceeding further.

Further three levels of zoning are recommended based on the passenger cum travel type. The Red Mode indicates the first cluster type (challenge 1), Yellow Mode indicates the second cluster type (challenge 2) and Green Mode indicates the third cluster type (challenge 3). For the Red Mode buses and areas are more tightly sealed or locked during travel. Here, buses withonly direct routes i.e. only source and destination stop and no intermediary stops, should be allowed, and details of passengers should be recorded for contact tracing. When the virus spread comes down and Mode status can change from Red to Yellow or Green. The outlined prevention strategy helps in containing the virus spread while travelling with high risk passengers.

The Yellow Mode buses travel has high virus spread as well. The travelers are in groups and infrequent. The route can have limited stops, with moderate frequency of buses and low waiting time at the sub stations. Passenger types who are frequent travelers should be included in the yellow mode. The Green Mode is the low frequency, high volume travel bus routes, hence may see increased seat occupancy with minimum social distancing. Increased frequency of buses with very low waiting time at the sub stations, sanitization of buses after every trip and constant monitoring of the journey are some of the key points for safety. The comprehensive epidemicprevention framework helps to frame the customized transport services based on passengertypes.

The framework aims for the transport service to reach or operate at green mode with no fear o virus spread. Nevertheless, transport services cannot be suspended at the risky areas. Therefore, the red mode operates at the high alert with extra care and precautions. Yellow mode is an

intermediate one with the moderate risk and if managed properly can be reached to green mode, and takes the red mode if situation gets worse. The framework provides a centralized yet decentralized network strategy to provide uninterrupted public transport services to the public with the reduced risk of virus spread during the pandemic.

5. Discussion and conclusion

From our study, three types of passengers groups emerged, from which corresponding challenges are derived, and respective strategies are devised. Further, epidemic prevention strategies are defined to effectively address the challenges based on agility, integrated movement, and public based partnerships through three modes: Red, Yellow and Green. Our study outcomes take supported from Gkiotsalitis and Cats (2021) who proposed three level of planning namely Strategic (provisioning transport network), Tactical (service capacity dimensioning) and Operational (crowd management) to manage public transport during COVID-19 pandemic. The passenger driven strategy and epidemic prevention strategy framework of our studyjointly constitutes strategic, tactical and operational planning. Further our epidemic prevention strategy framework which focuses on Preparedness, Protection and Service Assurance strongly correlates with PASS (P: Prepare–Protect–Provide; A: Avoid–Adjust; S: Shift–Share; S: Substitute–Stop) approach proposed by Junyi Zhang (2020) for public transport policymaking during health pandemics. Further three modes: Red, Yellow and Green in epidemic prevention strategy becomes necessary as prevalence of the disease in a region, at a given time, greatly influences the risk of virus spread as demonstrated by Tirachine and Cats (2020). The authors state measures taken on public transport services such as restrictions should be customized based on the intensity and phase of the outbreak.

At the passenger driven transport strategy, Challenge 1 comprises of older passengers who are vulnerable to the infection. Within these vulnerable passengers, two streams are seen, one with potential to pay for safer services and another without, leading to the challenge of providing safer services for both. Therefore, the travel strategy includes, providing appropriate buses as per the paying capacity, giving frequent breaks and availability of health response and safety teams. Further based on mode type the passengers are travelling, services are aligned by adhering to requirements of respective modes. If these types of passengers are travelling in red and yellow mode, services will be more cautious and vigilant compared to green mode due to the vulnerability nature of passengers. In Challenge 2, passengers are young, more comfort seeking and travel longer distance yet not frequent travelers. Therefore, the travel strategy includes, providing appropriate buses, frequent breaks, mandatory pandemic related app download and only highway travel. In Challenge 3, passengers are young, short distance and frequent travelers hence there remains less chance of catching infection. Therefore the travel strategy includes, providing normal buses, only essential breaks, and mandatory pandemic related app download.

For all the three challenges and modes, timely and relevant travel information dissemination remains a must. Junyi Zhang (2020); Gao et al. (2021); and Dong et al. (2020) stress the same, indicating accurate, timely and relevant information sharing with the public in an interactive manner as crucial. One of the important measures in all the three modes of epidemic prevention strategy includes cleanliness and hygiene of vehicles and stations through appropriate sanitization. Research studies of Gkiotsalitis and Cats (2021); Tirachini and Cats (2020); Musselwhite et al. (2020) highlight the same, stressing on cleaning of vehicles, improved ventilation of vehicles, mandatory face masks and sanitization. Our study presents the need of technology as the part of integrated movement to ensure information sharing, contact sharing, dynamic bus scheduling, usage of pandemic related mobile app and contactless transactions in both passenger driven transportation strategies and epidemic prevention strategies. This closely correlates with the arguments of Krishnakumari and Cats (2020); Junyi Zhang (2020); Gao et al. (2021); Dong et al. (2020); Muñoz et al. (2013); Hickman (2001); Tirachine and Cats (2020); Junyi Zhang (2020); Gao et al. (2021); UITPb (2020); Dong et al., 2020; Chen and Pan (2020) which states leveraging the technology to optimize service operations through information sharing in an interactive manner, usage of digital epidemiology app and cashless transactions. One of the important measures in framework includes ensuring social distancing to minimize the risk of virus spread. Research studies indicate the social distancing of at least 1 m forms an effective non-pharmaceutical measure to reduce COVID transmission (Tirachine and Cats, 2020; Chu et al., 2020; Muñoz et al., 2013; Junyi Zhang, 2020; Gao et al., 2021; Dong et al., 2020; Chen and Pan, 2020).

Novel corona virus had brought the world to standstill for a moment affecting almost all the industries due to lockdown. Among these public transport was one of the worst hit industries with unprecedented losses coupled with restriction on mobility due to spread of virus. Transport service customization address the specific requirements of customer groups to avoid the risk of virus spread and forms a part of the recommended policy options. The proposed framework will give better understanding about the passengers, their types, associated challenges and respective strategies to manage the pandemic situation efficiently especially for the intercity bus transport. The framework, thus, helps to frame suitable strategies, action plans to ensure public transport service availability even during the health pandemic. The Transport Policy needs contact and service strategies separately based on the passenger types.

Contact strategies involve contactless travel, on route information to authorities, social distancing. Contactless travel should be promoted as much as possible such as online ticket purchase, e-tickets and minimum touch points in the bus. Status information must be communicated with authorities while on route through technological interfaces such as mobile apps and websites for any likely cases and change of routes to be intimated. Information should be communicated frequently with authorities in red mode because of its high sensitivity to risk. In the yellow mode, intermittent information communication keeps the authorities updated on the important health or safety issues. Only required information communication gets transmitted in the green mode, including about uncertain events. Social distancing should be followed in the yellow and green modes at both sub-stations and buses. At the substation, passengers are made to sit at alternate seats and maintaining considerable distance while boarding bus between the passengers. Boarded passengers should be allowed to sit on alternate seat with considerable distance between them. Social distancing minimizes the virus spread among the passengers due to contact.

Policy recommendations for service involve routes, areas status, recording passenger details, stops, waiting times, sanitization of waiting area and bus. Travelling near sealed routes must be avoided to contain the risk of catching virus. Bus and waiting area sanitization help in minimizing the risk of virus spread among the users who use these services. Offering contactless sanitizer dispenser and wash basins with soap dispensers at the platform level could be effective. If possible, wet sanitizing wipes must be provided to every traveler with a suggestion to use them before touching anything or gripping anything especially to high risky passengers. Bus and waiting area sanitization should be frequent in red mode, moderate in yellow mode and occasional in green mode due to risk and exposure levels.

Public transport moves a lot of people, to the same destination at the same time. The relevance of public transport for a developing country like India becomes high where we witness low personal transport, low income, inadequate transport infrastructure, inadequate usage and higher imbalance in modal split of transportation (Namboodiri, 2007; PrassenjitLahiri, 06 June 2020). Around 37.6% households in urban India and 47% of households in rural India are dependent on public transport such as bus, since they do not own a vehicle (India Census, 2011). Further, in intercity bus industry of India, around 477.5 billion pkm of service gets provided by state transport undertakings (STUs) indicating the importance of intercity bus services in connecting Indian

villages and cities. Despite the risk of COVID, public transport being the only choice will remain crucial for enabling people, especially lower-income citizens to commute (PrassenjitLahiri, June 06, 2020). The large dependence on bus transport in India motivates our study and we explore passengers travel behavior and their preferences before the pandemic outbreak and how likely their preferences change due to the novel corona outbreak.

5.1. Policy implications

The proposed transport strategy and epidemic prevention strategy frameworks helps public transport organizations to devise appropriate response plan to effectively manage COVID like health pandemics to ensure services are provided even during these times. Since public transport system can form one of the transmission channels of infection, the study finding helps government and companies to minimize the virus spread through adopting the strategies framed here.

The one size fits all strategy, evidently, cannot be applied. The study has, therefore, identified the different segments of customers, their travel behavior and perception and framed respective response mechanisms. The study can help governments to provide instructions to transport organizations to frame contingency policies tailored for different segments of passengers. With help of the study finding, the public transport can be made efficient and effective by redesigning services even with the restrictive capacity.

These frameworks help government to ensure public transport services to public especially who do not have alternate choice of transport, low income group and essential workers. Specific and relevant service parameters can be focused during the pandemic situations based on passenger perceptions instead of considering all the parameters. The framework helps governments to take policy decisions transport service based on scientifically sound methodologies instead of making contingency adjustments in an ad hoc manner. The frameworks proposed in the study can be applicable to all situations such as during COVID, post-COVID, future health pandemics and normal situation because of its nature of agility and integrated technology movement.

However, the study has some limitations. The study is mainly based on empirical evidence in pre-COVID and from literature in COVID and post-COVID situation. Therefore, the theoretical framework proposed must be tested empirically. Further the data for pre-COVID is mainly from southern India and require to be tested in other regions as well. This study mainly focuses on intercity bus transport and can be further customized to apply for urban transport.

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