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Considerations for Social Distancing on Public Transportation During the COVID-19 Recovery

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Issue

COVID-19 has presented public transit agencies with unprecedented operational and fiscal challenges. In the San Francisco Bay Area, for example, public transit ridership remains approximately 90% below pre-pandemic levels as of November 10, 2020, according to Transit App. It is generally agreed that personal protective measures (i.e., masks, face shields, gloves), sanitation, and air ventilation —combined with social distancing—reduces the spread of COVID-19. However, experts do not agree on the minimum distance required on transit. While some research exists, a recommended social distance for travelers in enclosed environments is not well understood and likely varies on a number of context sensitive variables discussed below.

Relationship of Masks, Ventilation, and Social Distancing

Properly worn masks provide two-way protection by containing the virus of the wearer and protecting others from the exhaled pathogen [1]. However, studies on the impacts of ventilation tend to vary on a variety of factors. For example, little or no ventilation can help reduce transmission of the virus to other people on a transit vehicle, but can also cause the virus to remain in the environment longer. In general, many studies suggest that the quality of ventilation—such as the number of air exchanges—the amount of fresh air, direction of air flow, and quality of air filtration can be important factors [2]. Additionally, the duration of a traveler's trip coupled with exposure to the virus could also impact the likelihood of transmission. However, there is a lack of quantifiable research on the duration of a transit trip in an enclosed space and the spread of COVID-19. Of the COVID-19

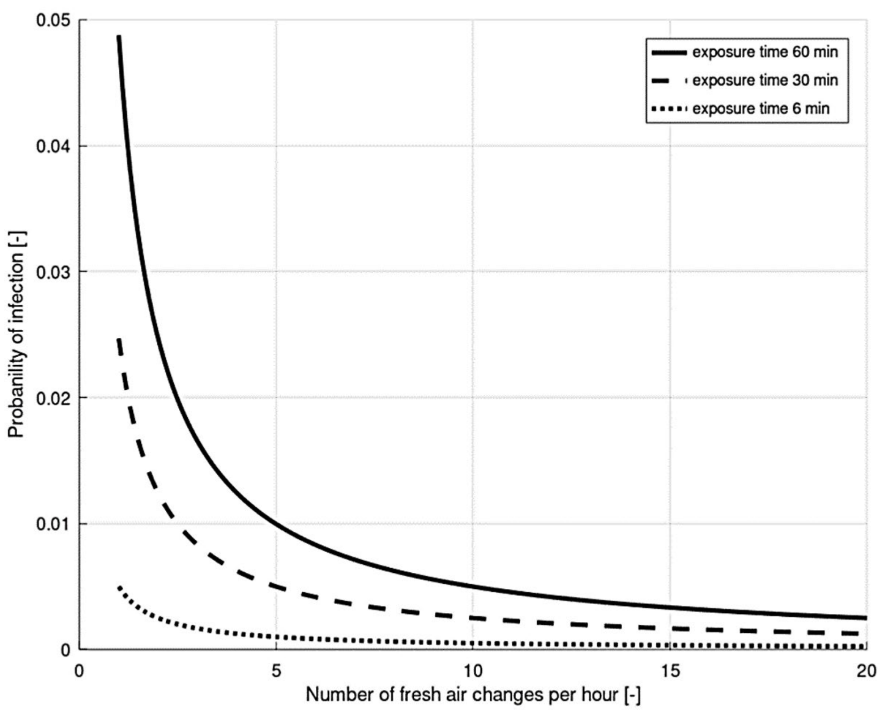
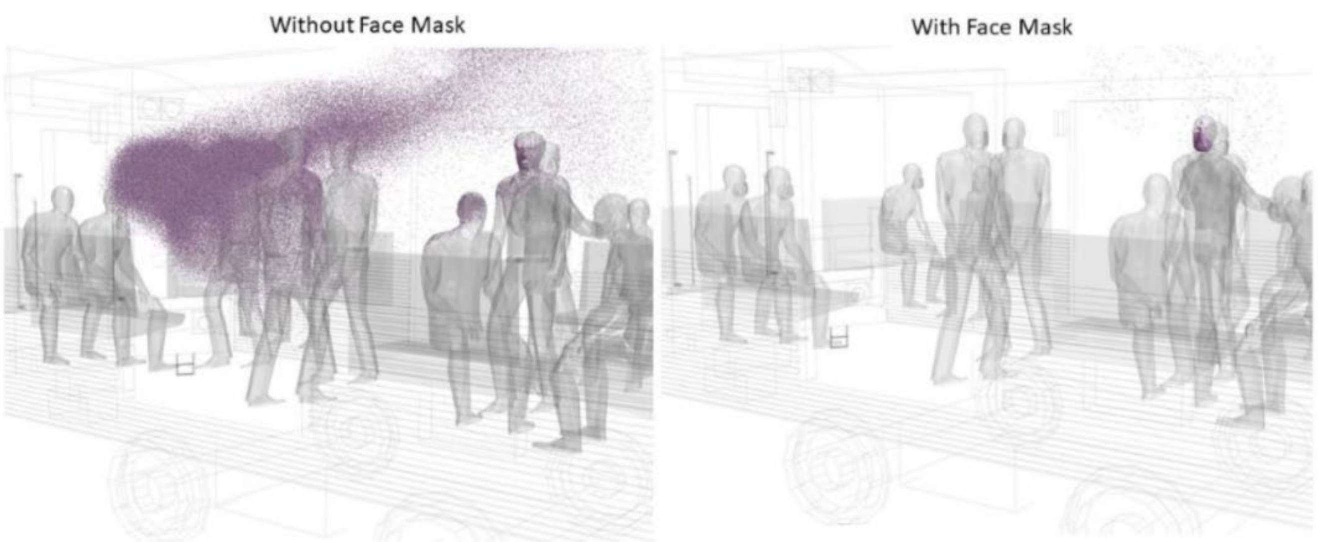


Figure 1. Impact of Fresh Air Exchange Rates on the Probability of Getting Infected

cases traced to transportation, the primary sources have been tour buses, planes, and cruise ships where travelers sit for extended periods of time with the same cohort of fellow passengers. However, these modes may not resemble the operational or behavioral patterns of intracity public transportation [2]. A study by the American Public Transportation Association (APTA) states “current HVAC systems in transit cars disperse the pathogen particles in a disordered way, helping pathogens to spread throughout the interior of the vehicle [and] may reach all the passengers in the car depending on the duration of a subway ride” [3]. However, the spread of infectious disease on bus transit may not be the same as subways. While both vehicles are enclosed spaces, the lack of ambient air underground and “piston effects” of pushing air through underground tunnels are some notable differences. The APTA study suggests the probability of contagion by infectious individuals in enclosed spaces can be determined by different air exchange rates using the Wells-Riley equation [3]. Although generic and not customized to a particular airborne virus or context, the equation suggests reduced probability of infection with an increasing number of air exchanges per hour [Figure 1]. Several factors could influence the potential transmission of infectious diseases, such as COVID-19, on public transportation. A combination of anecdotal and emerging research suggests that improving air circulation, minimizing speaking, requiring masks, social distancing, reducing the duration of travel, and other measures have the potential to further reduce the probability of infection [2] [3].

APTA also conducted a computational fluid dynamics simulation on a generic rail/subway car comparing a situation where a person standing coughs with and without a mask [4]. The analysis found that in cases where the individual who coughed wore a mask, most large airborne pathogen particles remained attached to the mask after coughing. The mask helped reduce the velocity of particles and kept concentrations close to the wearer’s face [Figure 2]. While small particles would remain in the air, the APTA study concludes it is unclear if their density and size are sufficient to infect other passengers [4]. Figure 2 highlights the probable importance of mask requirements coupled with enforcement, education, and outreach on proper ways to wear a mask and its role in protecting others.

Figure 2. Simulation of Airborne Pathogen Spread With and Without a Face Mask, 5 Seconds after Cough



Reprinted and truncated from [2]

In one case study involving an intercity bus trip, a symptomatic passenger rode a bus with 39 others for two hours without a mask, and infected five people. However, when the passenger put on a face mask before boarding his second bus, a 50-minute ride on a minibus with 14 other passengers, no transmission of COVID-19 was reported [5].

Epidemiologist Dr. Antonio Dans presented a meta-analysis of peer-reviewed articles on the effectiveness of physical distancing in public spaces using a variety of personal protective equipment (PPE) practices [Table 1]. The analysis suggests that one-meter (approximately 3 ft) of social distancing with non-N95 masks could be up to 94% effective for preventing the transmission of airborne pathogens compared to up to 97% efficacy with two-meter (approximately 6 ft) social distancing and non-N95 masks. Dans concludes that distancing and PPE must be used in conjunction to compensate for the lack of sufficient ventilation in indoor settings. In order to be effective, masks must be worn properly and enforced by public transit agencies. However, enforcement of mask policies by bus operators has the potential to escalate into violence against drivers by passengers who refuse to comply with the policy.

Table 1. Meta-Analysis of Effectiveness of Interventions for Preventing Indoor Transmission of Airborne Pathogens

PPE and Social Distancing Practice	Transmission Prevention	Risk of Transmission
Non-N95 Masks with Eye Protection	92.74%	7.26%
1M Distancing + Non-N95 Masks	94.39%	5.61%
2M Distancing + Non-N95 Masks	97.20%	2.81%
3M Distancing + Non-N95 Masks	98.60%	1.40%
4M Distancing + Non-N95 Masks	99.30%	0.70%
1M Distancing + Non-N95 Masks + Face Shields	98.77%	1.23%
2M Distancing + Non-N95 Masks + Face Shields	99.38%	0.62%
3M Distancing + Non-N95 Masks + Face Shields	99.69%	0.31%
4M Distancing + Non-N95 Masks + Face Shields	99.85%	0.15%

Reprinted and truncated from [6]

A recent study by Clipman et al. (2020) of 1,030 respondents representing 24 counties in Maryland found that social distancing results in a much lower chance of COVID-19 infection [7]. The study used an online recruitment through a survey firm with quotas for age, gender, race, and income based on the population of Maryland. Respondents were asked about the types and frequency of visiting different locations in the prior two weeks, including indoor locations (e.g., large gatherings, homes of friends and family members, gyms, salons, grocery stores, pharmacies, restaurants, places of worship) and outdoor locations (e.g., beaches and pools). Participants were also asked if they had used public transportation and about their social distancing practices and mask wearing at these locations. Using a multivariable analysis, infection was found to be significantly more likely among younger respondents, those who visited a place of worship, and those who took public transportation. The study found that a history of infection was about 4.3 times more common among participants who stated that they had used public transportation more than three times in the prior two weeks, compared to participants who stated they had never used public transportation in the two-week period [7]. However, in other locations (e.g., France and Japan) no coronavirus clusters have been found associated with public transit use.

Experts have noted that in Japan riders are more likely to comply with mask requirements and travel quietly on public transportation, reducing the spread of COVID through talking [8]. Others note that the lack of identifiable cases on public transportation may be due to the difficulty to trace and test individuals who rode a public transit line at a particular time of infection [8].

Studies on the “right” social distance on public transportation are limited and most simulate COVID-19 or study different microorganisms that may not have the same pathology. Hu et al. (2020) quantified the transmission risk of COVID-19 on high-speed rail in China using data from 2,334 index patients and 72,093 close contacts with travel times varying 0-8 hours between December 2019 and March 2020 [9]. The study found that an index patient had an average attack rate of 1.5% when seated in the same row and 0.32% when seated within three rows. The attack rate increased an average of 1.3% for each hour of co-travel for passengers in adjacent seats.

Setti et al. (2020) suggests that the six feet of social distance may be insufficient to prevent indoor airborne transmission of COVID-19, however, the study is not specific to public transportation [10]. Buhat et al. (2020) simulated the spread of infectious disease in the Manila Light Rail System and a 49-seat public bus. The simulations found that individuals must have protection with more than 90% effectiveness to inhibit transmission of the disease and physical distancing by more than 1m (3.28 feet) reduces the risk of being infected. Additionally, the study concludes that larger capacity transit vehicles will generate more infections, while smaller vehicles will cause travelers to be infected faster. The study concludes that a decrease in crowd density on larger vehicles or a decrease in travel time on smaller vehicles could be a strategy to help reduce infection [11]. Most importantly, the simulation found that “a person within 2 meters of an infectious individual will have a 50% chance of being exposed while a person within 1 meter of an infectious individual will have 100% chance of being exposed” [11]. However, exposure does not necessarily result in infection. Sanitation and personal protective measures (e.g., masks) can influence whether an exposed individual becomes infected [11].

In the U.S., the use of partitions on public transit has generally been limited to protecting the driver from passengers. However, others have suggested that adding shields or physical partitions between seats help increase capacity on public transportation [12] [Figures 3 and 4].

Figure 3. Example of Optimal Socially Distanced Seating With and Without Plastic Partitions

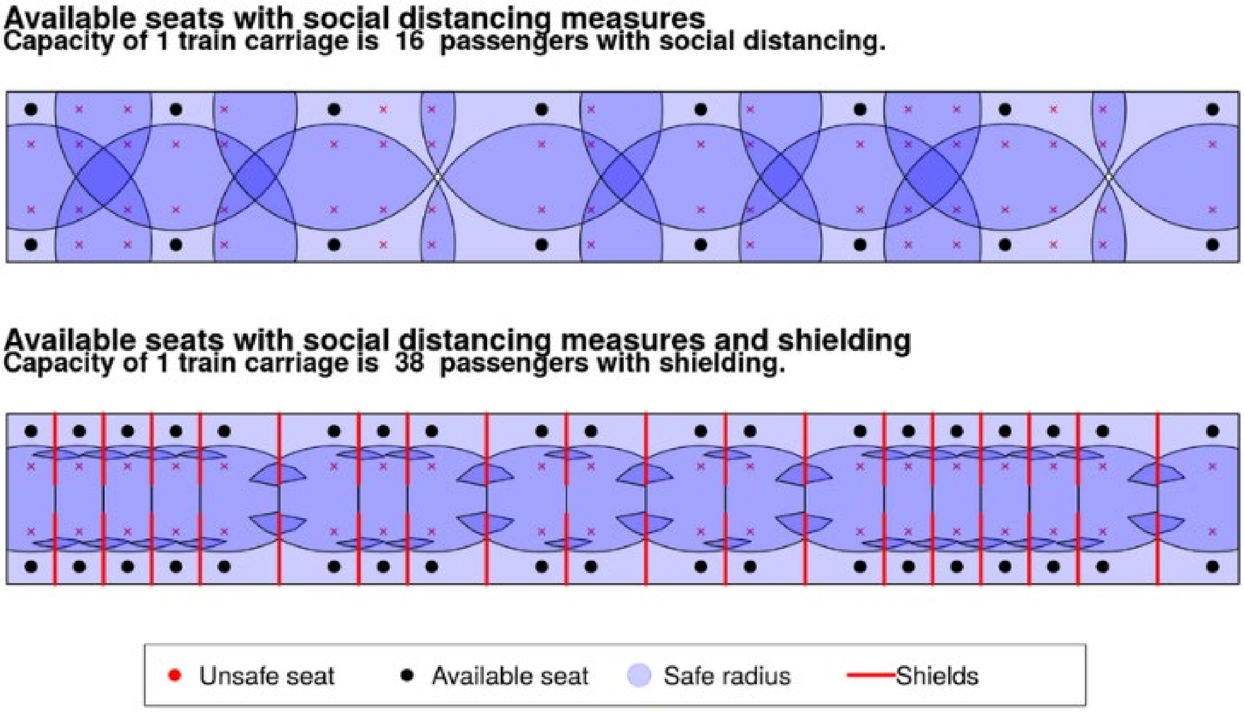


Figure 4. Example of Partitions on LRT-1 in Manila

Passenger Thresholds

Table 2. Reduced Vehicle Loads

	MBTA (3ft Distancing) [13]		Metro Transit [14]	
	40' Bus	60' Bus	40' Bus	60' Bus
No. of PAX	20	31	10	15
Percent of Peak Load	36%	39%	Not Available	Not Available

A few public transit agencies are beginning to propose and implement increased vehicle capacities. Table 2 shows vehicle load standards for the Massachusetts Bay Transportation Authority (MBTA, Boston) and Metro Transit (Twin Cities). Some transit agencies also alert riders that if a bus nears capacity, operators may bypass stops and turn on the "Drop-Off Only" head-sign. Riders on board can continue to exit buses at their requested stop [15].

International Practices

A study by WSP conducted a literature review comparing international social distancing and mask guidelines as of May 2020. The study found that most countries recovering from the pandemic have varying policies on public mask use and consider 1 (3.28 feet) to 2 meters (6.56 feet) to be a minimum safe distance [16] [Table 3]. However, the report notes that public transportation practices can vary widely as a result of public health guidance, with some countries establishing more stringent policies. While the Centers for Disease Control (CDC) recommends a 6-foot minimum physical distance in public spaces (and to the extent possible on public transportation), the San Francisco Bay Area's Healthy Transit Plan recommends public transportation agencies provide a minimum of 3-foot physical distancing [17]. The study by WSP also notes that some countries recommend or require the public to wear face masks, while others do not. As such, some public transit agencies have adopted face mask policies while others have not [16].

In Manila, Philippines, the Department of Transportation (DOTr) began reducing physical distancing requirements from one meter to 0.75 meters in mid-September 2020. DOTr adopted an ambitious approach to reduce distancing requirements every two weeks, down to 0.5 meters in late September and 0.3 meters in mid-October [18]. Within days after implementing the 0.75 distancing requirements, the policy was reversed when public health officials identified a clustering of cases associated with transportation settings [19] [20].

A number of other studies around the world have not found a link between contagion clusters and public transportation. In other East Asian countries, some governments have implemented policies of social distancing less than one meter (e.g., Singapore). However, these countries tend to have strict compliance with public safety protocols, near ubiquitous mask usage, and limited talking on public transportation—all of which can help reduce the spread of airborne pathogens. Anecdotal evidence suggest that the U.S. is unlikely to achieve that level of conformity in an American cultural context. Additionally, strict enforcement may not be practical or lawful.

Taiwan is widely recognized as a success story for pandemic containment. As of October 2020, the government reported just over 500 total cases among a population of nearly 24 million. Taiwan implemented a number of measures above and beyond compulsory masks and social distancing to reduce the spread of COVID-19. Both Taiwan Railways and Taipei metro required temperature taking using infrared cameras and banned anyone from boarding with a temperature of 100.4F or higher. Those arriving to the island were banned from using public transport until they completed a quarantine. The government also employed up to hourly cleaning on its public transit vehicles [21].

Table 3. International Comparison of Physical Distancing and Mask Guidelines for the General Public

	World Health Organization	European Centre for Disease Prevention & Control (ECDC)	China Ministries of Health	Australian Government Department of Health	New Zealand Ministry of Health	US Centers for Disease Control & Prevention (CDC)	Public Health Agency of Canada
Recommended minimum safe physical distance for the general public	1 meter (3.28 feet)	1 meter (3.28 feet)	1-1.5 meters (3.28-4.92 feet)*	1.5 meters (4.92 meters)	1-2 meters (3.28-6.56 feet)**	1.83 meters (6 feet)	2 meters (6.56 feet)
Recommended general public use of mask or face covering	Only if you are unwell	Only if you are unwell	Yes	Only if you are unwell	Only if you are unwell	Yes	Yes

*Depends on province and other conditions; **1 meter for people that you know; 2 meters for strangers; *Reprinted from* [15]

The Role of Community Transmission

A white paper by Sam Schwartz Engineering suggests that COVID-19 case rates could be tied to community spread, rather than correlated to public transit ridership; however more research is needed. For example, the study notes that as of September 2020, public transit ridership had stabilized in Austin, Columbus, Hartford, Salt Lake City and San Francisco. However, in Hartford COVID-19 cases had fallen while in Austin, Columbus, Salt Lake City, and San Francisco, COVID-19 cases had rapidly increased [2]. The white paper also points out that in New York City, there were 150 million public transit rides taken between June and mid-August 2020, yet the positive COVID-19 test rate dropped from 3.3% to 1.0% over this same period [2]. However, a recent study by McLaren (2020) concludes that public transit ridership may contribute to the disparity of COVID-19 deaths among minority populations, when accounting for other factors such as income, poverty, education, occupation, and healthcare insurance [22].

Public Perception

Transit agencies may also consider public perception and the potential risk that reduced social distancing could have on rebuilding rider trust. In Honolulu, for example, the Department of Transportation Services adjusted rider limits on urban routes. The agency limits standard buses to 20 passengers and large buses to 30 passengers (similar to MBTA) between 6AM and 6PM. However, riders have posted pictures and video on social media showing crowded buses during off-peak periods, raising concern among some riders [23]. As such, public perception may be important among agencies trying to rebuild trust and confidence in public transportation post-COVID. Public transit agencies may consider implementing periodic surveys on how reduced social distancing may impact their perceptions and willingness to ride public transportation during the pandemic recovery period.

Demand Management Practices

Implementing demand management practices may be one way to mitigate potential rider concerns about reduced social distancing protocols. There are a number of passive and active demand management strategy policies that could be considered in conjunction with reduced social distancing that may be help to reduce potential risks of overcrowding and infection. For example:

- Transit agencies with real-time passenger counters can add crowding information to their smartphone apps and websites, letting travelers decide if they want to board or wait for the next vehicle;

- METRO in Harris County, Texas, has reduced seating by 50 percent by tagging seats as unavailable in order to adhere to social distancing measures. Once buses have reached capacity, digital signs advise individuals to wait for next bus [24];

- Chicago Transit Authority (CTA) is managing overcrowding by giving bus operators authority to run as "drop-off only" and bypass certain bus stops if their bus is becoming crowded. Any stops that a bus passes up will be served by the following bus on that route [25]; and

- Seat reservation policies, such as: 1) a reserved seating model where passengers are assigned to a seat or 2) a no seat assigned reservation model where passengers are assigned to a transit vehicle but can make the choice which seat to use. Seat reservation policies can help public transit agencies collect rider data to support contact tracing and reduce social interaction (e.g., assigning seats based on origin and destinations to minimize social contact) [26].

Policy Considerations

The vast majority of literature suggests that requiring masks and social distancing are the two most important measures to reduce the spread of COVID-19. While masks generally reduce the spread of the virus, some masks can also protect the wearer (e.g., N95/KN95 and N99). Some studies suggest that physical distancing may be less important in situations where individuals are masked, not talking, together for a brief period of time, and there is efficient ventilation [2] [27] [28]. Although research on precise social distance recommendations on public transportation vary, some key considerations public transit agencies may consider in their decision-making:

- What is transit's health, fiscal, operational, and public affairs priorities?

- What measures are needed to keep public transit agencies fiscally solvent?

- Are there additional health and demand management practices that could be implemented alongside reduced social distancing requirements?

- What type of enforcement is available to ensure compliance with PPE requirements?

- Should there be greater distances in priority seating areas designed for vulnerable populations?

Finally, the availability of an effective vaccination and/or treatments that dramatically reduce the mortality rates of COVID-19 could justify the reduction of social distancing required on public transit during the pandemic recovery phase. Public transit agencies should work closely with public health officials to actively monitor the latest epidemiological research, conduct contact tracing, and adapt policies and procedures based on the latest advice from the medical community.

References and Further Reading

[1] International Union of Railways (2020). UIC COVID-19 Task Force. Railsilience: Masks Ventilation and Social Distancing. https://uic.org/IMG/pdf/railsilience_masks_ventilation.pdf

[2] Sam Schwartz Engineering (2020). Public Transit and COVID-19 Pandemic: Global Research and Best Practices. https://www.samschwartz.com/apta-public-transit-and-covid19-report

[3] International Association of Public Transport (2020) Public Transport Is COVID-Safe. https://cms.uitp.org/wp/wp-content/uploads/2020/10/Policy-Brief-PTisCOVID-Safe.pdf

[4] American Public Transportation Association. (2020). Transit Leadership in the Post-COVID-19 Mobility Landscape. Part One: Measures to Promote Safe Mobility.

[5] Xiaopeng Liu and Sisen Zhang (2020). COVID-19: Face masks and human-to-human transmission https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7228242/

[6] https://twitter.com/nababaha/status/1304809394408833025/photo/1

[7] Steven Clipman et al. (2020). Rapid real-time tracking of non-pharmaceutical interventions and their association with SARS-CoV-2 positivity: The COVID-19 Pandemic Pulse Study. Clinical Infectious Diseases, https://doi.org/10.1093/cid/ciaa1313

[8] Feargus O'Sullivan (2020). In Japan and France, Riding Transit Looks Surprisingly Safe https://www.bloomberg.com/news/articles/2020-06-09/japan-and-france-find-public-transit-seems-safe

[9] Maogui Hu et. al. (2020). Risk of Coronavirus Disease 2019 Transmission in Train Passengers: An Epidemiological and Modeling Study, Clinical Infectious Diseases, https://doi.org/10.1093/cid/ciaa1057

[10] Leonardo Setti, et al. (2020). Airborne Transmission Route of COVID-19: Why 2 Meters/6 Feet of Inter-Personal Distance Could Not Be Enough. Int. J. Environ. Res. Public Health, 17, 2932. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7215485/

[11] Christian Buhat et al. (2020). Modeling the Transmission of Respiratory Infectious Disease in Mass Transportation Systems. medRXiv,. https://www.medrxiv.org/content/10.1101/2020.06.09.20126334v1.full.pdf

[12] Beth Daley (2020). Social distancing is making public transport worse for the environment than cars – here's how to fix it https://theconversation.com/social-distancing-is-making-public-transport-worse-for-the-environment-than-cars-heres-how-to-fix-it-142299

[13] Ally Donnelly and Jim Haddadin (2020). MBTA Sets New Guidelines for Overcrowding as More Riders Return https://www.nbcboston.com/news/local/mbta-sets-new-guidelines-for-overcrowding-as-more-riders-return/2129012/

[14] https://www.metrotransit.org/health

[15] AC Transit (2020). Passenger Limits and Protective Wear (COVID-19 Service Updates) http://www.actransit.org/passenger-limits-and-protective-wear-covid-19-service-updates/

[16] WSP (2020). Global Practicesfor Protecting Employee and Customer Health During the COVID-19 Pandemic https://new.mta.info/document/17981

[17]Health Transit Plan (2020). Riding Together: Bay Area Healthy Transit Plan http://healthytransitplan.com/

[18] Alexis Romero, Neil Jayson Servallos, Sheila Crisostomo, Vince Nonato (2020). Reduced Commuter Distancing Up For Review; DILG Agrees More Public Transportation Must Be Deployed. https://www.onenews.ph/reduced-commuter-distancing-up-for-review-dilg-agrees-more-public-transportation-must-be-deployed

[19] Michelle Abad (2020). What the WHO, experts, studies say about physical distancing in transport https://www.rappler.com/newsbreak/iq/what-who-experts-say-physical-distancing-transport

[20] Sharleen Banzon (2020). It's official: One-meter distancing to be maintained in public transport https://www.topgear.com.ph/news/motoring-news/one-meter-distancing-public-transport-duterte-a2578-20200919

[21] Hannah Steinkopf-Frank (2020). Public Transport Revisited To Limit Contagion Squeeze. https://worldcrunch.com/coronavirus/public-transport-revisited-to-limit-contagion-squeeze

[22] Jolanie Martinez (2020). Crowded buses stir rider concerns over COVID safety on city transportation https://www.hawaiinewsnow.com/2020/09/07/crowded-buses-stir-rider-concerns-over-covid-safety-city-transportation/

[23] John McLaren (2020). Racial Disparity in COVID-19 Deaths: Seeking Economic Roots with Census Data. National Bureau of Economic Research. Working Paper 27407. https://www.nber.org/system/files/working_papers/w27407/w27407.pdf

[24] Metro (2020). METRO Safety Measures and Service Modifications in Response to COVID-19 https://www.ridemetro.org/Pages/Coronavirus.aspx

[25] City of Chicago (2020). Mayor Lightfoot Announces CTA To Provide Rear Door Boarding, New System to Reduce Crowding on All Buses https://www.chicago.gov/city/en/depts/mayor/press_room/press_releases/2020/april/BusRearDoorEntry.html

[26] Social Distancing on Public Transport (2020). https://www.railway-technology.com/contractors/computer/sqills-ticketing/pressreleases/social-distancing-public-transport/

[27] Derek K Chu, Elie A Akl, Stephanie Duda,Karla Solo,Sally Yaacoub,Holger J Schünemann,Derek K Chu,Elie A Akl,Amena El-harakeh,Antonio Bognanni,Tamara Lotfi,Mark Loeb,Anisa Hajizadeh,Anna Bak,Ariel Izcovich,Carlos A Cuello-Garcia,Chen Chen et al. (2020). Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis. The Lancet. https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)31142-9/fulltext

[28] Jones Nicholas R, Qureshi Zeshan U, Temple Robert J, Larwood Jessica P J, Greenhalgh Trisha, Bourouiba Lydia et al. Two metres or one: what is the evidence for physical distancing in covid-19? BMJ 2020; 370 :m3223 https://www.bmj.com/content/370/bmj.m3223

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