**The impact of extreme weather on public transportation resilience and equity in Philadelphia**

**1. Introduction**

Extreme weather events, such as floods and severe winter storms, pose significant challenges to urban transportation networks, often leading to service disruptions and exacerbating socioeconomic disparities. Public transit systems play a crucial role in ensuring urban mobility, particularly for transit-dependent populations. However, research indicates that transportation infrastructure remains highly vulnerable to climate-related disruptions, with floods alone threatening nearly 27% of global transit networks (Dawson et al., 2019). Service failures caused by extreme weather not only disrupt daily commutes but also disproportionately affect marginalized communities, who rely on public transit for access to employment, healthcare, and education (Coleman et al., 2024). Understanding how severe weather impacts transit accessibility, ridership patterns, and service reliability is essential for improving resilience and promoting equitable mobility.

This study aims to analyze the effects of extreme weather on Philadelphia’s public transit system, focusing on the Southeastern Pennsylvania Transportation Authority (SEPTA). Given SEPTA's vital role in regional mobility, we will examine passenger flow across different transit modes—including buses, subways, and regional rail—to assess how severe weather events influence ridership and service availability. A key aspect of this research is determining whether certain neighborhoods and demographic groups experience greater disruptions than others, highlighting potential disparities in accessibility and resilience. By identifying patterns of service interruptions and infrastructure vulnerabilities, this study will provide data-driven recommendations for strengthening SEPTA’s preparedness and ensuring equitable access to public transportation during adverse weather conditions.

**2. Research Objectives and Scope**

This study focuses on three interrelated research areas:

1. **Impact of Extreme Weather on Ridership Patterns**
   1. Investigate how severe weather events, such as floods and winter storms, affect passenger flow across SEPTA’s transit network.
   2. Analyze ridership data before, during, and after extreme weather events to identify changes in public transportation usage.
   3. Evaluate the extent of service disruptions across different transit modes, including buses, subways, and regional rail.
2. **Disparities in Transit Accessibility and Service Reliability**
   1. Assess whether extreme weather disproportionately impacts certain communities based on socioeconomic factors, geographic location, and transit dependency.
   2. Determine whether lower-income or transit-dependent populations face longer delays, more frequent route cancellations, or reduced service frequency compared to other areas with more resilient infrastructure.
3. **Infrastructure Vulnerabilities and System Resilience**
   1. Identify structural and operational weaknesses within SEPTA’s network that contribute to service disruptions during extreme weather events.
   2. Pinpoint critical failure points, such as flood-prone stations, aging infrastructure, and gaps in emergency response.
   3. Develop recommendations for improving SEPTA’s resilience through infrastructure investments, adaptive transit planning, and emergency preparedness strategies.

**3. Literature Review**

Research has consistently shown that extreme weather events disrupt public transit systems and exacerbate social inequalities in urban mobility. Dawson et al. (2019) highlight that a significant portion of global transit infrastructure is at risk of climate-related disruptions, with flooding being the most critical threat to urban transport networks. Piraveenan et al. (2024) further demonstrate that infrastructure bottlenecks and transit failures can lead to cascading delays, affecting not just the immediate disaster-impacted areas but also broader regional mobility.

In terms of equity, Coleman et al. (2024) and Golub et al. (2024) emphasize that transit-dependent populations—often low-income communities—experience longer recovery times and greater accessibility challenges following extreme weather disruptions. Research on wildfire and flood evacuations has found that public transit users, particularly those without access to private vehicles, are frequently overlooked in disaster response planning (McCaffrey et al., 2024). To address these disparities, Nguyen et al. (2021) stress the importance of integrating transit equity considerations into disaster mitigation efforts, ensuring that transit-dependent populations are prioritized in both emergency response and long-term resilience planning.

Infrastructure resilience remains a key focus in transportation research, with Padgett et al. (2022) advocating for flood-resistant transit infrastructure, underground drainage systems, and elevated roads to mitigate the impact of severe weather. Chang et al. (2024) further highlight the role of data-driven decision-making in strengthening transportation systems, calling for enhanced early-warning mechanisms and targeted infrastructure investments. As climate change intensifies the frequency and severity of extreme weather events, urban transit networks must adopt proactive strategies to enhance resilience and ensure equitable mobility.

1. **Importance of the Topic**

As climate change increases the frequency of extreme weather events, urban transit systems like SEPTA face growing challenges in maintaining reliable and equitable service. Severe weather disruptions can restrict access to essential services, disproportionately affecting transit-dependent populations and exacerbating existing mobility inequalities. Without effective resilience strategies, these disruptions will continue to undermine economic stability, environmental sustainability, and social equity.

By identifying vulnerabilities and disparities in transit accessibility, this study aims to inform data-driven policies that enhance SEPTA’s operational resilience. The findings will help transit authorities, urban planners, and policymakers develop targeted interventions that ensure reliable service during extreme weather conditions. Strengthening Philadelphia’s public transit infrastructure against climate risks is essential not only for enhancing day-to-day mobility but also for fostering long-term urban sustainability and social inclusion.

1. **Data to be collected**

The study will collect a range of quantitative and qualitative data to analyze the impact of extreme weather on SEPTA’s public transit system. The data sources include transit records, meteorological data, and demographic statistics to ensure a comprehensive evaluation.

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| Category | Specific Data Collected | Source |
| **Transit ridership data** | **- Daily or weekly or monthly passenger counts before, during, and after weather events, from 2019 to 2024 - Mode-specific ridership (bus, regional rail)** | **SEPTA ridership databases, transit reports** |
| Service disruptions | - Delays, cancellations, and route deviations due to extreme weather - Infrastructure failures (e.g., station closures, track flooding) | SEPTA incident logs, real-time service alerts, maintenance reports |
| Weather data | - Historical weather patterns and extreme event records - Temperature, precipitation, snowfall, and wind speed during events | National Weather Service, NOAA, local reports  <https://www.weather.gov/> |
| Socioeconomic & geographic | - Demographics of affected areas (income, car ownership, transit dependency) - Geographic distribution of disruptions (mapping affected transit zones) | U.S. Census, American Community Survey (ACS), <https://www.census.gov/programs-surveys/acs> |
| Temporal patterns | - Seasonal variations in ridership trends and weather impacts - Peak vs. off-peak disruption analysis | Longitudinal analysis of transit data, time-segmented ridership data |

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