Enhancing transport system resilience during mass participation events

Dr. Kristina Wolf *[1], Dr. Matt Burke[1], Dr. Peter Helm[1], Prof. Phil Blythe[1], Rose Bunker[1]

*corresponding author: Kristina.Wolf@newcastle.ac.uk
[1]School of Engineering, Newcastle University, Newcastle upon Tyne, UK

Abstract

Extreme weather events, including flooding and heatwaves, are projected to become more frequent and intense in the future, posing significant challenges to urban infrastructure, the environment and society. Mass participation events, such as sports fixtures, are particularly at risk, as large crowds of participants and spectators are exposed to challenging outdoor conditions. This case study examines the impacts of the heatwave followed by extreme rainfall during the 2023 Great North Run, the world's largest half-marathon held in North East England. Integrating near-time weather and transport data with insights from a participant's survey, this case study provides insights into the impacts of extreme weather on participants' return travel, travel options, and travel delays. We anticipate that these findings will help authorities and organisers enhance the resilience of similar future events.

Keywords: extreme weather; mass participation events; Great North Run; extreme rainfall; stakeholder engagement

Introduction

The UK Met Office predicts warmer and wetter winters, hotter and drier summers, and an increase in more intense rainfall (Met Office, 2025), which can directly impact urban infrastructure, including road surface damage and transport service failures (Markolf et al., 2019).

The UK Met Office (2024) assessed the impact of future climate conditions on British sporting events, including the world's largest half-marathon, the Great North Run (GNR), which could experience temperatures 2.5°C above current averages by the 2050s. The 2024 Olympics and the 2024 UEFA Euro Cup have already highlighted the impact of extreme weather on athletes' health and performance, as well as on transport services due to capacity challenges. Compared to large-scale events featuring professional athletes, literature highlights the need to understand the implications of extreme weather for regional events (Werner, 2024), which present unique logistical challenges at the community level.

This case study aims to assess the impact of extreme weather on transport systems and participants' travel during the 2023 GNR event, which was marked by a heatwave and followed by heavy rainfall, resulting in flooded metro stations and service disruptions. Findings will include practical ideas for more resilient travel and infrastructure that can improve public safety and mitigate pressure on emergency services during future mass participation events.

Methodology

This case study employed a mixed-methods approach, incorporating near-real-time weather and transport data from the Met Office, Newcastle Urban Observatory, and the Tyne and Wear Urban Traffic Management and Control Centre, and drawing on regional stakeholder discussions.

Further data stems from a participants' survey, featuring 319 participants with a 90% confidence level and a 5% margin of error, with questions on participants' locations, the impact on their travel, health, future participation, and recommendations for future events.

Time-series weather and transport data extraction, transformation and analysis are performed in the Jupyter Notebook development environment using core Python libraries, and the results are visualised in ArcGIS Pro 3.0. Thematic mapping of qualitative data was performed using NVivo.

Results and discussion

Following temperatures of up to 24 degrees, while the average ranges from 10 to 15 degrees in September, thunderstorms produced heavy rainfall (ranging from 15mm to 41 mm) from 2 pm, resulting in direct damage to the South Shields metro station infrastructure, including doors and lifts. As a result, participants diverted to the nearby ferry station. While the ferry continued to operate, it ran at full capacity, indirectly impacting travel times due to long queues until late in the evening. Flooding at Tyne Dock metro station disrupted the metro service to Bede metro station. **Figure 1** visualises incidents, impacted metro stations and roads with the highest increase in travel time.

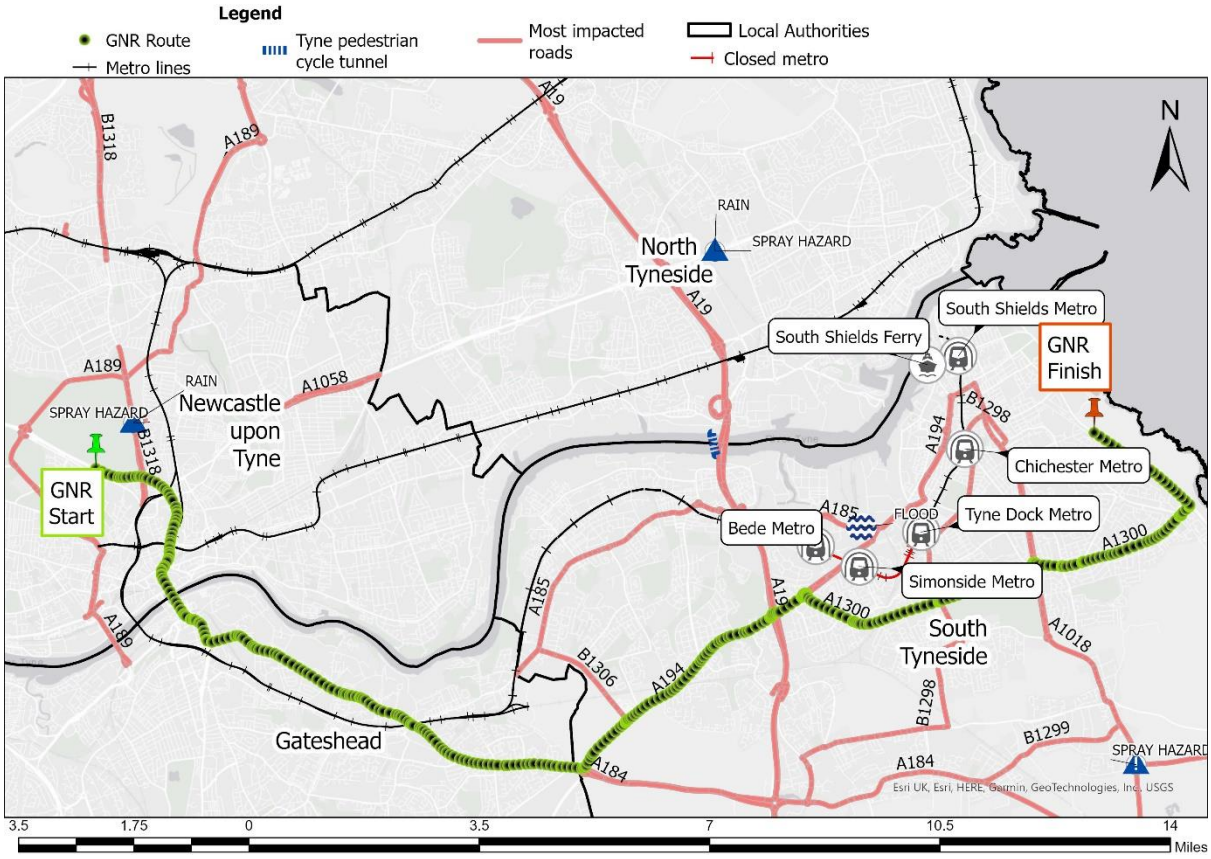

Figure 1: Impacts of extreme weather on transport systems during the 2023 GNR.

30% (96 participants) reported changing travel plans and transport modes. 95 people reported that it was due to the major or moderate impact of rainfall. 52 people attributed their change in travel plans to a major or moderate impact of temperature. When comparing planned and actual usage of transport modes, the metro usage decreased (-35%), mainly due to service disruptions during the event, while the uptake of cars, buses and ferries has increased. The highest increase was in walking (+106%), as participants walked longer distances to locations unaffected by flooding to get a lift or walked entirely home, noting distances of up to 13 miles and the impact on their well-being, due to fatigue and the extreme weather.

To enhance resilience, it is suggested to prepare alternative routes, such as safe walking, cycling, and road routes, to activate if primary routes are compromised. While the Tyne Pedestrian Tunnel could serve as an option, not all alternatives are equally practical, accessible or safe for everyone due to individual needs, such as limited mobility. Another aspect is to explore additional, underused, lesser-known routes. Adaptive transport solutions, such as repurposing available vehicles and using baggage coaches, can transport participants. Deploying express shuttle routes between key locations and providing alternative destinations to major transport hubs are subject to feasibility and existing road closures.

Conclusion

Using the example of the 2023 GNR, the world's largest half-marathon, this study assessed the impact of extreme weather on mass participation events. Quantitative data analysis, participant survey and stakeholder discussions helped identify practical ideas for enhancing resilient travel

and infrastructure. As a next step, this case study aims to develop contingency plans that incorporate measures to enhance transport networks around the GNR area and provide recommendations for future events.

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