

# COVID-19 Cross-Group Benchmarking Review of Recent Activities: Public Report



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## Overview

The purpose of this document is to help operators optimise their response to the ongoing COVID-19 pandemic by sharing knowledge and experience from a wide range of organisations globally, including many of the largest operators in the world's major cities. The focus is on both short-term measures to deal with specific challenges arising from the pandemic in the present, as well as on longer-term impacts, such as the funding crisis or more permanent changes to travel patterns and behaviour, that operators are having to respond to and plan for.

This document summarises recent updates and key findings related to COVID-19, sourced from the benchmarking group members and activities within the groups: over 100 metro, rail, bus and light rail operators participate in the international benchmarking groups (see Appendix A for a list of benchmarking groups and members) managed through the Transport Strategy Centre (TSC) at Imperial College London.

All information provided is anonymised to respect confidentiality rules of the benchmarking groups (unless any information has been sourced publicly).

Full references of relevant literature on COVID-19 in the transport industry are provided at the end of this document, along with a short description for each piece of research.

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## Despite a promising outlook for demand recovery towards the end of 2021, the future of public transport remains uncertain at this stage in the evolution of the pandemic

The need for flexibility and to be ready to adapt to uncertainty around COVID-19 has been brought to the forefront of our minds once more with the recent emergence of the new Omicron COVID-19 variant. It is clear that all public transport operators and their authorities need to build in such flexibility in their recovery and resilience plans. This report provides insight into measures and initiatives that operators are having to consider and implement to accommodate returning demand onto their networks. Not only do operators need to **practically and safely manage returning customers**, it is also important to influence and encourage the re-establishment of travel habits which will ultimately aid **revenue recovery** and wider economic recovery in cities in the long term.

Nonetheless, we must accept that the pandemic has changed the way we work across much of the world and customers have more flexibility than ever before on whether or not they travel, and how they wish to travel. Along with the potentially long-term **changes in customer needs**, it is important that public transport providers adapt and **respond to new demands in passenger travel**, such as through **flexible ticketing**.

The latest patronage figures from September-November have shown very **encouraging signs of recovery**, with all regions and modes recovering to some of their highest levels relative to pre-pandemic demand: demand in the Asia/Pacific region which had dropped slightly earlier in the year (due to experiencing the impacts of some of their first larger COVID-19 outbreaks) have since seen a rapid and sharp increase in demand to high levels. In Europe however, public transport demand has started to stall slightly in November following **new outbreaks of the virus**. As we see in this report, the introduction of **strict criteria for public transport travel** in some European locations to curb some of the high rates of COVID-19 infection (including Berlin BVG where a “Vaccinated. Recovered. Tested.” policy has been introduced, and the partial lockdown in the Netherlands), may be indicative of more difficult times ahead for public transport in the coming months.

A key internal issue, both driven and exacerbated by the pandemic in many locations, is the ongoing challenge of

**high levels of staff absence and shortages**. The causes behind staff unavailability are complex and vary across modes and regions. Some of the contributing factors directly related to COVID-19 are restrictions on training, hiring freezes, close contact isolation, and postponed annual leave. As we see in this report, an increasing number of operators are introducing **staff vaccine mandates** and the next months will provide some insight into how staff availability is affected by this. The Omicron variant was already causing a staff absence crisis for UK rail operators at the end of December 2021.

The COVID-19 pandemic has presented the public transport sector with significant and unique challenges since its impacts were first felt in 2020. Public transport recovery from COVID-19 had started to look very encouraging in many locations, however with the recent surges in virus infection rates across much of Europe, along with the unknowns associated with the recent emergence of the Omicron variant, operators must continue to respond to changing priorities and adapt under highly uncertain circumstances. Of course, ongoing concerns around funding gaps continue to be of critical importance for public transport operators and we plan to focus on finance and funding in the next report in 2022.

## Asia/Pacific metro demand surpasses European demand recovery; continued growth in Latin America

### Recent Metro Demand Trends

Average metro ridership by region as a proportion of pre COVID-19 demand (weekday demand indexed to January or February 2020) is shown in Figure 1. The graph is based on daily demand data that is collected in the COMET metro benchmarking group.

There has been a strong recovery in metro demand in all regions with several metros in Europe and Asia consistently above 80-90% of pre COVID-19 demand. However, demand is beginning to stabilise in Europe due to new COVID-19 outbreaks.

- In **Europe**, metro demand recovered very strongly following the easing of restrictions earlier in the year. However, data suggests that **demand began to stabilise** towards the end of October and throughout November (**77%**), **dipping slightly** at the beginning of December (**76%**) as COVID-19 infection rates have begun increasing.
- In **Asia/Pacific**, metro demand recovered very quickly from the impact of new outbreaks in June and July 2021. After dropping to levels below the European average for the first time in September and into October, average demand recovery in the Asia/Pacific region is back at some of the region's **highest levels (77%)** since the start of the pandemic.
- In **North America**, significant growth had been seen by mid-September and this upward trend has continued in recent months. Average demand has recovered to between 42% (November) and 45% (beginning of December) of pre-pandemic demand, reaching the highest level of recovery for the region since the start of the pandemic.
- In **Latin America**, average demand has been on a very steady recovery trajectory since March 2021. Although Latin America has experienced lower levels of demand recovery compared to the Asia/Pacific and European regions,

recovery has been stable in the past six months and has reached the highest level of pre-pandemic demand month after month. Average demand recovered to above **60% for the first time** in November.

### Comparison of Recent Multi-Modal Demand Trends in North America

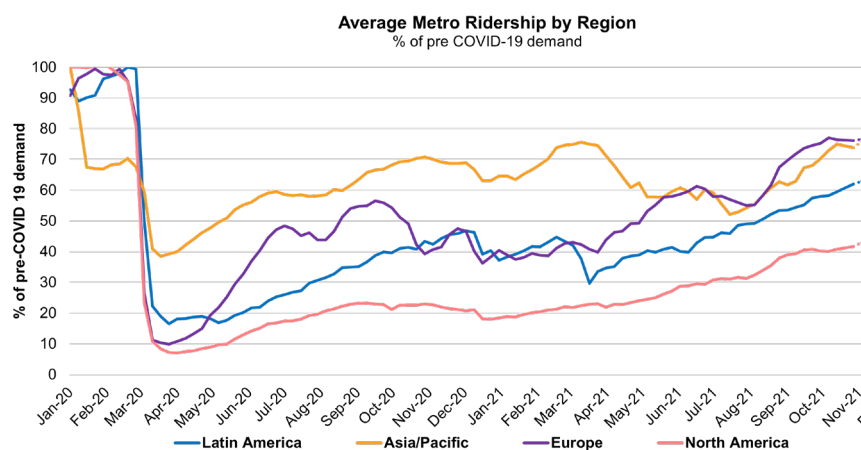
Figure 2 shows **average bus, light rail, suburban rail, and metro ridership** (monthly total demand indexed to corresponding 2019 month) for operators in **North America**, based on available data in the benchmarking groups and supplemental data from the US National Transit Database for US operators.

- **Light rail and bus** modes continue to lead demand recovery in the region and both modes follow a very similar trend. In October, bus demand had recovered to an average of **53%** relative to pre-pandemic levels vs. **52%** for light rail demand.
  - Bus demand had reached a pandemic high of 56% of pre COVID-19 levels in September, linked to the return of in-person schooling. This was followed by a slight dip in demand in October for those reporting data, but this includes a significant drop for one operator due to a decline in student ridership (fall break, parent protests against mandatory student vaccination) as well as a severe flooding event. Initial data (not yet shown in Figure 2) received from some North American bus operators suggests that November demand was back up at September levels.
- Light rail and bus demand recovery levels have consistently remained approximately 25% above levels seen for metro and rail modes.
- **Metro** demand for the region had experienced strong growth in recent months, reaching a high of 41% of pre-pandemic levels in September. Average demand has since dipped slightly (**39%**) largely for non-pandemic related reasons (e.g. rolling stock issues at one metro).
- **Suburban rail** demand (albeit based on a small sample size) has been steadily recovering throughout the year and this trend has continued into recent months. Demand recovered

Figure 1:

Average metro ridership by region as % of pre COVID-19 demand

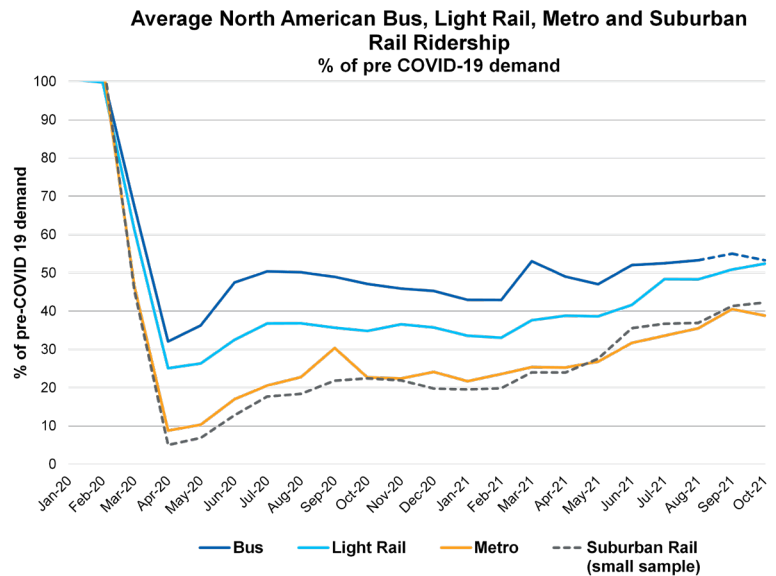
Source: TSC/COMET



**Figure 2:**

Average North American ridership by mode as % of pre COVID-19 demand

Source: TSC bus, light rail, suburban rail and metro benchmarking groups / National Transit Database (Federal Transit Administration)



to 42% of pre-pandemic levels in September, the **highest levels** seen since the start of COVID-19.

## As customers return, operators must plan not only for pandemic-related challenges (e.g. crowding) but also efforts to encourage demand

Public transport demand has, in recent months, been recovering to its highest levels of pre-pandemic demand since the beginning of the crisis. As operators welcome back larger volumes of passengers, they are faced with many pandemic-related challenges, such as how to **practically and safely manage customers**. However, there are also new opportunities that are emerging from changing customer travel patterns and expectations.

It is essential that public transport operators continue to review their plans and **maintain flexibility** as they restore customer confidence and revenue, and contribute to the economic recovery of their cities and regions.

### Safe management of crowding with further demand growth

For many operators, concerns around crowding were largely erased during the pandemic due to very low volumes of passengers. Whilst some metros did experience **crowding at different times or locations** due to the changing demand profile of customers, station closures or lack of staff, **adjusting staffing and service levels** can be helpful to ensure demand can be met at these new times without creating new bottlenecks.

- A medium-sized European metro experienced a **change in the location of crowding** from stations serving business and shopping locations to stations near construction sites.
- An Asian metro replaced individual manual temperature checks with thermal imaging sensors to **reduce bottlenecks** at station entry points.

As shown in the above examples, metros did at times experience crowding events in specific locations / parts of the network, partly due to the pandemic circumstances. Despite low levels of ridership overall, such crowding events had a significant impact on metros and the affected customers.

It is important for operators to consider the **knock-on effects of station closures** in their resilience plans, particularly as staffing shortages due to sickness and isolation are otherwise going to present recurring challenges, including more frequent **service disruption** and **crowding outside stations**.

A summary of initiatives and measures available for managing crowding on-board and in stations (in the pandemic context) is provided below:

- **Infrastructure and physical measures:**
  - Gate line restrictions including automatic fare gate closures and re-opening, queues and group entry systems outside stations, flow sensors/counters within stations, changing escalator speeds and directions to restrict platform entry.
- **Staffing:**
  - Dedicated stewards or ambassadors in ticket halls, corridors and platforms, social distancing tracker to re-distribute stewards to the busiest stations, police enforcement, mobile stewards in trains to enforce distancing.



- **Customer information:**
  - COVID-19 policy alerts (posters, audio announcements, passenger information displays), advanced crowding information (apps, journey planners, social media), real-time crowding information (stations, platforms, trains).
- **Fares and Promotions:**
  - Encouraging digital/advanced ticket purchases, fare discounts for off-peak and weekend travel, marketing and communication campaigns.
- **Service response:**
  - Dispatch of additional trains when train capacity limits are reached, demand monitoring and longer term service strategy adjustments, development of pre-planned service schedule options and demand triggers, use of additional staged ‘gap trains’ to supplement capacity during events, extended service hours during events.

### Operator involvement in the planning process is key for the success of large scale events during COVID-19

Large scale events such as sports matches, conferences, concerts and festivals, inevitably cause crowding given the fixed start and end points. Although still prohibited in many locations, a number of cities have hosted major events or mass gatherings in 2021. A key **lesson learnt** that has been identified by operators for planning and facilitating travel to such events during a pandemic is the importance for operators to have **input into the event planning process**. This is to ensure that event capacities account for transport demand.

Similarly, an important finding is the **sharing of demand and crowding models with event organisers** to ensure these are taken into account. Many operators referred to or adapted existing crowd control plans in facilitating major events in their city.

### Successful customer information tools were typically developed by either starting with a simple product or using existing open data formats

A major digital advancement for public transport during this pandemic, and very early on in many cases, has been the successful development of **passenger crowding information tools**. Operators have successfully implemented new tools quickly during the pandemic by generally **starting with a simple product** and **adding functionality over time**, or by using **existing open data formats**.

Other best practices identified include:

- **Limiting the number of crowding categories** for clarity from a user experience point of view
- Ensuring **flexibility** so that thresholds and ranges can be quickly adjusted throughout and beyond the pandemic and during events
- Continuously **monitor data quality** after launch.

### Transport for London's participation in the UK Government's Test Events Research Programme

Transport for London has been taking part in a series of test events as part of the UK Government Test Events Research programme<sup>1</sup>. As part of the programme, events require COVID status certification for entry and have been heavily regulated and monitored (e.g. the number of COVID-19 cases reported following the event). The Phase 1 events held earlier this year during the UK summer included the Euro 2020 final at Wembley Stadium (75% of full capacity), the Wimbledon Tennis tournament (50% of full capacity) and the BRIT awards, one of the first permitted indoor events in London (22.5% of full capacity).

Transport for London has been feeding data to the programme to ensure that planned events and capacities in the future take into account transport demand flows and crowding. Active travel has been promoted at these events, and station wayfinding has been important to ensure a steady flow of people and reduce bottlenecks.

### Planning for a more rapid implementation of service schedule changes is necessary and possible during COVID-19

The time it has taken operators to enact service schedule changes during the pandemic varies significantly. For example, across the metro community this timeframe ranges from just a few days to one year. Of course, a number of factors impact the speed at which a service change can be scheduled, including:

- The complexity and permanence of the change
- Staffing and resources
- The use of pre-existing schedules
- The timetabling and rostering software
- The degree of stakeholder intervention and approvals required.

One example of a practice to reduce service implementation time during COVID-19 is to plan for specific demand levels at which **a service review is triggered**, allowing plans and **approvals to be made in advance** and rapid implementation.

However, many operators are already operating maximum (pre-pandemic) service levels to facilitate social distancing, and so are unable to increase service levels in response to demand in the short term.

### Fare initiatives have been widely considered to respond to changing customer needs and to restore public transport demand

A large number of public transport operators have, and continue to, make fare changes on a temporary or trial basis. This is to adapt to different demand patterns and customer needs and to attract and retain demand into the future.

Across the benchmarking group members there have been a wide range of fare discounts, promotions and campaigns designed to attract particular customer segments back.

- A recent example is from OC Transpo in Ottawa where **unlimited free travel**<sup>2</sup> is being offered throughout December 2021.
  - The fare promotion aims to encourage passengers to return to the system, although this largely follows the complete closure of the system in October 2021 after a series of derailments rather than COVID-19 related reasons only.
- Taipei TRTC has implemented a customer loyalty scheme, rewarding frequent passengers with cashback payments.

Although fare initiatives require short-term investment, the immediate objective is to encourage passengers to make their first trip back on public transport, with a longer term aim of re-establishing these habits.



Source: Ottawa OC Transpo

Source: <https://pendlertjek.dk/en>

### Flexible ticketing aligns with current travel patterns but pricing strategies need careful consideration

Previous report issues have covered examples of flexible ticket products developed to better cater for the needs of commuters who have adopted a hybrid work pattern due to the pandemic.

Flexible ticket options continue to be pursued by public transport operators and governments, and a further example is **Denmark's Pendler20 ticket** being offered by all operators in the country. This flexible ticket, currently being trialled, targets commuters who travel on a same route up to three times a week and allows for **20 optional travel days within 60 consecutive days**. In order to help customers weigh up the cost of different fare products, the Danish Department of Transport developed an **online calculator**<sup>3</sup>.

An online calculator may be a useful tool for operators to avoid **unintended consequences** of flexible tickets. In the UK, for example, the launch of the rail network's flexible ticket (8 days of travel in any 28 day period) was met with **criticism by some commuters for being too expensive** with cost at about 68% of the equivalent season ticket. However, the pricing by the UK Government (and not the rail operators) was deliberate to **avoid losing revenue** and to **avoid incentivising fewer travel days** to save money (e.g. only two rather than three days in the workplace).

A key consideration for operators considering flexible ticket options therefore includes how to **develop an attractive offer** for those wishing to commute **more than two days** per week.

### Staff availability issues continue to be a challenge for operators across many regions

Lack of staffing has become a challenge for many public transport operators over the course of the pandemic. Several European and North American bus companies are experiencing driver shortages for a number of reasons:

- A European bus operator reports that their organisation is facing a shortage of drivers due to COVID-19 (e.g. restrictions on training), despite attractive benefits and pay and that this will have a **knock-on effect on the delivery of planned bus service expansion**.
- A North American bus operator has **taken steps to increase the number of drivers** that are being recruited following a hiring freeze during the pandemic. Efforts include:
  - Doubling bus driver class sizes
  - Developing a targeted marketing campaign
  - Streamlining their recruitment process and waiving the application fee
  - Assisting applicants with the administration required for the commercial driver's license.

Figure 3 shows **metro staff availability** as a percentage of frontline employees available for work between January 2020 and August 2021, by region:

- All regions, except for Asia/Pacific, experienced a significant reduction in staff availability in early 2020.
  - Europe and North America returned to near pre-pandemic levels of availability in August 2020, but then experienced a second, smaller reduction in staff availability in 2021.
  - Metros in the Asia/Pacific region experienced some initial decreases in staff availability from late 2020, and availability has since been fluctuating but remaining over 90%. Of course, several cities in the Asia/Pacific region were more severely impacted by COVID-19 in 2021 compared to 2020.
  - Metros in Latin America experienced a more prolonged reduction in staff availability throughout 2020 and 2021. Staffing has only recently started to recover.
    - » A contributing factor has been the region’s much wider definition of vulnerable staff which has meant that many have been long term isolating or performing alternative roles and are only now starting to return.
- **Station staff**, with the most customer contact, had the **largest decrease** in availability across both years, followed by maintenance staff and then train drivers.
- Few metros have reported staff unavailability as currently preventing normal service.
  - The primary causes of staff absence are currently **non-COVID related sickness and close contact isolation** rather than COVID-19 infections.
  - A small number of metros reported postponed annual leave resulting in staff availability issues.

Recent developments around **vaccine mandates** may further impact on staff availability across many regions, where public transport operators are moving towards adopting mandatory vaccination as a condition of unemployment. Where implemented, unvaccinated staff (without an exemption) would no longer be eligible for work or pay. This could potentially present a new risk for operators where vaccine hesitancy amongst employees is high. Recent examples of vaccine mandates in public transport organisations are described in the “practical examples” section of this report.

## Practical examples to manage COVID-19 operational challenges

This section summarises recent information on practical examples or decisions around practices being considered by transport operators to manage operational challenges arising from the COVID-19 pandemic.

### Berlin BVG introduces “Vaccinated. Recovered. Tested” policy for customers

Recently, Berlin BVG announced that customers can only travel on their public transport network if they can prove that they are **vaccinated, tested or recently recovered**. This policy has been developed in response to new COVID-19 outbreaks in Germany.

### Staff vaccine mandates emerging across the regions

Across the world, there are signs of a **recent shift toward mandatory vaccination** for public transport staff. For example, the MTA in New York has implemented its policy for either mandatory staff vaccination or weekly testing, which saw a network of 120 testing sites open. A political debate around a vaccine mandate is ongoing. Further examples of operator mandates are provided below.

- A North American bus operator is mandating the COVID-19 vaccination for employees and has specified that regular testing will not be available as an alternative.
  - Employees who were not fully vaccinated by 29th November 2021 will no longer be eligible to work and will not receive payment.
  - The employment status of unvaccinated employees will be reviewed in early January.
- A further North American bus operator has mandated the vaccine for all its staff and offered clinics on its premises to support the mandate.
  - Approximately 96% of drivers are in compliance with the mandate.
  - 3% of drivers have applied for religious and/or medical exemptions.
  - 1% of drivers are on long-term leave and will need to show proof of vaccination before resuming service.

**Figure 3:**

Average Metro Staff Availability

Source: TSC/COMET



- In the US, Pinellas Suncoast Transit Authority in St. Petersburg, Florida, requires staff to be vaccinated against COVID-19 **before commencing employment**.
- A public transport operator in the Asia/Pacific region implemented a mandatory vaccination policy for all employees.
  - This follows a **consultation with all employees** on COVID-safe measures.
- A further operator in Asia/Pacific is **escalating its policy from mandatory testing to mandatory vaccination** for all frontline staff.
  - September 2021: mandatory testing for frontline staff implemented and unvaccinated frontline staff are redeployed to depots.
  - October 2021: mandatory testing for non-frontline staff.
  - January 2022: employees who are either fully vaccinated or fully recovered from COVID-19 (within 270 days) are eligible to work.
- In Moscow, the **vaccination of service sector employees (including public transport staff) is mandatory** according to a government decree adopted by the City of Moscow. Within the sector, it was a requirement for 60% of staff to receive the first dose of a COVID-19 vaccine by 15th July 2021, followed by full vaccination a month later on 15th August 2021. The decree specifies that any staff who do not meet the requirements may be suspended.

A common concern in the North American bus industry, and perhaps across the public transport sector, is that a vaccine mandate would **risk impacting on hiring and retention**, as well as alienating staff. This is reportedly particularly problematic for organisations already facing challenges of **driver shortages** and where losing more drivers through imposing a vaccine requirement is too much of a risk.

### US bus company makes final push with a financial incentive programme to encourage vaccinations ahead of the federal vaccine mandate

In North America, the CEO of a bus company addressed a letter to all employees to incentivise vaccine uptake ahead of the federal US vaccine mandate for companies with 100 or more staff members. Key elements of the letter are:

- The key headline centres around getting vaccinated ahead of the vaccine mandate and to **benefit from the financial incentive programme**
  - “Don’t wait for a mandate, get it done now. What will you do with your incentive \$\$?”
- **USD \$900 financial incentive** for employees who received a first dose of the vaccine by 30th September 2021 and continue to be on the active payroll by 27th November 2021 (including all employees who participated in a first vaccine incentive round ending 30th June 2021),
  - Dropping to USD \$600 for a first dose received by 15th October 2021),
  - Dropping further to USD \$300 for a first dose of the vaccine by 31st October 2021;

- A final requirement of the vaccine incentive programme is that employees schedule their vaccination appointments when they are **off duty**.
- Once the incentive programme ends, any mandates that need to be followed will simply be enforced and non-compliant employees will be placed on unpaid leave status.
- Employees submitting fraudulent vaccine documents will be subject to termination and prosecution for misuse of public funds.

### Vaccination incentives and disincentives for the unvaccinated where a mandate is not legally permitted

In an opposite scenario, a North American operator is not permitted to mandate vaccinations per state law. In an attempt to increase staff vaccinations, the operator is therefore encouraging staff to get vaccinated through **incentives** (e.g. paid leave, USD \$100 store giftcard) and **disincentives for the unvaccinated** (e.g. ending eligibility for paid sick leave for COVID-19 illness, loss of healthcare premium discount and access to business travel).

### PEPA filters and foam blocks adopted by European bus operators to aid ventilation

- In Europe, a bus operator is installing pathogen eliminating particulate air filters (PEPA) to their vehicle ventilation systems where possible.
- Two European operators have fitted foam blocks to their hopper style windows in the passenger areas, to avoid them being fully closed.
  - Academic modelling suggests that the amount of additional fresh air that circulates into the vehicle is 7 litres per second per window.

### Paris RATP’s application allows for the public reporting of crowding on public transport

In Paris, RATP’s travel app has a new feature<sup>4</sup> (‘passenger density crowdsourcing’) since May 2021:

- The feature allows passengers to **submit crowding levels** when travelling on the city’s public transport system.
- The service is **anonymous, free, easy to use**, helps improve passenger comfort and assists with social distancing.

### Few operators are currently making definitive long term plans for mask wearing on public transport

COVID-19 policies have evolved and changed throughout the pandemic, including policies on mask wearing on public transport. Recent work in the metro benchmarking group analysed changes in mask wearing from the early pandemic period (March to May 2020) to more recently in June 2021, as well as predictions for the future (the ‘new normal’) as shown in Figure 4:

- At the **beginning of the pandemic**, many public transport operators did not have a mandatory requirement for mask



**wearing.**

- In many cities, mask wearing was recommended but not mandatory, whereas the majority of the European operators had not implemented any mask wearing requirements at this stage of the pandemic.
- By **June 2021, masks had become mandatory on most public transport systems**, with the exception of some operators in the Asia/Pacific region where the pandemic had been largely contained up until this point.
- In the **longer term**, the future of mask wearing policies on public transport remains unclear as **few decisions have been made** in this area.
  - Transport for London maintained its mandate on mask wearing, contrary to a complete lifting of all COVID-19 restrictions and policies on a national level on 19th July 2021 (reinstated in December 2021 with the emergence of the new Omicron variant).
  - The US Federal Government has further extended its mask mandate from January 2022 to 18th March 2022<sup>5</sup>.

**Singapore’s special transit police unit responds to situations of mask refusal by passengers**

Singapore’s mask wearing and social distancing requirements on public transport are enforced by transit police and dedicated ambassadors:

- TransCom, Singapore’s **special transit police unit**, operates across stations, trains, bus interchanges and terminals and **responds to mask non-compliance**, particularly after continued refusal after being reminded to wear a mask.
- **Safe Distancing Ambassadors** are deployed to ensure adherence to social distancing requirements and to remind customers of the need to wear a mask.
- First-time offenders are given a SGD \$300 fine which increases with repeat offences.



Source: Paris RATP

**Figure 4:**  
Summary of Mask Wearing Requirements Over Time

Source: TSC/COMET



# Endnotes

- 1 <https://www.gov.uk/government/publications/events-research-programme-phase-i-findings/events-research-programme-phase-i-findings>
- 2 <https://www.octranspo.com/en/news/article/unlimited-no-charge-transit-in-december/>
- 3 <https://pendlertjek.dk/en>
- 4 <https://www.ratp.fr/en/groupe-ratp/newsroom/innovation/a-new-collaborative-feature-ratp-app-travel-peace-mind>
- 5 <https://www.transit.dot.gov/TransitMaskUp>

# References

## Relevant COVID-19 Literature

**Barbieri DM, Lou B, Passavanti M, Hui C, Hoff I, et al. (2021) Impact of COVID-19 pandemic on mobility in ten countries and associated perceived risk for all transport modes. PLoS ONE 16(2): e0245886.**

Description: A cross-country study researching the individual mobility patterns for all transport modes before and during restrictions. The study findings suggest that air and bus travel are perceived by the public to be the riskiest transport modes for COVID-19 transmission, and avoidance of public transport for commuting and non-commuting trips is found across all 10 countries included in the research.

**Dai J, Liu Z, Li R (2021) Improving the subway attraction for the post-COVID-19 era: The role of fare-free public transport policy. Transport Policy.**

Description: This paper reviews the impact of fare-free policies in three Chinese cities to attract passenger demand. The study identifies that the role of the fare-free policies in helping recover demand is limited and recommends the use of multi-pronged approaches in combination with fare-free policies.

**Di Carlo P, Chiacchiarretta P, Sinjari B, Aruffo E, Stuppia L, De Laurenzi V, et al. (2020) Air and surface measurements of SARS-CoV-2 inside a bus during normal operation. PLoS ONE 15(11): e0235943**

Description: Air and surfaces of buses in an Italian town were tested during regular operations with average passenger loads of 123 passengers per run. All air and surface samples tested negative for the presence of the Sars-Cov-2 virus, indicating the effectiveness of cleaning, ventilation, and social behaviour policies (i.e. social distancing and wearing of masks). It should be noted that the infection status of passengers at the time of testing was unknown.

**Dong H, Ma S, Jia N, Tian J (2021) Understanding public transport satisfaction in post COVID-19 pandemic. Transport Policy, Elsevier.**

Description: The aim of this research is to understand passengers' psychological responses to the pandemic over time as public transport begins to resume its operations with the pandemic almost entirely contained in China. A cross-sectional survey was conducted in eight cities of China where the public transport system had been temporarily closed because of the pandemic. The results indicated that (1) passengers' feelings of safety enhanced their overall satisfaction with regard to public transport, (2) state anxiety has a negative effect on perceived safety, (3) state anxiety increases as passengers are psychologically closer to the pandemic, and (4) passengers pay more attention to information that is psychologically closer to the pandemic and perceive lesser safety on public transport. These findings not only reveal the internal mechanisms behind how passengers

perceive safety but may also provide insight for future disaster emergency management. Based on the results, some feasible suggestions are proposed to avoid the loss of ridership and help public transport systems recover.

**Gkiotsalitis K (2021) Public transport planning adaption under the COVID-19 pandemic crisis: literature review of research needs and directions. Transport Reviews, Volume 41, Issue 3, Taylor and Francis.**

Description: This literature review aims to systematically review and synthesise the literature on the impacts of COVID-19 on public transport to identify the need to adjust planning measures, and, on the other hand, the existing methods for public transport planning at the strategic, tactical and operational level. Intervention measures that can support public transport service providers in planning their services in the post-shutdown phase and their respective modelling development requirements are identified. This can support the transition from the initial ad-hoc planning practices to a more evidence-based decision making.

**Ku, D., Yeon, C., Lee, S., Lee, K., et al. (2021) Safe traveling in public transport amid COVID-19. Science Advances, Volume 7, Issue 43.**

Description: Simulation of the exposure to infection on public transport and analysis of the risk of infection in an environment where mandatory prevention measures are in place. The simulation finds that the mandatory wearing of masks provides a similar effect to a 2m social distance in preventing COVID-19, whereas social distancing with masks during peak hours reduces infection rates by 93.5% and 98.1%, respectively.

**Hörcher, D., Singh, R., Graham, DJ., (2021) Social distancing in public transport: Mobilising new technologies for demand management under the Covid-19 crisis. Transportation.**

Description: This paper reviews the literature of five demand management methods to enforce social distancing on public transport and the practical applicability of each method: 1. inflow control with queueing, 2. time and space dependent pricing, 3. capacity reservation with advance booking, 4. slot auctioning, and 5. tradeable travel permit schemes.

**Hunt, M. (2020) Covid-19 Transmission Rates on Rail, Technical report, RSSB.**

Description: A recent report by the UK Rail Safety and Standards Board (RSSB) estimated the infection risk on UK rail as a function of the inter-personal contact risk, the number of contacts per journey, and any mitigating factors. The risk of infection was estimated to be 1 in 11,000 journeys or 0.009% per journey. The report was published in August 2020, and so infection parameters were based on disease dynamics at that

time. Since then, infection dynamics have altered with the introduction of new variants, and the RSSB acknowledges that the quoted infection risk is likely to increase.

**Moreno, T. et al (2021) Tracing surface and airborne SARS-CoV-2 RNA inside public buses and subway trains. *Environment International* 147 (106326) 1-11.**

Description: Air and surfaces of buses and subway trains in Barcelona were tested - 30 out of 82 air and surface samples showed evidence of target RNA genes of the Sars-Cov-2 virus, with surface swabs showing more positive results than air samples. After bus cleaning, there was a reduction in positive surface swab samples, however 4 from 30 samples still yielded positive results. Further testing on the efficacy of cleaning is recommended.

**Mutambudzi, M. et al. (2020) Occupation and risk of severe COVID-19: prospective cohort study of 120 075 UK Biobank participants. *Occupational and Environmental Medicine*.**

Description: Research identifies that essential workers have a higher risk of severe illness from COVID-19. Risk to public transport workers is found to be double that of non-essential workers.

**Tardivo A , Zanuy AC , and Martin CS (2021) COVID-19 Impact on Transport: A Paper from the Railways' Systems Research Perspective. *Transportation Research Record*.**

Description: Analysis of the impact of the COVID-19 pandemic on the rail sector identifies resilience, return, reimagination, reform, and research, as the necessary steps to provide service and enhance rail competitiveness and resilience in the event of future crises.

**Yabe, T., Tsubouchi, K., Fujiwara, N. et al. (2020) Non-compulsory measures sufficiently reduced human mobility in Tokyo during the COVID-19 epidemic. *Scientific Reports* 10, 18053.**

Description: A study of mobility patterns in Japan showed that reductions in mobility (attributed to soft lockdown policies) were associated with reductions in the case reproduction number.

**Zachreson C, Mitchell L, Lydeamore MJ, Rebuli N, Tomko M, Geard N. (2021) Risk mapping for COVID-19 outbreaks in Australia using mobility data. *Journal of the Royal Society Interface* 18: 20200657.**

Description: COVID-19 outbreaks in Australia were found to be well predicted by mobility data - especially at locations associated with habitual travel patterns e.g. workplaces.



# Contact us



## The TSC at Imperial College London

The Transport Strategy Centre (TSC), previously known as The Railway and Transport Strategy Centre, was established in 1992 as a centre of excellence serving the railway industry on strategic, economic and technology issues. Today, the TSC is a globally recognised team specialising in performance benchmarking, research and policy for industry and government.

The Applied Research Team within the TSC works directly with industry to improve performance in public transport worldwide, based on a systematic process managed and facilitated by the TSC through multi-year international benchmarking projects.

Imperial College London is a global university with a world-class reputation in science, engineering, business and medicine. Well known for its excellence in teaching and research, Imperial College London is consistently rated in the top 10 universities worldwide.

## Thank you for reading this report.

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# Appendix A

## List of Benchmarking Groups and Members

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### COMET

Community of Metros  
Benchmarking Group

#### American Metros

- Metrovías (Buenos Aires – Argentina)
- Washington Metropolitan Area Transit Authority (WMATA – United States)
- Sistema de Transporte Colectivo (STC – Mexico City)
- Société de transport de Montréal (STM – Canada)
- MTA New York City Transit (NYCT – United States)
- Ottawa-Carleton Transportation Commission (OC Transpo – Canada)
- Rio de Janeiro (Metrô Rio – Brazil)
- Metro de Santiago (Santiago – Chile)
- Bay Area Rapid Transit (BART – United States)
- Companhia do Metropolitano de São Paulo – Metrô (MSP – Brazil)
- Toronto Transit Commission (TTC – Canada)
- SkyTrain (BCRTC – Canada)

#### European Metros

- Transports Metropolitans de Barcelona (TMB – Spain)
- Berliner Verkehrsbetriebe (BVG – Germany)
- Société des Transports Intercommunaux de Bruxelles (STIB – Belgium)
- Docklands Light Railway (DLR – United Kingdom)
- Metro Istanbul San. Ve Tic. A.S. (Metro Istanbul – Turkey)
- Metropolitano de Lisboa (ML – Portugal)
- London Underground Limited (LUL – United Kingdom)
- Metro de Madrid (Spain)
- Moscow Metro (Russia)
- Tyne and Wear Metro, (Nexus – United Kingdom)
- Oslo Sporveien (Norway)
- Régie Autonome des Transports Parisiens Métro (RATP Métro – France)
- Régie Autonome des Transports Parisiens RER (RATP RER – France)

#### Asian Metros

- Bangalore Metro Rail Corporation Limited (BMRC – India)
- Bangkok Expressway and Metro Public Company (BEM – Thailand)
- Beijing Mass Transit Railway Operation Corp. (BMTROC – China)
- Delhi Metro Rail Corporation Ltd (DMRC – India)
- Roads and Transport Authority (RTA – United Arab Emirates)
- Guangzhou Metro Corporation (GMC – China)
- MTR Corporation Limited (MTR – Hong Kong)
- Jakarta MRT (Indonesia)
- Nanjing Metro Operation Corp. (China)
- Seoul Metro (South Korea)
- Shenzhen Metro Operation Corp. Ltd (China)
- Singapore Mass Rapid Transit Corporation Ltd (SMRT – Singapore)

- Shanghai Shentong Metro Group (SSMG – China)
- Syarikat Prasarana Negara Berhad (RapidKL – Malaysia)
- Taipei Rapid Transit Corporation (TRTC – Taiwan)
- Tokyo Metro Co., Ltd. (Japan)
- Sydney Metro (Australia)
- Sydney Trains (Australia)

## ISBERG

### International Suburban Rail Benchmarking Group

- Ferrocarrils de la Generalitat de Catalunya (FGC – Spain)
- Queensland Rail (Australia)
- S-Tog, Danish State Railways (DSB – Denmark)
- PRASA – Metrorail (South Africa)
- MTR Hong Kong (East Rail, West Rail, Tuen Ma & Tung Chung Lines – Hong Kong)
- MTA Long Island Rail Road (LIRR – United States)
- London Overground – London Rail (United Kingdom)
- Metro Trains Melbourne (Australia)
- MTA Metro-North Railroad (United States)
- S-Bahn Munich, Deutsche Bahn (DB) Regio (Germany)
- Commuter Rail, Vygruppen (Vy – Norway)
- Bay Area Rapid Transit (BART – United States)
- Sydney Trains (Australia)
- East Japan Railway Company (JR East - Japan)

## IMRBG

### International Mainline Rail Benchmarking Group

- Danish State Railways (DSB - Denmark)
- Irish Rail (Ireland)
- Nederlandse Spoorwegen (NS – Netherlands)
- Société nationale des chemins de fer belges (SNCB – Belgium)
- New South Wales TrainLink (New South Wales, Australia)
- Via Rail Canada (Canada)
- V/Line (Victoria, Australia)

## GOAL

### Benchmarking Group of North American Light Rail Systems

- Niagara Frontier Transportation Authority (NFTA – Buffalo, NY)
- Maryland Transit Administration (MTA Maryland – Baltimore, MD)
- Calgary Transit (C Train – Calgary, AB)
- Charlotte Area Transit System (CATS – Charlotte, NC)
- Dallas Area Rapid Transit (DART – Dallas, TX)
- Edmonton Transit System (ETS – Edmonton, AB)
- Hampton Roads Transit (HRT – Norfolk, VA)
- Ottawa-Carleton Transportation Commission (OCTranspo – Ottawa, ON)
- Pittsburgh PAAC (The T – Pittsburgh, PA)
- Tri-County Metropolitan Transportation District (TriMet – Portland, OR)
- San Diego Metropolitan Transit System (MTS – San Diego, CA)
- Sound Transit (ST– Seattle, WA)
- Toronto Transit Commission (TTC – Toronto, ON)
- Utah Transit Authority (UTA – Salt Lake City, UT)



**International Bus  
Benchmarking Group**

- Transport Metropolitans de Barcelona (TMB, Barcelona)
- Société des Transports Intercommunaux de Bruxelles (STIB, Brussels)
- Dublin Bus (Dublin)
- IETT Isletmeleri Genel Müdürlüğü (IETT, Istanbul)
- Rapid Bus Sdn Bhd (Rapid Bus, Kuala Lumpur)
- Companhia Carris de Ferro de Lisboa (Carris, Lisbon)
- London Buses (LBSL, London)
- Societe de Transport de Montréal (STM, Montréal)
- Mosgortrans (Moscow)
- MTA – New York City Transit (NYCT) & MTA Bus (New York)
- Régie Autonome des Transports Parisiens (RATP, Paris)
- King County Metro Transit (KCM, Seattle)
- SMRT Buses (Singapore)
- Transport for New South Wales (TfNSW, Sydney)
- Coast Mountain Bus Company (CMBC, Vancouver)



**American Bus  
Benchmarking Group**

- Capital Metropolitan Transportation Authority (Cap Metro – Austin, TX)
- Niagara Frontier Transportation Authority (NFTA – Buffalo, NY)
- Charlotte Area Transit Systems (CATS – Charlotte, NC)
- Dallas Area Rapid Transit (DART – Dallas, TX)
- Des Moines Area Regional Transit Authority (DART – Des Moines, IA)
- Greater Dayton Regional Transit Authority (GDRTA – Dayton, OH)
- Lane Transit District (LTD – Eugene, OR)
- Mass Transportation Authority (MTA – Flint, Michigan)
- Foothill Transit (San Gabriel Valley, LA County, CA)
- Hampton Roads Transit (HRT – Hampton, VA)
- Jacksonville Transportation Authority (JTA – Jacksonville, FL)
- Milwaukee County Transit System (MCTS – Milwaukee, WI)
- Orange County Transportation Authority (OCTA)
- Pittsburgh PAAC (Port Authority – Pittsburgh, PA)
- Regional Transit Service (RTS – Rochester, NY)
- Rhode Island Public Transit Authority (RIPTA – Providence, RI)
- Greater Richmond Transit Company (GRTC, Richmond, VA)
- Omnitrans (San Bernardino, CA)
- San Joaquin Regional Transit District (RTD – Stockton, CA)
- Pinellas Suncoast Transit Authority (PSTA – St. Petersburg, FL)
- Spokane Transit Authority (STA – Spokane, WA)
- Utah Transit Authority (UTA – Salt Lake City, UT)
- Clark County Public Transportation Benefit Area (C-TRAN – Vancouver, WA)



**RIAMBIG**

**Railway Infrastructure Asset Management  
Benchmarking Group**

- Queensland Rail (Brisbane, Australia)
- KiwiRail (New Zealand)
- Public Transport Authority Perth (Perth, Australia)
- Sydney Trains (Sydney, Australia)