

Urban Transportation and how its Future will be affected by COVID-19

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June 2020-August 2020

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Profiles

Program Coordinator: Sruthi Suresh



Sruthi Suresh is a high school senior who is passionate about STEM education. She is the leader for AGRAJ STEM Research an organization whose main objective is to develop interest among students especially for underprivileged students. She is a Governor's STEM scholar 2021. Agraj Seva Kendra is a nonprofit organization which provides an opportunity to students to apply creativity and critical thought to the solutions of Science, Technology, Engineering, Arts and Mathematics (STEAM) beyond the confines of the classroom. During the summer, Sruthi Suresh came up with an idea to involve fellow students in research experience. The idea of doing a service project was born. As the Program Coordinator of "Allies Against COVID-19: Implications of COVID-19 and Future Proceedings for Pandemic" Sruthi recruited students and selected and formed different teams under subject matter experts from industries. One of the team is: "Urban Transportation and how its future will be affected by COVID-19."

"Urban Transportation and how its future will be affected by COVID-19" Team

Advisor: Noorie Rajvanshi



Noorie Rajvanshi is Staff Scientist at Siemens with more than ten years of experience in the field of environmental sustainability, energy and urban development. She currently serves as chief data and strategy

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Noorie's previous work in urban development focused on evaluating environmental and economic impacts of growing cities and collaborating with cities across the North America to identify technology and infrastructure solutions that best fit the city's energy demand and production characteristics using in-house City Performance Tool (CyPT). Noorie has led consulting projects with more than 15 cities across North America, through which she collaborates with Mayors' Offices, City departments, utilities, transit agencies, and more to collect data, test results, and create pathways for leveraging technology to reach the economic and environmental targets.

Prior to joining Siemens, Noorie graduated from the University of Florida with a PhD in Mechanical Engineering and a minor in Environmental Engineering. Her graduate work was funded through an interdisciplinary NSF-IGERT fellowship program. Following the PhD, Noorie worked as a post-doctoral fellow at the Center for Life Cycle Analysis (CLCA) at Columbia University, studying the impact of crystalline silicone photovoltaics.

Noorie served as a Research Fellow for Project Drawdown where she authored 3 chapters in the New York Times Bestseller book "Drawdown: The most comprehensive plan ever proposed to reverse global warming." She is an active member of several organizations including the [Association of Climate Change Officers](#) and [The Corporate EcoForum](#) where she has been inducted into the CEFNext Community Practice of Leaders.

Teaching Assistant: Archana Pradeep



Archana Pradeep is a senior at Monroe Township High School. Her favorite course in high school is biology, and she hopes to explore this field further by pursuing a career in the medical field. Apart from academics, her hobbies include singing and dancing, and she enjoys volunteering at Saint Peter's University Hospital. She also loves spending time with her family and working with kids, all of which has inspired her dream to become a pediatric oncologist. Collaborating on this research project opened her eyes to the field of urban transportation and sustainability and how deeply it is being affected by COVID-19. Furthermore, this project was a valuable experience that helped further educate her on the role of transportation and sustainability in society.

Profile of Authors

Shweta Iyer



Shweta is a high school senior who was introduced to the concept of sustainability through a school project about smart cities, which sparked her interest in sustainable urban infrastructure. Having studied civil/mechanical engineering in high school, she is planning to pursue a career in civil engineering and hopes to help promote sustainability through this career. Outside of school, she is part of the Events Team of Bye Bye Plastic Bags New Jersey, in which she helps organize events to raise awareness about environmental issues. She also spends some of her time tutoring children in mathematics through the STEMnijas organization. In her free time, she enjoys reading, writing stories, and spending time with her family.

Sanjana Kaloth

Sanjana Kaloth is 14 years old and in her freshman year of high school. She is a passionate dancer and singer, and also enjoys painting and enjoying nature. Sanjana was one of the junior shadows in this project and researched the changes in perceptions of public transport and how they affect low-income communities.



Mahanth Komuravelli

Mahanth Komuravelli is currently an 8th grader at Monroe Township Middle School. He enjoys playing the piano, and has been learning for over 6 years. Mahanth is interested in the subjects Math and Science, and loves competing in Math competitions. He enjoys conducting research on mostly science-related topics. He enjoyed assisting on this research paper and loved the overall experience.

Nishi Desai

Hello, my name is Nishi Desai and I am a sophomore in high school. Currently, I am in the S.T.E.M Academy for the Biomed field. I have been learning classical dance for the past 5 years. My hobbies include cooking, reading, and painting. I gained valuable experience volunteering at the Centrastate Hospital.



Leah Thomas

Hello, my name is Leah Thomas, and I'm currently a senior in high school. I live in Dallas, Texas and have spent most of my life here. In the coming years I would like to be work for a company involved in Biology research, but this project allowed me to understand the influence that Biology has on Urban Transportation and Sustainability through COVID-19, so a focus on Sustainability in a future career would peak my interest as well. Outside of Academics, I love to sing, dance, play piano, and write. I'm also very driven by my faith and family and I really enjoyed being a Research Analyst for this project and working with my Junior Shadow, Sanjana Kaloth!



Gaurika Suresh

Hi, my name is Gaurika Suresh! I am currently a junior at Waubonsie Valley High School, Aurora, IL. I am an active participant in music and business activities. I am in Waubonsie's "Soundcheck", one of the top show choirs in the state of Illinois. My love for business and finance comes from an awesome club called "Business Professionals of America". I love being involved in my community through volunteering or any other kind of service. Out of school, I love to spend time with my friends and make good memories with them.



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Executive Summary

In less than 10 years 60% or more of the world's population will be living in urban areas¹. The growth of urbanization is creating unprecedented challenges for cities and local governments that will result in profound impacts on the quality of life for city residents. Transportation is an important aspect of daily routine for urban dwellers. Whether it is use of public transit to get to work or school or using car sharing services, sidewalks or other modes of active transit, inhabitants of a city rely heavily on various transportation modes. In recent years, cities have faced a lot of challenges due to population growth, aging infrastructure, urban sprawl and densification and have been actively trying to solve these shifting transport needs through actively planning various mobility networks.

The current COVID-19 pandemic has thrown a wrench into this planning and how urban planners have viewed the future of transportation in cities. The pandemic has completely disrupted our understanding and vision of urban transportation and has thrust questions of future of urban mobility – Will cities recover? What will public transit look like? Will they be more inclusive and kinder to lower income neighborhoods? Will private cars reduce or expand their dominance over public streets and spaces? Will uptake of new technologies like autonomous vehicles accelerate, post-pandemic?

This work is a collection of research papers by high school students who participated in 8-week summer program set up by Agraj Seva Kendra to research Implications of COVID-19 and Future Proceedings for Pandemic.

This particular group of 7 students set forth to investigate the future of urban transportation after COVID. The work has been organized as chapters with four independent topics.

Chapter 1 investigates main concerns urban transportation might have post-COVID. Would people care more about safe, sustainable, or economic transportation.

Chapter 2 asks the question – will cities be more inclusive post-COVID? How would any changes to public transit impact low-income neighborhoods?

¹ United Nations, Department of Economic and Social Affairs, Population Division (2019). World Urbanization. <https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf>

More and more companies are advocating work from home as a permanent option for their employees, in addition virtual school might also become a reality. Chapter 3 looks at how this will impact the urban transportation.

Finally chapter 4 investigates how the uptake of new transportation technologies particularly autonomous vehicles might be accelerated due to the pandemic.

CHAPTER 1

The Main Concerns of the Transportation Industry in the Aftermath of the COVID-19 Pandemic

Shweta Iyer and Mahanth Komuravelli

Introduction

Transportation is the backbone of cities around the world. Whether it refers to cars, trains, buses, bikes, or our own feet, it is used by people of all ages and all backgrounds. It is how we get from one place to another, how we go about our daily business, and it is what keeps our cities running. In recent years, as the issue of climate change and pollution has become a major dilemma, the transportation industry has been moving towards the goal of sustainability. There has been an increase in public transportation usage, shared mobility, and the electrification of both private and public vehicles.

The arrival of COVID-19 has impacted people across the world, affecting a wide range of businesses and industries. The transportation industry has especially been hit hard during this pandemic. This crisis has changed the direction that we are heading in for the future. As expected, travel has decreased dramatically in the past few months. Road travel in the United States alone has decreased by 50% [1] and in the UK, it has dropped by 73% [2]. Shared mobility and public transportation have also suffered as the risk of contracting the virus is greater due to the lack of social distancing in these modes of transportation. Public transportation usage has decreased by 70 to 90% in large cities around the world and ride-hailing services have dropped by 60 to 70% [3]. Meanwhile, the biking industry is experiencing a tremendous profit as the number of people using bicycles as a form of transportation has increased.

Arguably, the three most vital aspects of transportation are being safe, sustainable, and economically beneficial. These three aspects are all interrelated, but prior to the pandemic, the transportation industry focused primarily on using technology to make transportation safer, faster, and more efficient. Cities were also starting to pay more attention to altering transportation to help transition towards a sustainable and environmentally friendly future.

However, with the pandemic instilling a fear of contamination in people's minds and hurting the economy severely, the primary focuses of the transportation sector will most likely shift towards making transportation safe and economically beneficial. However, sustainable transportation will still be indirectly focused on and promoted in the process, as it will be used to aid the other two aspects.

Literature Review

A. Traveling Safer and Smarter

Safety has always been a main priority of the transportation industry, but the way that it has been perceived has changed over the years. Many new technologies that emerge are targeted towards making transportation safer and helping all types to coexist safely.

Public transportation has long since been viewed as a safer mode of transportation than automobiles. An estimated 1.2 million deaths occur each year due to vehicle accidents [9], with almost 1.35 million vehicle-accident related deaths in 2016 [8]. On the other hand, public transportation has a 90% less chance of an accident occurring than an automobile does [5]. As a result, many people are shifting over to public transportation due to this as well as other factors such as lowered costs and travel time.

In the past few years, autonomous vehicle (AV) technology and artificial intelligence (AI) is also being used considerably in the area of making transportation safer. With more than 90% of road accidents being caused by human error in the EU alone [8], AVs could be the way forward. AI can use real-time data to accurately predict the shortest route with the least traffic possible and using an AV would remove the occasional human error of taking the wrong direction, which reduces the inefficiency of trips. People will be able to reach their destinations quicker and spend less time on the road, which reduces the amount of fuel used and consequently reduces costs and GHG emissions.

During the pandemic, decreased travel reduced the number of vehicle accidents that occurred. France reported a 40% decrease in deaths caused by road accidents and California experienced a 50% decrease in serious injuries caused by accidents [11]. However, this is no longer the only concern with regard to transportation safety. COVID-19 has drastically changed the world's definition of what is considered "safe transportation". Previously, safe transportation would be defined as having a reduced risk of accidents and crashes, a category under which

automobiles would not necessarily fit. However now, safe transportation also refers to a reduced risk of contracting illnesses, a category that private automobiles now correspond to.

Transportation industries are now tasked with adjusting transportation so that social distancing can be followed. Consequently, several ride-sharing companies have experienced a significant decrease in ridership as people are now hesitant to use a vehicle that was used by strangers who could spread the virus. While ride-sharing has gone down, biking is now being seen as a safer mode of transportation and is being used more frequently, with some bike businesses seeing as much as a 200% increase in orders [12]. In regard to public transportation, this would mean a significant decrease in riders. It is estimated that to meet social distancing requirements, public transport systems will need to reduce its capacity to 15 to 35 percent of previous capacity [10]. Currently, public transportation systems are taking several different steps to enforce social distancing rules. Cities are trying to encourage those for whom public transportation is not required to use other forms of transportation or simply stay at home. In some countries, such as France, peak hour transportation is reserved for workers and students [10]. In this way, priority is being given to essential and front-line workers and those for whom public transportation is the only affordable option. With the help of individual businesses, companies, schools, and city governments, transportation systems are also working to make start times for different activities more flexible and spread throughout the day to reduce transportation demand during peak hours.

Public-transit occupancy during peak travel periods can far exceed the level that permits safe physical distancing.

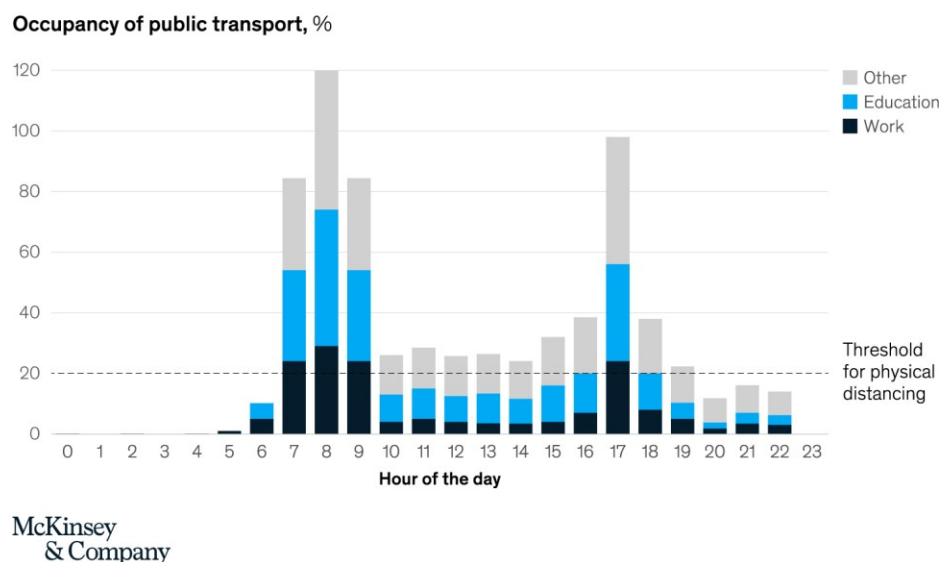


Figure 1: Public Transportation Capacity [10]

Overall, transport systems' main goal now is to ensure that social distancing is followed and that crowds are avoided. Social distancing and safety issues will also greatly reduce the number of people who can/will take public transit, leaving them to find another transportation mode.

Furthermore, with the rate of progress of AI and AVs before the pandemic, it is likely that these technologies will play a large part in the future of transportation post-COVID-19.

B. The Impact of the Transportation Industry on the Environment

Of all the carbon dioxide emissions produced by all world industries, the transportation sector contributes to almost 22% of that [4]. Moreover, between 25 to 30% of all global greenhouse gas emissions are produced by the transportation industry alone [4]. Several harmful gases are released into the air from different types of vehicles. They can then be inhaled which can cause several health complications including reduced lung function and respiratory problems [4]. In fact, air pollution causes an estimated 4.2 million deaths each year [2].

Before COVID-19, certain steps were being taken to make transportation more sustainable and to lessen the magnitude of the impact that it has on both environmental and human wellbeing. Technologies such as autonomous and electric vehicles were being studied and implemented more often. Electrification of vehicles, especially public transit vehicles, is seen as one of the main potential solutions to reducing emissions. Furthermore, of all vehicles, automobiles contribute the most to emissions. As a result, steps were being taken to reduce automobile usage. Many cities were experiencing a decrease in the number of workers who drove alone, while there was an increase in public transit, biking, and walking. In fact, an increase in public transportation usage has been in effect for several years, with a 28% increase since 1995 [5]. While the pandemic has slowed the progress of some of these efforts, it has led to a development in others.

One benefit of the pandemic is that with the decrease in travel due to the lockdown, emissions have decreased in the short term. There has been a 5.5 to 5.7% decrease in carbon emissions overall; Paris experienced a drop in nitrogen oxide levels of 70% and Delhi, which has had terrible air quality in the past, experienced a 75% decrease in PM2.5 pollution (particles that are 2.5 micrometers in diameter) [2]. Although this has resulted in benefits for the short term, it also brings up the question of the long term.

As expected, the lockdown resulted in a decrease in travel, however, the public transportation industry was especially affected. Public fears over contamination and the difficulty in social distancing has led to a decrease in public demand. Reduced frequency as well as lower

capacity of public transport systems has also further reduced the number of riders. Avoiding public transportation and other forms of shared mobility isn't a trend that is going to go away soon and it could have terrible implications for the future. For example, if only 1 in four people who previously traveled by transit and carpool began to drive alone, the city of San Francisco could see a rise in travel times by 20 minutes. This number could increase to 40 if 3 in 4 workers switched [6]. As a result, traffic congestion would increase greatly, resulting in even more inefficient fuel consumption as travel times increase, thus leading to an increase in emissions.

However, another trend that is becoming more popular during the lockdown is the use of biking and walking to travel. As BBC reports, the month of March saw an increase in bike-share system usage of 150% in Beijing and 67% in New York [2]. With fewer cars on the road (resulting in safer conditions and better air quality), more people are willing to bike or walk to their destinations.

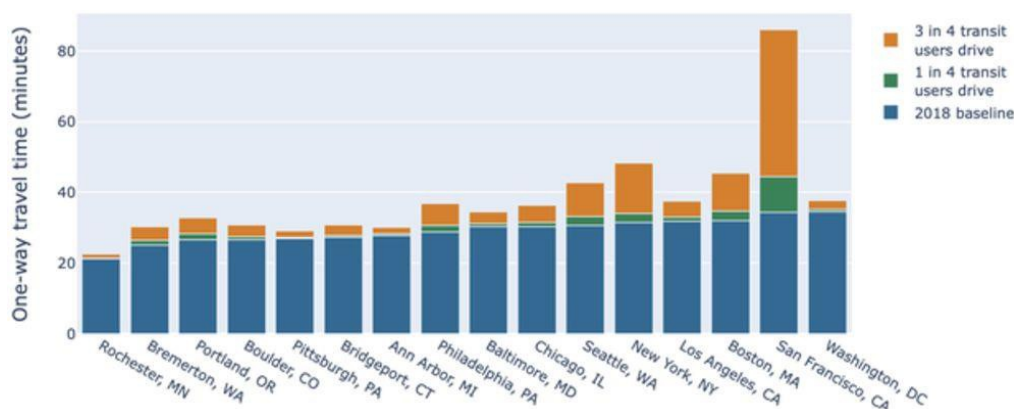


Figure 2: Travel times for different cities under certain conditions [6]

To further encourage these types of transportation and to ensure that social distancing requirements can be followed, cities have been making changes to regulations and infrastructure. Many cities have created temporary pop up bike lanes and widened sidewalks. Bogota, for example, opened 75 miles of roads to cyclists, Lima created 300 kilometers of new bike lanes, and Oakland blocked off 10% of streets to road vehicles [7].

Unfortunately, the post COVID transportation industry will face the task of restoring the public's confidence and trust in shared mobility and public transportation, preventing an increase in private vehicle usage, and encouraging the use of walking and biking.

C. Transportation's Role in the Economy

The travel industry is one of the biggest contributors to the economy, generating \$5.7 trillion in revenue and contributing 319 million jobs to the market [15]. In other words, the sector employs about 1 in every 10 people [15]. The travel industry is also linked to other industries such as tourism and construction, which provides millions of other occupations such as construction workers/planners, engineers, hotel workers, restaurant workers, etc. In summary, the travel industry is a crucial part of the economy.

The COVID-19 pandemic has greatly impacted the economy, placing the global economy in a recession. The IMF states that the world economy will experience negative growth by 3%, and described this economic period as similar to the economic growth (or lack thereof) of the Great Depression in the 1930s [13]. Unemployment has become a large issue, with thousands of people experiencing cuts in their income or losing their job completely. The unemployment rate in the United States alone went from 3.7% to 10.4% from 2019 to 2020 [13]. Cities are now tasked with providing jobless workers with a source of income and unemployment benefits to help them during their period of unemployment.

World economies struggling with rising unemployment

Yearly unemployment rate change, 2019-2020

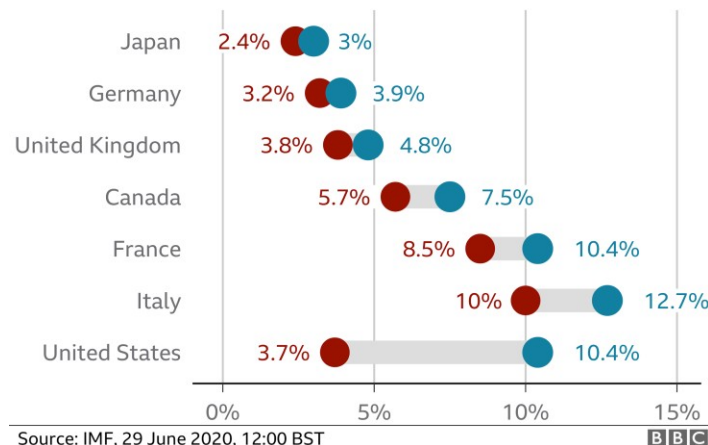


Figure 3: Unemployment Rates in Different Countries [13]

Due to the lack of travel, the travel industry is one of the industries that has been hit the hardest by the pandemic. State lockdowns, discouraging non-essential travel, and fears of contamination, while put in place for public safety, only spell disaster for the industry. For example, during the lockdown, the San Francisco Bay Area Rapid Transit system was losing almost \$55 million each month due to the drop in public transportation ridership [18]. Furthermore, an estimated \$450 billion loss in GDP will be due to the travel industry in the US

alone, with an additional \$55 billion loss in tax revenue in 2020 [14]. Moreover, it is predicted that the US will lose 4.6 million jobs due to the decrease in travel (with 3.6 million of those jobs directly related to travel) [14]. Additionally, those who have lost their jobs, as well as those who feel their jobs are in danger, will proceed to spend less, putting less money back into the economy and thus further weakening the economy.

As a result, world governments are now faced with the issue of bringing the economy back to pre-pandemic levels and to revitalize both the economy and the travel industry. Luckily, investing in transportation and transportation infrastructure could be the path to a new normal.

Improving the Economy Equals Improving Sustainability

With the current state of the economy, cities and governments are tasked with finding a solution to bring the economy back to pre-COVID-19 conditions. As a result, cities' focus will be primarily on the economy. However, transportation infrastructure has long since been used as a way to stimulate the economy. Therefore, it is likely that cities will invest in transportation as a way to boost the economy. Because many of the new transportation trends and technologies that were being developed before the pandemic dealt with sustainability, investing in transportation not only helps the economy but also indirectly promotes sustainable transportation.

It is estimated that every \$1 spent on transportation infrastructure can generate economic returns of \$1.5 to \$2 [16]. In addition to economic benefits in terms of money, there are also other economic benefits to investing in transportation. For example, job opportunities in the areas of planning, construction, implementation, and maintenance are immense. Moreover, with a key focus of the transportation industry being the shift of electric vehicles, it is estimated that working to make 50% of vehicles run on electricity could generate 10 million jobs [17]. The multiplier effect can then take place as those who are employed in transportation projects will be able to spend their earnings on goods and services, providing income to the suppliers of those goods. This creates a cycle which will ultimately add more money to the economy than initially invested, allowing the benefits of transportation investment to far outweigh the costs.

Additionally, there are steps that cities can take to encourage the use of sustainable transportation while also helping the economy. In response to the fears caused by the 2005 July terrorist attacks on London public transportation, there was a 13% increase in bicycle trips as compared to June 2005 [7]. The increase in bicycling, rather than cars, was partly due to a congestion charge established two years earlier which put a cost on driving in certain areas.

The congestion charge not only decreased congestion but it also generated a revenue of 150 million pounds in just 2019 alone [7]. Currently, cities can look to such past events to see that such fines can not only encourage sustainable transportation but also generate economic growth, thus achieving two goals at once.

With the growing trend of bicycling, investment in the cycling industry can not only encourage more people to use it but also generate economic growth. For example, in Europe, the cycling industry generated 650,000 jobs in 2016 in several different sectors [7]. As the International Energy Agency found, “Bicycle parking infrastructure delivers five times higher retail spend than the same area of car parking” [7]. Furthermore, New York stores that were located near bike lanes experienced a 50% increase in trade [7]. Bicycling is a sustainable and economically efficient mode of transportation that also allows for flexible social distancing, making it an ideal transportation mode to promote. Overall, the economic benefits of investing in the bicycling industry as well as the public’s growing interest in it make it likely that cities will invest in it.

Public Transportation

One aspect of sustainable transportation is public transportation, which has been greatly affected during the pandemic. Without intervention from government and private companies and a direct focus on public transportation, it will be difficult for the sector to recover. However, the economic return of investing in public transportation has proven to be considerably high in the past, which is a motivator for cities to focus on it as a way to bring the economy out of the recession.

It is estimated that a one-dollar investment in public transportation can expand the economy by \$5 [5]. At a time when the economy is shrinking due to a lack of consumer confidence, this could help minimize the consequences of low consumer morale. During a time where so many workers have lost their jobs or have had their pay reduced considerably, public transportation investment can also provide thousands of jobs. An estimated one billion dollar investment in public transportation could generate around 50,000 jobs [5]. Additionally, during the Great Recession in the US, investment in public transportation created 31% more jobs per dollar than constructing new roads did [7]. UNECE also estimates that 5 million new jobs could be created around the world if countries part of UNECE invested twice as much in public transport as they are now [17]. Furthermore, with more efficient and safer public transportation, it becomes easier for people to travel. They will be more likely to travel to places that they may not have traveled to without public transportation and they may go on more recreational trips (ex. shopping), which will allow for more money to be added into the economy.

With proper investment and attention, it is possible for the public transportation industry to bounce back and improve the economy in the process. The more improvements and investments that are made, the more likely it is that more people will use it rather than private automobiles. This will ultimately help reduce the negative environmental consequences of private automobiles, such as road congestion, emissions, safety hazards.

Safe Transportation will Lead to Sustainable Transportation

In the aftermath of COVID-19, the transportation industry's other main concern is to make transportation safe in terms of contamination. The industry has to rebuild itself and restore people's confidence in travel by adapting to what is now considered "safe transportation".

Traveling Back to the Past: Walking and Biking is the New Norm

As previously mentioned, the lockdown has resulted in a trend where people are moving back to walking and biking as a form of transportation. With public transportation being seen as having a high risk of infection, rather than invest in purchasing a car and then paying for all the costs that come with owning a car, many people who previously frequented public transportation turned to walking and biking. Buying a bike is a much cheaper option for many, especially during this time of uncertainty regarding jobs (high unemployment and pay cuts). These forms of transportation are seen as safe due to the added ability to social distance of your own accord. Moreover, as it is recommended to stay at home as much as possible during the lockdown, biking and walking are seen as a way to get a bit of fresh air and exercise. The lack of vehicles on the road also clears up space for cyclists and pedestrians, thus creating safer conditions, and better air quality, another motivation to bike or walk.

Cities have an incentive to promote these forms of transportation as they will help with the congestion problems that could arise in the aftermath of the virus. With public transportation being viewed as risky, more people are likely to switch to other forms of transportation. Additionally, lower capacity in public transportation will also require people to find another way to commute. If everyone who no longer wants to/can use public transportation shifts to automobiles, traffic and congestion could reach staggering levels, which is dangerous both in terms of the environment and public safety. On the other hand, bicycling has proved effective in reducing congestion in the past, with bike-sharing systems reducing the amount of congestion in Washington DC by 4% [7].

Cities are already taking steps to continue to encourage bicycle usage. Making it safer, not just in terms of safety from vehicle accidents but also safe for people of all ages, backgrounds, and genders is another key factor that will motivate more people to use it. People have brought up that pre-COVID-19 walkways and bike lanes weren't big enough for adequate social distancing. Therefore, several cities (ex. New York, Budapest, and Berlin) have expanded bike lanes or created temporary bike lanes. Some cities have designated certain streets as cyclists and pedestrians only or have reduced the speed limits on those streets. Many are also designing future plans to revolve around biking infrastructure. Milan, for example, is structuring its COVID-19 recovery plans to encourage bicycling in an attempt to avoid an increased number of vehicles on the road and subsequent increase in pollution. They plan to build more cycle lanes, which in the process will reduce space for cars, and are making bicycling safer by reducing vehicle speed limits [2]. Berlin's "Good Move" plan, London's StreetSpace plan, and Paris's COVID-19 recovery plan also involve similar techniques to give priority to pedestrians and cyclists and thus move towards a more sustainable future [11]. These decisions are already showing results, with some areas seeing better traffic management due to bike lanes and easier access to important locations such as hospitals.

Cities are already seeing bicycling and walking as a solution to congestion and safety issues amidst the coronavirus. They are taking this crisis and turning it into an opportunity to reorganize city space. By improving bicycle and pedestrian infrastructure to make it safer and more appealing to the public, they are promoting more sustainable modes of transportation. As the benefits of the changes that some cities have made so far are realized, more cities will be likely to follow suit, making these temporary changes permanent.

The Growth of Technology

Even before the pandemic, AI in technology was becoming more widespread. Everything was slowly becoming digital (digital payments, online ticket bookings, etc.). Although technologies like AVs weren't quite ready for public use, autonomous shuttles, trains, and buses were being tested around the world. In a world with COVID-19, people want to minimize the amount of contact they come into with strangers. Therefore, it is likely that automation and other forms of AI will be used more often, and in the process will help with sustainability as well.

Currently, AVs are already being used to deliver goods during the lockdown. During the height of the pandemic in China, AVs were used to deliver medical supplies to highly infected areas, thus allowing local hospitals to receive supplies without the need to endanger any more people's lives. AVs were also used to collect data about people's social distancing and mask-

wearing patterns as well as to disinfect roads. In the United States, AVs are being used to again deliver supplies and in some cases, COVID-19 tests [19]. Once AVs become more widespread, this trend could catch on and in the coming years, more delivery trucks could become autonomous. As a result, AVs will be able to reduce travel time through efficient planning and organized routes, thus allowing for less fuel consumption and emissions.

AI and other technologies are being used more frequently as well. Beijing, for example, is implementing technologies to scan for people who are using public transportation with a fever and New York is testing technologies like UV lamps to sanitize public transit [21]. Additionally, the Paris Metro is using AI to monitor the number of people on public transit and to enforce mask regulations [21]. AI is already used to collect data about the number of people/vehicles that pass through an area during a certain time. It could be modified to limit the number of people in an area to allow for social distancing, and in that way, it can be used to lower congestion and overcrowding during peak hours (such technologies are already being used in the United Kingdom). Using it to control the number of vehicles on the road could prevent traffic and fuel wastage from increased travel time. AI can also use complex algorithms and calculations to create different scenarios of what will happen if certain changes to transportation are made and thus can help with future transportation planning. For example, it can be used to determine the consequences of designating certain roads as pedestrian/cyclist only, reducing transit frequencies, or closing certain routes. This can all help make future urban planning easier and more efficient.

Furthermore, before COVID-19, airplanes were a popular mode of transportation for longer trips. However, even before the pandemic, the airline industry was beginning to suffer as people were often not satisfied with the experience of traveling in an airplane (small seats, long process, security, etc.). Many people were beginning to opt for a long road trip rather than have to go through the long process of flying as well as the associated high costs and limitations. People's hesitation to fly has only increased due to COVID-19. On the other hand, AVs could potentially provide a comfortable and flexible trip, making it likely that even more people will move away from airplanes once AVs are open for public use. With airplane emissions contributing to 9% of all transportation-related GHG emissions in the US alone [20], this is good news for the environment.

Overall, the post-COVID-19 period will see a great increase in technology usage in transportation. While the main goal of using AI and automation in transportation is to make it

safer and more efficient, especially safer for public health, these changes are also making transportation more sustainable.

Conclusion

COVID-19 has greatly impacted our way of life and has changed the course of the transportation sector for the future. Prior to the pandemic, the use of AI and autonomous technology to make transportation safer, faster, more convenient, and more efficient was the main concern of the industry. Due to rising emission levels and climate change, sustainability was also starting to grow in importance. However, COVID-19 has drastically changed the priorities of the industry as well as the public. People's main concern is no longer just being able to get somewhere quickly. It is now more important that the mode of transportation they are using has the lowest risk of infection as possible. As a result, the sector will be focusing on making transportation as safe as possible and making sure to generate revenue and employment opportunities to replace the loss that occurred during the height of the pandemic.

Consequently, cities are changing their structure to account for the changes in transportation trends. Cyclist and pedestrian infrastructure is becoming a central focus for several cities and AI is being used to help with social distancing and sanitation. Several cities and economies will be focusing on transportation as a way to generate profit and jobs to help the economy and the industry bounce back. As a result, transportation is being made more sustainable in the process. Although COVID-19 is a setback in several aspects, it can also be seen as an opportunity for a shift to a more sustainable future during a time when it is really needed.

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CHAPTER 2

Changes in Perceptions of Public Transportation Post-COVID-19 and How They Will Impact Low-Income Neighborhoods

Leah Thomas and Sanjana Kaloth

Introduction

With the current climate of the COVID-19 pandemic and social injustices that the United States is battling, it is easy to lose sight of how various groups of people are being impacted when our communities may not be affected directly. COVID-19 in particular has caused a lot of hardship for low-income families especially, and their lives have been changed in more ways than one. Knowing this, it is important to focus on how residents of low-income neighborhoods are surviving during this time and to raise awareness of the struggles that they are having to face. A major resource for low-income communities is public transportation, so analyzing how perceptions towards public transportation are shifting can help society become more informed and take action to push the world forward in the aftermath of this pandemic.

To start off, it is necessary to establish some context about our nation. The United States has been viewed as a leader in the global economy, racking up a GDP (that measures the market value of goods and services produced by working individuals in the nation) of roughly \$21,539.689 billion, as of the first quarter of 2020 (Federal Reserve Bank of St. Louis [1]). Despite being one of the wealthiest countries in the world, if not the wealthiest, there are still disparities between social classes in the country, and these are only projected to be exacerbated with the COVID-19 pandemic. Each one of the fifty American states contains at least one impoverished city, and some of the main ones consist of families who earn less than \$25,000 a year and who live well below the poverty line, sometimes even relying on food stamps to get through their everyday lives (usatoday.com [2]). As observed, the wealth in the United States is not evenly distributed, and some of this can be attributed to differences in the rate of returns on investments, wealth accumulation of some families related to differing savings rates, and even housing that can divide people by financial, employment, and even racial status (equitablegrowth.org [3]) and deepen the difference between wealthy and low-income families.

Firstly, it is important to identify what makes a community or a family, specifically, low-income? A low-income family earns an income less than or barely above the poverty level. Families do not need to be “poor” to be considered low-income. For many families who live in the nation’s largest cities, the value of rent is so expensive that families earning well over the median national income are considered to be “low-income” families who need federal assistance to afford housing. Low-income individuals have less of a disposable income than others and can sometimes find it difficult to pay their bills as well.

While stable families might live in suburbs and have easy access to all their necessities, families in low-income neighborhoods struggle with additional issues that the average person doesn’t even think about. The environment that low-income families live in is typically characterized by limited access to resources, poor residential areas, high crime/violence rates, inadequate school systems, and a lack of local job opportunities, to name a few. This is because neighborhoods of concentrated poverty tend to separate residents from the resources, they require to reach their potential and live comfortably (U.S. Department of Housing and Urban Development [4]), while simultaneously restricting the larger community from receiving the neighborhood’s human capital. One main reason for the challenges that low-income families continue to face is the spatial mismatch between suburban jobs and poor urban neighborhoods in which minority residents live. This difference in location makes it hard for low-income individuals to become employed and creates communities with problems that are magnified for future generations as well. While these conditions not only add to the stresses that individuals in low-income neighborhoods face daily, they are actually also associated with poor mental health outcomes and can directly impact brain functioning for people living in poverty, according to the Anxiety and Depression Association of America [5]. In fact, the CDC has reported that 8.7% of people who have incomes below the poverty level report severe psychological distress, which adds to the hardships that they already have to deal with and proves that the stresses of living a low-income lifestyle have serious impacts. These facts also help explain the heavy reliance that low-income families have on public transportation and, unfortunately, these struggles are only heightened by the novel COVID-19 pandemic.

Current Status and Literature Review:

Over the past few months, we have witnessed how COVID-19 has halted life globally. Forcing over one-hundred countries to go into lockdown, this virus has taken the world by storm and has threatened the lives of people of all age groups, failing to discriminate. With 20.6 million

confirmed cases and roughly 749,000 deaths worldwide, many countries are beginning to reopen after the quarantines placed in March, despite the evident risks that the virus can have on certain communities.

When considering COVID-19's influence on health, it is proven to be highly transmissible and extremely risky for individuals with underlying medical conditions. It poses grave dangers upon the elderly, but can still harm young children, sometimes leaving permanent after-effects that serve as reminders of the infection. Since March, COVID-19 has strained healthcare systems resulting in a lack of adequate testing, PPE for front line workers, and even hospital necessities (like ventilators, beds, etc.). It's also sparked a wave of movements for vaccine development. Through Operation Warp Speed, a federal funding program that provides money for vaccine research, companies are racing to release an approved version of a vaccine for the coronavirus that could save millions of lives, earn the companies a fair reputation, and produce a large amount of revenue from its manufacturing.

Not only has the COVID-19 pandemic impacted health and medical institutions on a global scale, it has also affected the economies of countries large and small alike. Some sources claim that in the United States alone, over 30 million people have filed for unemployment and have not been able to work or find a new job during this time. Many businesses have shut down all together or are adjusting to the pandemic by meeting in an online format. Stock market trends show that cleaning and technology companies used for teleworking have done well, but a majority of other businesses have suffered losses because of COVID-19.

Besides forcing medical, economic, and security systems around the world to adjust to new circumstances, the virus has also changed the way people view public transportation and sustainability, and we will dive deeper into these changes shortly.

Overall Perceptions of Public Transportation in the United States

Public transportation is defined as a system of forms of transportation that are available to the public, run on fixed routes, and often charge set fares. Public transportation can be mostly found in urban areas and is primarily funded by the Department of Transportation's Federal Transit Administration (FTA) in the U.S., an organization which also provides federal assistance and relief to public transportation companies (Federal Public Transportation Program [6]). Additionally, federal funding for public transportation is also available from other surface transportation programs that distribute money from highway projects or non-transportation

projects in the fields of healthcare, education, or veterans' affairs into public transit projects. From 2010-2017, public transportation program funding was in between \$10 and \$11 billion, but this amount has risen to around \$13 billion from 2018-2020, as shown in the graph below.

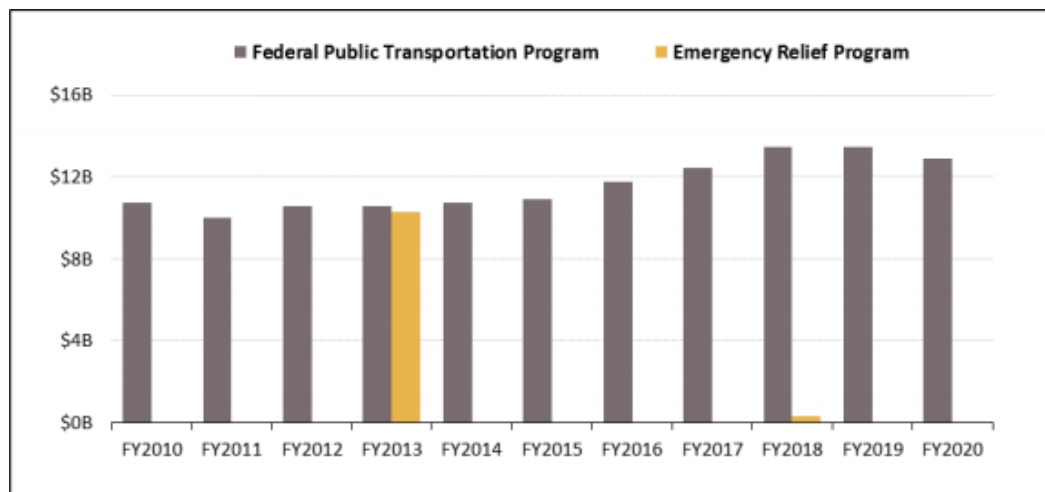


Figure 1: Federal Public Transportation Program funding [6]

Specifically, about \$1.1 billion per year on average has been transferred from highway programs to public transportation programs from the year 1992 to the year 2016, which highlights the increase in funding that public transportation is receiving from federal organizations.

Overall, most Americans believe that public transportation is necessary for a whole host of reasons. Firstly, public transit allows the U.S. to reduce our fossil fuel consumption amidst the climate crisis that the world is facing. Public transportation can reduce pollution, congestion, and travel times, while minimizing social inequality as well by enabling equal conditions for everyone and being a source of conversation. Transit additionally improves economic efficiency. It provides job opportunities and can connect individuals to sources that would prevent them from spending money excessively. An article in Chicago Policy Review [7] delved into how public bus routes can deconcentrate poverty and promote equity, and it discussed a study that identified that public transportation connecting suburbia to urban neighborhoods could help reduce the concentration of poverty in urban residences by introducing families to necessary resources that could help them restore their communities instead of being trapped within them. The study used U.S. census data from 1970 to 2010 and showed that the presence of a public bus route in Atlanta's suburbs is associated with a 2.32 increase in the poverty rate on average, which signifies that the people living in poverty are more spread out and are not confined to a single community. By distributing poverty and supporting equity, bus and other public transportation

services could be the start to revitalizing entire communities and bringing them out of poverty. A survey review from the Mineta Transportation Institute [8] also focused on how Americans perceived public transportation as being beneficial pre-pandemic. The report concluded that survey respondents supported public transportation and believed that it brought collective benefits to the community, such as reducing traffic congestion, air pollution, and commute costs. A section of the polls was centered on what Americans thought about the relationship between public transportation and vulnerable residents, and the results showed that 75% of respondents claimed that public transit is valuable as a transportation alternative for low-income, elderly, and/or disabled individuals. Some of the responses are shown in the picture below. And, in fact, these opinions are accurate.

Table 6. Poll Questions Testing If Respondents See a Link between Public Transit and Providing Mobility Options for Vulnerable Populations (Poor, Disabled, and/or Elderly)		
Sponsor or author, date	Question wording	Response
Questions asking if public transit is an important strategy for providing transportation for vulnerable populations		
City of Colorado Springs (The Kenney Group), 2011	I'm going to read a list of benefits that are often attributed to public transportation. For each statement I read, tell me if you think the benefit is very important, somewhat important, not that important, or not important at all.	Very or somewhat important 95%
	Public transportation provides transportation options to people with special mobility needs, such as the elderly, disabled, and people who are unable to drive.	
City of Colorado Springs (The Kenney Group), 2011	I'm going to read a list of benefits that are often attributed to public transportation. For each statement I read, tell me if you think the benefit is very important, somewhat important, not that important, or not important at all.	Very or somewhat important 94%
	Public transportation provides mobility to low-income families and individuals who cannot afford the costs of owning a car.	
Indian Nations Council of Governments, 2010	Please tell me if you agree or disagree with each of the following statements:	Agree 90%
Natural Resources Defense Council, 2012	I don't use public transportation but I support it because it helps others who don't have cars or can't drive.	Very or somewhat convincing 82%
	I am going to read you some statements given as reasons to support increasing local funding to expand transportation choices in your community, including public transportation like buses or trains. After hearing each statement, please tell me whether you find it very convincing, somewhat convincing, or not convincing as a reason to support increasing funding for more transportation choices. If you do not believe the statement, please tell me that too.	
	Expanding and improving our transportation options will help those of poor or modest incomes or those without cars have a way to get to their jobs, training programs or schools. And by providing reliable public transportation for seniors and people with disabilities, we can help them live independent, dignified lives where they are able to stay in their own homes.	

Figure 2: Mineta Transportation Institute survey responses referencing connection between public transit and vulnerable populations [8]

Public Transportation and Low-Income Communities

Families living in low-income neighborhoods rely heavily on public transportation for a variety of needs. Besides using it to commute to places of work, public transit is used by low-income individuals to connect them to medical resources, educational institutions, grocery stores, and much more. The National Association for State Community Services Programs [9]

also claims that use of public transportation fosters self-sustainability, builds up independence, and permits spending on other household necessities. The Association's article *The Stranded Poor: Recognizing the Importance of Public Transportation for Low-Income Households* states that transit also provides a resource for low-income individuals who may not have/may not be able to afford privately-owned vehicles. Since many essential, low-income jobs are important sources of income for these families but are located outside of urban and more into suburban areas, access to public transportation is crucial. In 2000, transportation costs accounted for 36 cents out of every dollar spent in the poorest fifth of American households, 98% of which was spent on purchasing and maintaining cars! If more public transit was available for families in these neighborhoods, cars would not be required, and funds would be able to be distributed towards other expenses. Because transit enhances mobility and interconnectedness, provides access to medical and educational needs, and is used to obtain resources regularly, a lack of public transportation could have devastating effects on low-income communities.

Already, the COVID-19 pandemic has threatened low-income families in a plethora of ways. Families in impoverished neighborhoods have suffered pay cuts and job losses due to the rising unemployment rates and company shutdowns or, if they are essential workers, their risk of contracting the virus is higher ([washingtonpost.com](https://www.washingtonpost.com) [10]). Many individuals living in low-income communities work in jobs that predominantly require in-person attendance, do not offer paid sick days, and do not have adequate medical insurance available for employees. For this reason, these workers are forced to go in knowing that they could be walking into a dangerous death trap; but they lack any other choice. Additionally, schools are shut down, resulting in more children staying home in potentially unsafe environments with low access to food in some homes or no one to properly supervise them. The virus has also exposed a sense of medical mistrust in low-income and racially segregated communities which makes them less likely to take care of their health and could result in them spreading the virus to others in the community. It is obvious that COVID-19 is dangerous, but the pandemic results in added struggles for low-income and impoverished families especially, hence why it is so imperative that public transit stays a constant for them during this time. But what happens when public transportation is not available for these families or when perceptions about public transit change?

Hypothesis, Data Analysis, and Discussion:

How Perceptions Are Changing

We presume that, without viable safety measures post-COVID-19, perceptions about public transport could worsen from what they were before the pandemic and there would be a higher risk associated with active usage, which could endanger low-income communities who frequently rely on it. Already, urban transportation usage has plummeted to its lowest levels in decades during this pandemic. Studies made by the transportation-data company ‘transit’ show that “ridership on bus and rail systems has already dropped by 74% in New York, 79% in Washington, D.C., 83% in Boston, and 87% in the Bay Area from pre-pandemic levels. The assumption that transit was accelerating infections stoked public fears” (theatlantic.com [11]). It was mentioned before that Americans considered public transportation to be an efficient and safe way to get around, but due to the fear that, now, public transportation allows for germs and virus particles to be spread easily, individuals are avoiding using public transportation and are turning to other modes. According to one survey conducted by the Boston Consulting Group [12], roughly a third of the respondents expressed that they were traveling at different times of the day to avoid crowds and minimize their risk of getting infected, and nearly a quarter said they would only board public transportation if ample empty seats were available.

In addition to fears about spreading the virus preventing people from using public transport, the lockdown in general has greatly minimized the need to travel at all. Major companies like Google and Spotify announced that their employees would be able to work from home until the end of 2020 and Twitter, Square, and Facebook are even allowing many employees to telecommute permanently. These changes by many other companies as well have resulted in a decline of public transportation usage, simply because it is not needed as much in the present time. The International Energy Agency [13] found that in the UK, the strict lockdown imposed in March led to a 95% decline in underground journeys in London, which is striking as that is the primary mode of transportation in the region. Similarly, major cities in the United States are facing declines in ridership. While the Eno Center for Transportation [14] calculated that New York’s subways and buses each saw an 87% decline in usage compared to 2019 by the end of March of 2020, Google Maps’ mobility report [15] just two weeks ago showed that there was a 39% decrease in the number of visits to transit stations compared to the baseline for that week. The graph below, provided by Time.com [16], presents a visual view of the trend that public transportation ridership in New York has seen due to the COVID-19 outbreak.

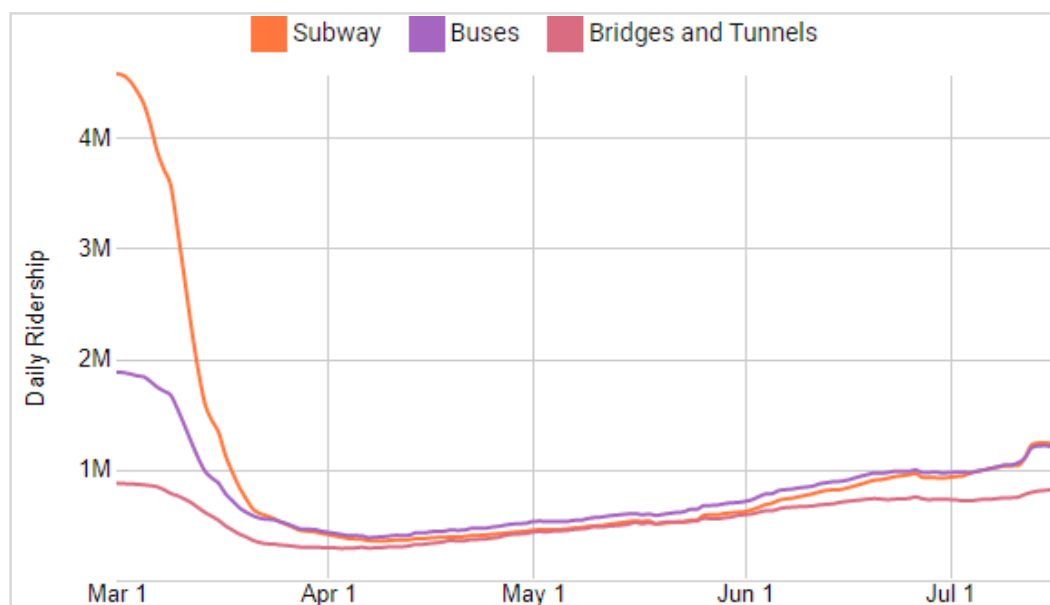


Figure 3: Rolling Average of Daily Public Transit Use in New York City over seven days [16]

Due to fears about the transmission of the virus as well as continued lockdowns imposed upon countries, the future for public transportation doesn't look too bright, at least in the short-term. The data mentioned previously depicts that the public's perceptions about public transportation have changed as people went from using it frequently to refraining from boarding it because of the health risks or because they have less of a need for it. In the coming months though, when social distancing is no longer a requirement, public transportation agencies may have difficulty regaining trust, and mobility patterns will be quite slow in returning to normal. Long-term, it is predicted that although some services may never fully rebound, others will need time and resources to provide as many services as prior to the outbreak [14]. Historically, this was also observed with the Severe Acute Respiratory Syndrome (SARS) epidemic in 2003. In Taipei, there were half as many underground trips during the peak of the 2003 outbreak and it took four months for passenger numbers to return to pre-crisis levels [13].

In addition to public transportation usage decreasing overall, public transit agencies have a lot to lose. San Francisco's BART system stands to lose around \$57 million in monthly revenue if the reduction in ridership and economic activity continues [14]. Among larger transit agencies that earn a substantial amount of their operating revenue from fares, these revenue losses could mean that the agencies take much longer to recover from the pandemic, which would mean that their services would be limited and riders would take even longer to regain trust in transit systems. King County Metro in the state of Washington has expressed to Time.com [16] that they are projecting an "unprecedented loss" of over \$25 million in 2020

because of fare revenue and sales tax declines. Many companies like King County already have additional expenses as they engage in cleaning campaigns to keep public transit safe. The Coronavirus Aid, Relief, and Economic Security Act (CARES, for short) is a \$2.2 trillion stimulus bill that included \$25 billion for public transportation relief in March and has been able to support some of transit agencies' funding, but companies are discovering that they will need much more help from Congress to sustain public transit during this time. In fact, an analysis done by the American Public Transportation Association [17] found that public transit agencies nationwide will face a \$23.8 billion shortfall through 2021, even after the CARES Act! This could result in layoffs, service cuts, fare hikes, or even an abandonment of transit lines claims Andrew Albert, chair of the Permanent Citizens Advisory Committee to the Metropolitan Transportation Authority. Time.com [16] states that "In Seattle and New York City, which got 15% of the total CARES Act relief despite handling more than a third of national transit ridership, the funds were predicted to last less than six months," and agencies in Chicago, Philadelphia, and Los Angeles are preparing for extreme pandemic-related losses in the coming months as well. In many of these locations, however, public transit is the backbone of these cities and of their local economies, and it serves a variety of socio-economic groups, so recovery post-COVID-19 is essential. It is clear to see how the changing perceptions during this time are affecting public transportation in terms of usage and revenue, but there may be other ways for people to continue traveling during this time.

Fortunately, lingering concerns about the safety and need for public transportation have prompted people to explore different modes of transportation, some of which include biking, walking, jogging, driving, etc. In fact, sidewalks have been expanded to allow for individuals to feel safer by having a bigger space to walk/run/bike/jog, as more people have been engaging in these activities to stay active while commuting from place to place. In addition, shared mobility services are being used in the pandemic as an alternative to public transport. For example, car sharing has remained popular in Europe and ride-hailing services are likely to rebound in most regions if they can promise cleanliness and a low risk of infection. In China, specifically, bike sharing rose 150% immediately following the lockdown mandate and it is worth noting that these shared modes, whether bikes, e-scooters, or cars, offer users the benefits of private, dedicated use without a large investment [12]. The International Energy Agency [13] also reported that U.S. cities were reporting increases in cycling during the start of the pandemic and these shifts could become more permanent in certain locations, with people using privately-owned and shared-mobility services as alternatives to public transit.

Impacts on Low-Income Communities

On the other hand, these various modes of transportation are not easily accessible for everyone, especially for many people of low-income. For example, there are more people using rental bikes to get from place to place while refraining from using public transit, but many rental bike kiosks require payment in the form of a credit card, a financial instrument some low-income individuals lack. Furthermore, low-income families typically lack access to/cannot afford privately-owned vehicles such as cars (hence why they rely so much on public transportation), which puts them in a tough position when perceptions concerning public transport are changing. From the outset of the COVID-19 pandemic, low-income families that already lacked access to resources were deprived of job opportunities as well. According to an interactive map created by the research company Urban Institute [18] (a picture of which is shown below), over 9 million low-income jobs are predicted to be lost nationwide due to the pandemic, many from neighborhoods in the Northeast and Western ends of the United States.

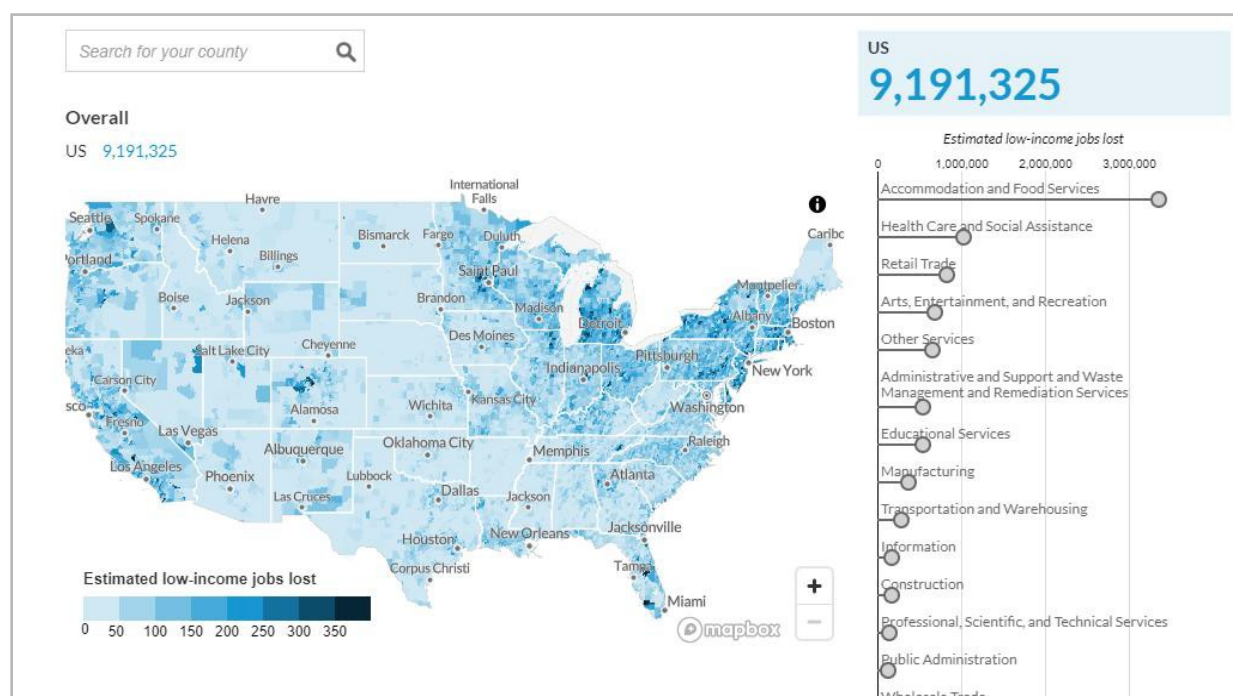


Figure 4: Urban Institute's Map of Total Estimated Low-Income Jobs Lost due to COVID-19 [18]

Often, these low-paying jobs are the ones that get cut during a pandemic, leaving the families who rely on them as a source of income in an even more vulnerable state than they were before. With more low-income families filing for unemployment during this time, they are left with less resources to help their children participate in active education, they may not have enough money to pay for medical care (leaving them more likely to spread the infection), will not be able to stock up on as many necessities, and may even be looking for other job

opportunities, for which they will need to rely on public transportation.

Prior to the start of the COVID-19 outbreak, residents of low-income neighborhoods around the U.S. were suffering from problems relating to public transportation. A publication on [sharedjustice.org](#) [19] mentioned that public transport was often not very affordable or easily located near low-income communities and highlighted that these issues were simply being ignored. An article on [greenbiz.com](#) [20] also stated that, pre-pandemic, “America’s inadequate transport infrastructure was being seen as a [driver of inequality](#), limiting access to jobs, education and other services for poorer households.” Yet even with these conditions, 20% of the nation’s poorest households do not own a vehicle, making them completely reliant on public transportation to achieve their daily tasks. This would mean that failure of transit systems to function appropriately during the pandemic is bound to be a disaster for the large proportion of low-income individuals in both urban and rural areas who frequently depend on transit.

Diving deeper into how low-income families would be negatively impacted by the lack of available public transportation, it can be observed that reduced and/or canceled transit services would make it difficult for them to access critical services such as food and healthcare (Center for Advancing Research in Transportation Emissions, Energy, and Health [21]). Especially during this time, when the world is focused on mitigating the spread of this virus, low-income families who cannot attend to their medical needs could be exposed to and/or spread virus particles, which could impact other populations as well. Low-income communities also typically do not have the technology that would allow for them to work from home, and many are essential workers whose jobs require them to travel in-person for work, which would leave them negatively impacted if public transport came to a halt. In the U.S. alone, 2.8 million transit riders (which comprises more than a third of total transit commuters) are considered “essential” during COVID-19, either working on the frontlines or behind the scenes to help cities obtain the resources they need to combat the pandemic head on ([gensler.com](#) [22]). Transit services also allow for individuals from low-income neighborhoods to leave their high-density living arrangements, in which social distancing measures are tough to maintain, so a lack thereof would make these populations more susceptible to the virus. While residents in low-income neighborhoods are struggling to survive comfortably during the pandemic, people of color in these neighborhoods are being disproportionately affected as well. According to the American Public Transportation Association [23], people of color account for less than 40% of America’s population, but make up 60% of transit riders. This is the case not only because workers of color are more likely to lack their own vehicles at home, which is supported by the fact that almost a

third of low-income African American households do not own a vehicle [20], but also because “people of color make up the majority of essential workers in food and agriculture (50%) and in industrial, commercial, residential facilities and services (53%),” according to the Working Economics Blog by the Economic Policy Institute [24]. Additionally, almost 1-in-6 workers among African American and Asian populations use public transit [23], which underscores the reliance that workers of color and low-income populations have on public transportation. If public transit is not available, the spread of infection could increase, low-income families would suffer, and industries would also be affected because their workers would not be able to commute.

Solutions

Evidently, because of the perceptions of public transport post-COVID, public transit use has decreased by a large amount, with low-income communities struggling to get from place to place. So what can be done to resolve this issue? This paper has a compiled list of three main solutions that can be put in place to restore public transportation to its pre-virus levels so it can support residents of low-income neighborhoods, especially, as well as the general public.

Infrastructure Changes

Firstly, there must be infrastructure improvement and modification. Previously, it was noticed that conditions of public transportation have not been suitable for low-income individuals to use regularly and due to the onset of the coronavirus, these conditions have likely worsened. Governments and agencies can work to improve transportation infrastructure by increasing the frequency of services, providing additional resources, and providing real-time updates on public transportation conditions so they can be attended to as soon as possible [13]. In terms of modification, new health and technological measures will have to be taken to ensure riders’ safety post-pandemic. For example, ample empty spaces between seats, protective mask mandates, sanitizer provision, recurrent cleaning of public transportation, temperature checks and entrances/exits, as well as automatic opening of all doors at stations could prevent direct contact and keep virus particles from spreading, thereby protecting more transit users. Even providing drivers and station workers with screens or shields would keep them safe and would limit their contact with others.

In addition to taking health precautions, a whole host of innovations can be implemented to completely change the public transportation experience. To minimize the risk of contagion, contact tracing technology could be used. Digital platforms are now able to identify potentially

contagious individuals and inform those who have come in contact with them. According to a blog by the World Bank Group [25], Beijing's subway set up a system of online pre-trip reservations and voluntary on-board check-ins using QR codes which enables the system to track individuals till they reach their destinations. Trip planning apps can also be used for riders to receive information that could help them decide the safest paths of travel (publicissapient.com [26]). For cities that are planning on slowly reopening transit, these apps could be useful as they allow for users to see capacity of public transportation before they board, and this information could help reduce the spread of the virus. Various trip-planning apps can even be connected to one platform to give the best suggestions to users, like in Los Angeles, California. Another example of novel innovations being used in public transportation to minimize the risk of contracting COVID-19 is contactless technology. In Auckland, New Zealand, riders have transit cards that can be refilled through smartphones or other retailers and can pay fares virtually, and these cards also connect to a trip-planning app to show seat availability. Registered transit cards additionally help with contact tracing and provide critical notifications to monitor transit. Seattle's Sound Transit as well as some transportation systems in Oslo, Norway have removed fare gates and replaced them with tap-and-go cards, as shown below. This alleviates crowding, promotes faster movement which results in on-time service, and keeps surfaces clean. These implementations could allow for technology and improved infrastructure to take precedence as the number one solution for bringing public transportation ridership back to normal levels post-COVID-19.



Figure 5: Visual of Sound Transit's Tap-and-Go Card System [30]

Increase in Federal and Local Involvement and Communication

Another factor that could help solve the problem of reduced ridership and public transportation safety/availability during this pandemic, especially for low-income individuals, would be an increase in government and company communication and involvement. As the virus has already heightened the struggles of low-income communities and those of color who rely heavily on public transit, cities must prioritize transit investment and engage with community members in underserved neighborhoods to truly understand their hardships and needs during this unprecedented time [22]. Typically, agencies are used to focusing their budgets towards other transportation projects, as The Wisconsin Department of Transportation generally allocates over 75% of its budget to highway maintenance (leaving only 25% for transit) and in New York City, one of the major hubs of public transportation in the U.S., a bus service that exceeds two million trips daily receives barely any money to keep it going, while a suburban project serving 162,000 trips receives \$10 billion. These stark contrasts emphasize the fact that public transit will require more attention from federal and local agencies so it can attend to the low-income families who need it most amid this pandemic.

Once more money is provided for public transportation projects, agencies will need to

target the populations that use it most--those of low-income neighborhoods. Spatial analyses, insight from professionals outside the transportation industry who could inform about the needs of a specific community, overall improved bus services, and increased connectivity for essential workers would have a direct impact on low-income families and would make sure that they are supported in the aftermath of the pandemic, according to an article on saludamerica.org [27] and the blog by the World Bank Group [25]. Government stakeholders must also play a role in incorporating equity goals and strategies into policy decisions to facilitate transit improvements and should even begin drafting additional recovery measures to ensure that transport companies are somewhat financially stable in the years to come.

Communication for new policies as well as from the community as a whole is also key. For new technologies to be put in place, riders will need to be aware when it will be implemented and how to use it, so there should be signs posted or information sent out to inform the public prior to the onset of the new technology. Reaching out to impacted communities for feedback on what services they would want can help community members and civic organizations understand the varying reliance that different groups of people around them have, and using transit operations to create local employment opportunities could help low-income neighborhoods thrive with economic growth (saludamerica.org [27]). Even the protests against ongoing police brutality directed towards low-income communities/communities of color can be seen as results of socioeconomic disparities that have gone unchecked in our nation, so it is important to equalize the playing field for these marginalized groups post-pandemic (axios.com [28]). San Francisco offers a good blueprint of a city that has communicated with low-income neighborhoods to cater to their needs during this time. When the pandemic began, the city pared bus service down to the most-used routines and offered overnight taxi rides home for essential workers. Even now, as services are increasing, they are leveraging data to prioritize routes near hospitals, grocery stores, and low-income neighborhoods, which is sure to benefit people that live in or travel frequently to these areas.

Exploring Other Mobility Options

Finally, transit agencies should look to explore alternative modes of transportation for the general public and should consider adjusting it to the needs of underserved people as well. Subsidized ride sharing, bike sharing, and electric scooters may offer safer alternatives for riders, especially in areas where buses are scarce, according to the Urban Institute [29], and even free bike-share and/or emergency bike lanes for essential workers could help these new services affordably reach increased masses of people. Regardless of whether these additional

mobility services are public or private, cities and agencies in them can look into integrating all public and shared modes of transportation on a single platform to enable quicker responses to disruptions, increased ridership, and an enhanced customer experience. These services will also make sure that disinfection occurs more frequently, and it will keep passengers safe while allowing them to travel regularly [26].

Conclusion

Overall, we have been able to look at how the COVID-19 pandemic has changed perceptions of public transit options and what results those perceptions have on low-income communities. Already, we have been able to see the general public shift from views in which they considered public transportation to be a sustainable, constant resource to refraining from using it due to both the fear that COVID-19 could spread much easily through public transportation as well as the general lack of need for it due to job opportunities offering options to telecommute. Unfortunately, accompanied by the job losses and pay cuts, these views are impacting people of low-income and are reducing their accessibility to public transportation, which is dangerous as many of low-income and people of color are essential workers who simply cannot work from home. Though residents of low-income neighborhoods are already vulnerable to inequalities in society, COVID-19 is exacerbating these hardships and is disproportionately affecting these residents. It must not be forgotten, however, that there is always something that could be done to improve the quality of life of those around us. Through effective and well-implemented solutions such as efforts made to improve infrastructure and introduce new technologies, increased government and community involvement, and the integration of alternative (and affordable) modes of transportation taken into consideration, public transportation could have the potential to make a comeback post-pandemic. By focusing on ways to move forward, the United States can work to ensure that public transportation is safe and secure for low-income families to use and can change the course of our recovery from this pandemic for the better.

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CHAPTER 3

How will Work from Home Culture Affect Urban Transportation and Sustainability post COVID-19

Gaurika Suresh

Introduction

Covid-19, an infectious disease caused by the newly found coronavirus, is a global pandemic that has forced much of the world's population to adapt to a new everyday lifestyle. The disease that was identified in Wuhan, China, is now being spread throughout the world. People of all ages can be infected by the newly spread coronavirus. Older people, and people with pre-existing medical conditions (such as asthma, diabetes, and heart disease) appear to be more vulnerable to becoming severely ill with the virus. Others with common respiratory problems are also much more susceptible to the virus, as it mainly attacks the recipients lungs. While the virus is much more dangerous to the people who already have other medical conditions, anyone can experience the extreme symptoms of the coronavirus. Covid-19 is most often spread through the air by coughing or sneezing or through any close physical contact.

People are encouraged to take common-sense precautions to prevent the spread of all infectious diseases, including COVID-19. As an initial reaction, people started turning their everyday lives to a typically home centered life. Adults who are able to, started working from home, most people cancelled any travel plans for any recreational purposes, many started doing any necessary and personal shopping online, and most students around the world shifted from attending school in person to online school. The significant increase in home culture has its many effects on the environment around us. Air quality, in regards to pollution (mainly from gasoline run vehicles) has had a huge turn around due to precautions taken for Covid-19. Pollution levels have reached an all time low in many large cities across the world. Traffic has also been minimal on roads and highways, hence the pollution decreases. As traffic also minimizes itself, roads have become much more safer for those who are still driving. Gasoline run vehicles and factories are the biggest contributors to worldwide air pollution and emission rates. Many different types of emissions have decreased due to these two leading factors. With the given head start the world has on sustainability, it is important, now more than ever, to create and execute any ideas that can contribute to making the world more sustainable and

environmentally friendly. Keeping in mind that many cities have already begun their process of obtaining sustainability, it is important to understand what the community can do to make sure that they can sustain the environmental advantages of Covid-19, even when the disease has been controlled or treated.

Defining Work from Home Culture and its Impacts

Home culture is simply the lifestyle run at one's home. Normally you eat your meals, shower, and sleep at home, which is a part of your home culture. How has the significance of home culture changed as we adjust to a life with a global pandemic? As mentioned before, many people have shifted to working from home and doing school online. Almost 96% of students attend school outside of their home and almost 88% of adults have some kind of commute to get to work. Most of these numbers were cut down to almost 10% when the pandemic hit, which then changed our perception of home culture. The new normal that we are still adjusting to consists of a mostly home led life. People are trying to find alternatives to daily activities that require them to go out to a public place, such as grocery shopping, going to the gym, and eating at restaurants.

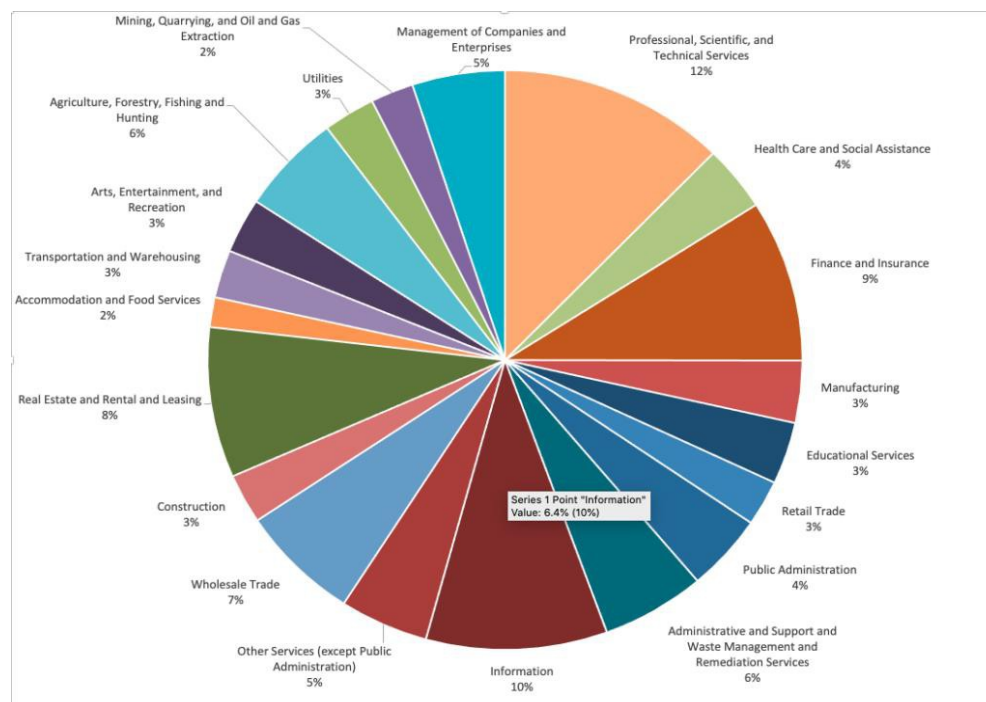


Figure 1: Percentage of people who work at home by industry.

Some industries still require workers to work in person such as construction, retail, foods, etc. But where it is possible, workers have taken this chance to start working from home. Covid-19 will also likely cause executives to rethink the need for travel to meetings, conferences, etc. They will learn that while virtual meetings may not have all the same benefits of being face-to-face, the savings may outweigh the costs much of the time.

With schools shut across the world, millions of children have had to adapt to new types of learning. While countries are at different points in their COVID-19 infection rates, worldwide there are currently more than 1.2 billion children in 186 countries affected by school closures due to the pandemic. With this sudden shift away from the classroom in many parts of the globe, some are wondering whether the adoption of online learning will continue to persist post-pandemic, and how such a shift would impact the worldwide education market.

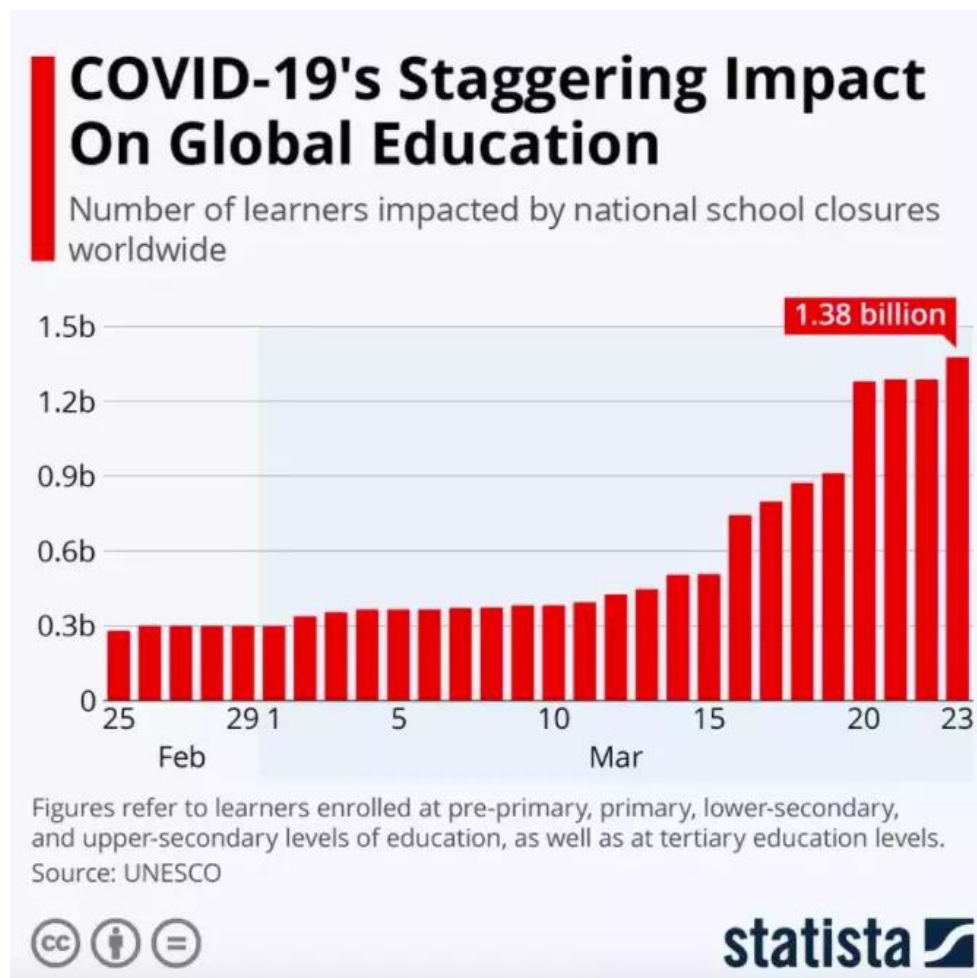


Figure 2: The graph shows the drastic increase in students participating in online schools across the globe.

So how does increased home culture have an impact on air quality, traffic, road safety, etc. ?

The restrictions have sent financial markets into free fall. But they have also given residents in some of the world's most polluted cities something they have not experienced in years: clean air. In the early days of the global response to Covid-19, we are starting to see a dramatic reduction in traffic, congestion, and pollution. While sadly, sustainability has not been a primary driver of remote work in recent years, being able to actually see the difference it can make may finally flip the switch for employers and employees. The annual environmental impact of half-time remote work (for those who both want to work remotely and have a compatible job) would be the greenhouse gas equivalent of taking the entire NY State workforce off the road. If we're looking at how this is affected by schools, there are almost 480,000 yellow school buses used to take students from their homes to their schools. Now that most schools have shifted to an online system, almost 460,000 yellow school buses (96%) are off the roads and haven't been used due to the pandemic. Additionally, reduced air travel has played a significant role in lowering air pollution rates. Lockdown events have reduced the population-weighted concentration of nitrogen dioxide and particulate matter levels by about 60% and 31% in 34 countries, with mixed effects on ozone. Reductions in transportation sector emissions are largely responsible for the NO₂ anomalies. The maps below show how levels of PM_{2.5} nitrate fell in China's Hubei province after the government imposed travel restrictions. Nitrate is one of the components that make up PM_{2.5}, tiny particles, about 3% of the diameter of human hair, that can penetrate deep into the lungs and enter the bloodstream, leading to heart disease, strokes or cancer. Nitrate aerosols are formed from nitrogen compounds, which can be emitted by human activities, especially burning fuel and diesel.

In early March, South Korea reported a large increase in COVID-19 cases. Since then, ground stations have been measuring the lowest levels of some pollutants for seven years. Although South Korea did not impose major restrictions on residents, changes in daily activity could have contributed to the drop.

Similar patterns unfolded across Italy following the introduction of a nationwide lockdown on March 9. Restrictions had already been implemented in late February in some northern regions, where COVID-19 cases had surged. The industrial belt across northern Italy often experiences high levels of air pollution, but estimates show otherwise this year.

Hypothesis: Increased home culture has bettered air quality, reduced emissions, lowered traffic, and made roads safer. With the given extra time due to increased stay-at-home lives, people

are given the opportunity to think about the changes they can make in their town/city/environment.

Future Action Plans

So now that we've established the specific impacts of home culture due to Covid, I decided to shift my focus on what some major cities have already done to obtain sustainability while staying efficient. Keep in mind, cities are in different stages of their road to sustainability and have different climate action plans. For some, because Covid did give an environmental boost, this accelerated their efforts into achieving their sustainability goals. But some other cities had to put it back because their government funds were being used for something more concerning just for their city. Copenhagen, Denmark is trying to become the first Carbon neutral capital by 2025. This is almost a full 25 years before other major cities have a shot at cancelling their emissions. Carbon neutrality, or having a net zero carbon footprint, refers to achieving net zero carbon dioxide emissions by balancing carbon emissions with carbon removal or simply eliminating carbon emissions altogether. Additionally, they have opened multiple subway lines which have already been put back into use because they have the pandemic under control. The biggest contribution to reducing CO₂ in the municipality is traditional district heating, which now accounts for virtually the entire municipality's heat supply. But this water-based infrastructure is not just about district heating, but also about district cooling. Since 2010, a growing part of major companies' cooling needs has been covered by remote cooling, where seawater is circulated around the companies. This could potentially rid the city's atmosphere of 80,000 tons of CO₂. When we think about future energy systems, we usually think only of electricity. We imagine smart power grids that integrate and deliver electricity for different purposes, like powering household appliances and commercial buildings, or charging electric vehicles. But power grids cannot dramatically reduce the amount of energy that is wasted at the source of the energy application. Here is where the power grid's twin – the smart thermal water grid – comes into play. Energy efficiency does not just draw on the usual suspects – renovation, triple-glazing, etc – but also exploits the heat that is currently wasted from industrial and commercial activities. A double-combo approach on energy efficiency is needed to maximise decarbonization, which can be most cost-effective by building thermal grids at scale. This requires a hard-boiled strategic and long-term plan – and brave policies. The effort to reduce CO₂ emissions must eliminate use of coal; however, it has been replaced by gas, another fossil fuel, only with better efficiency. That does not reflect a strong commitment to fight climate change. Not to mention that the

import price tag amounted to almost 65 billion euros in 2016. Coal alternatives such as gas are still CO₂-emitting fossil fuels and as such half-measures that blur the climate change debate. Ultimately, European and other international efforts must eliminate all of them, especially now that our industries can implement 100% renewable energy systems cost-effectively. Some other cities that are working to achieve carbon neutrality are Amsterdam, Glasgow, and London. Dubai has also created very sustainable and energy efficient neighborhoods to enhance their everyday lifestyle. With all the excess time we have at home, it is important to understand how other cities have maintained sustainability and how their ideas can help plan for other cities post-covid.

Conclusion

Through this research paper, we have learned the staggering effects of Covid-19 on the environment. We researched all the miniscule details, which ultimately tied all together as an impact led to another. Covid-19 did give the world a head start in their Climate Action Plans and helped people notice the changes that need to happen. Hopefully, these changes will continue to change others' perceptions on being active in regards to environmental sustainability. As cities have already begun their journeys in becoming more sustainable, everyday we are one step closer to making the world the best place it can be.

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CHAPTER 4

Impact of COVID-19 on New Vehicle Technology Uptake

Nishi Desai

Introduction

COVID-19 will definitely have a huge impact on the upcoming technology uptake, as well as different vehicle manufacturers. For example, the use of autonomous vehicles, such as self-driving cars are sure to greatly increase, and the probability and the likelihood that they will be used in the future is also going to likely be very high. Furthermore, new technologies such as 3D printing will also be used more frequently, in order to produce much more needed and necessary supplies, such as more masks, gloves, and face shields. Manufacturing companies are also making a great effort to provide and produce designs for important and crucial medical equipment. In addition to that, the need for autonomous vehicles is sure to greatly accelerate, as well as increase, in many countries, following the COVID-19 pandemic. Additionally, as the use of the mode of transportation, public transit (trains, buses, etc.), will start to slowly decrease because of several public health issues that it may potentially pose to citizens, transportation modes such as cars, and more specifically, autonomous and electric vehicles, will also slowly start to gain popularity post the pandemic. In addition, the data for 2017 showed that electric vehicles have around 1.2% of all sales in total in the world, and 40 companies are currently developing road going self-driving vehicles. A benefit of electric vehicles includes that they produce zero direct emission, which in turn, helps to improve the air quality in urban areas. However, electric vehicles produce fewer life cycle emissions than vehicles that are conventional. This is because most emissions are lower for the generation of electricity than for the burning of gasoline, or diesel. The company, Ford, announced in 2019 that they are going to be expanding their alliance globally to include electric vehicles, and along with that, they will also collaborate with ARGO AI in order to introduce autonomous vehicle technology in both the U.S.A, and Europe. Furthermore, Volkswagen and Ford have said that they will team up in order to take upon the challenge of creating a self-driving car. Both of them have planned to use technology from Argo AI (artificial intelligence), in ridesharing services, maybe even as early as the year of 2021. Regarding the company, Tesla, all new cars have advanced technology which

is capable of self-driving features in the near future. In addition, post the COVID-19 pandemic, the amount of use of public transportation, autonomous vehicles, electric vehicles, and conventional vehicles is sure to change based on the different circumstances.

Current Status and Literature Review

Currently, electric vehicles are expected to “survive” the pandemic better than vehicles that are conventional. This is because of the government's commitment to meet the overall emission target. In addition, COVID-19 has also made an effect on the automotive sector, which is currently at a standstill of many OEM and supplier factories, which will produce approximately 7.5 million fewer vehicles in the year of 2020. Furthermore, the pandemic could also delay and setback the development of certain advanced technologies, such as autonomous driving in cars. Carmakers and technology companies have said that making and producing autonomous vehicles is going to be much harder, as well as slower, than they had first thought. Many have overestimated when they thought that autonomous vehicles would be introduced upon the world. In addition, researchers at Argo say that the cars that they are currently testing in both Miami, Florida, and Pittsburgh, Pennsylvania, have to navigate situations and obstacles every day. Unexpected events may occur, and self-driving cars may not be able to handle them all. Ms. Malek said that she believed it would take several years, or maybe even a decade, to make driverless cars that could travel anytime, to anywhere. In addition to that, autonomous vehicle (AV) testing may also be suspended, and investment in mobiles may drop drastically. As more and more people start to work from home because of the current situation, the use of vehicles such as cars, trains, and buses, may also start to drop, since people aren't commuting as much as they were before. However, these changes may be temporary, and mobility, such as public transit, is likely to rebound in the upcoming years, and continue to increase market share.

Regarding the ride share industry during the COVID-19 pandemic, services such as Uber and Lyft have dropped to almost 70%. This is mainly because people have the fear of getting infection by traveling. However, in the upcoming years following the post COVID-19 pandemic, the use of ridesharing services may slowly start to increase.

What will be different post COVID-19

I believe that post COVID, the use of autonomous vehicles will definitely increase. For example, countries such as China are starting to use self-driving cars after the lockdown. China is seeing

an acceleration in using autonomous vehicles as they start to emerge from the COVID-19 pandemic. Countries that have been heavily impacted by the outbreak, particularly, China, South Korea, and Japan, account for a significant share of the global auto manufacturing around the world. Furthermore, as the pandemic goes on, sectors of Chinese society continue to apply robot services and AI (artificial intelligence), in order to prevent the citizens from getting the virus. In turn, the sales of autonomous vehicles will greatly increase around the world, in order to impose non-contact policies to ensure the citizens' health and safety. Russ Rader, the Senior V.P of Communications at the Insurance Institute for Highway Safety, says that "The building blocks of driverless cars are on the road now," For example, front crash prevention systems have already been in place for the past several years, and they have also been able to warn drivers of an obstruction on the road, and whether or not they need to apply brakes. Additionally, the first big step towards autonomous vehicles was in 2017, which was when Google Inc., said that it would have a system that would be ready to market soon. Therefore, Google's goal is to increase car utilization from approximately 5% to 75%. This means that fewer cars will be on the roads, as well as the highways. As the world starts to recover from the impact of the pandemic, the use of autonomous vehicles and self-driving cars will also greatly increase and will be put into place by many countries throughout the world. I also believe that post pandemic, the use of public transit and ridesharing services may drop because of the potential risk of infection.

Data and preliminary analysis

The restrictions on dining, and everyday life, during the outbreak have also increased demand for non-contact deliveries, and operations, which both rely on technologies and vehicles that are autonomous. Regarding autonomous technology, there are 6 levels of automation. To start, Level 0 is no driving automation. These vehicles have no automation feature. Most vehicles on the road today are this level, which is manually controlled by the driver. However, this level does include systems that may help the driver such as the emergency braking system. Level 1 is driver's assistance, which is the lowest level of automation. These types of cars have low-level driver assistance features. These features in the vehicle include lane departure assist, or adaptive cruise control, which in turn allows the cars to follow traffic at a safe distance. However, the driver monitors other aspects of driving such as braking and steering. Level 2 of automation is partial driving automation. This means ADAS, or advanced driver assistance system. These types of cars can control steering, accelerating, and decelerating. Tesla's Full

Self-Driving Autopilot system and Cadillac (General Motors) are both examples of level two automation technology. The vehicle can change lanes and navigate, but for safety reasons, the driver has to monitor traffic. Level 3 is conditional driving automation. These types of vehicles are thought to be “proper” autonomous vehicles without the need for any human intervention. Humans do not need to pay attention to the road, however they should still be present and alert in case, if necessary, for any reason. These types of vehicles have “environmental detection” and can make decisions for themselves. Level 4 is high driving automation. Vehicles that are a level 4 can drive themselves, and essentially, no driver is needed. However, humans still have the option to override if absolutely necessary. These types of vehicles are more geared towards ridesharing. For example, NAYA, which is a French company, is selling Level 4 cabs and shuttles in the U.S.A that can reach a top speed of 55 miles per hour. In addition to that, both companies, Volvo and Baidu, have also announced a partnership to develop Level 4 electric and autonomous vehicles together, that will then go on to serve the robotaxi market in China. Finally, Level 5 is full driving automation. In these types of autonomous vehicles, “dynamic driving task” is not needed; it is eliminated. These cars will not have steering wheels, acceleration pedals, or even braking pedals. Although none of these vehicles are currently available to the general public, these cars are currently going through extensive testing in many parts of the world. In addition, these types of vehicles will also have no restrictions over where they can go and where they can travel. These 6 levels of automation listed above are related to autonomous vehicles. Advanced technology can also help the car to avoid drifting into parallel lanes, as well as warn other drivers that may be behind them. Furthermore, other safety technologies, such as the use of several cameras, sensors, and radars, can also help the vehicles to identify any safety risks or issues that may be imposed on them while driving, in order to help prevent any crashes, collisions, or accidents that may happen. Autonomous vehicles are also rich in physical safety features, such as airbags and seatbelts, however they are not very rich in features such as digital security. In addition to this, the number of electric car sales are growing during the COVID-19 pandemic, and are expected to reach almost 10 million, according to a report and study done by the International Energy Agency. Furthermore, data collected from months January 2020 to April 2020 shows that global passenger car sales are set to decline by almost 15%. Autonomous vehicles are sure to become increasingly popular following the COVID-19 pandemic because of several reasons, some of which include safety and efficiency.

Conclusion

In conclusion, new technologies and vehicles will be very different post pandemic. COVID-19 will have a long-term impact on the world regarding the different technologies that will be used. For example, there will definitely be a huge increase and acceleration in the use of artificial intelligence (AI) in several human jobs. In addition, working will become much more distant, and working from home will also be put into place much more often than it was before. There will also be several new and advanced technologies such as online payment systems, as well as online appointment scheduling, which are extremely crucial when there is no contact necessary, or needed. Autonomous, as well as electric vehicles, will also certainly gain much more popularity post the COVID-19 pandemic. This is because autonomous vehicles provide many benefits, some of these including the potential to drastically reduce car crashes and fatalities, prevent injuries, and save lives. Professor Robert W. Peterson of the Center for Insurance Law and Regulation at Santa Clara University School of Law says that over 90% of car accidents are caused by driver errors, and so the use of autonomous vehicles can possibly reduce accidents that are related to human error. In addition, the use of self-driving vehicles will also reduce the amount of parking spaces that will be needed. Furthermore, autonomous vehicles can also boost productivity levels, and they can also increase fuel efficiency. Regarding economic benefits, autonomous vehicles could also reduce the cost spent in treating injuries from car accidents. In addition, regarding efficiency and convenience, self-driving cars could also result in smoother traffic flow and reduce traffic jams, or congestion. In addition to that, regarding mobility, automated vehicles could also provide many new mobility options for many more Americans. However, autonomous vehicles do come along with a couple of negative effects. For example, self-driving cars can get either damaged, flooded, or stolen. In addition to that, there are also several different legislative and regulatory obstacles that come along with the use of these self-driving cars, one of them including privacy. Security is also another big issue, mainly because hackers may be able to take control of these self-driving vehicles. Although autonomous vehicles have some negative aspects to them, they also have several benefits, as mentioned above. To conclude, both the making and the use of new technologies and vehicles, such as autonomous and electric, will definitely be greatly affected post the COVID-19 pandemic. They are bound to have a substantial effect on both our society, as well as our community.

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Acknowledgements

The authors gratefully acknowledge all logistics and scheduling support from our teaching assistant Archana Pradeep. We would also like to thank Dr. Sindhu Suresh and Sajini Menon for envisioning and Sruthi Suresh for coordinating the Allies against COVID program which gave us the opportunity to explore our research interest in the field Urban Transportation and Sustainability. Finally, we would also like to thank Cathe Reams and Soumya Kundu for stepping in as a guest judge for final project presentation and providing invaluable feedback on our work.