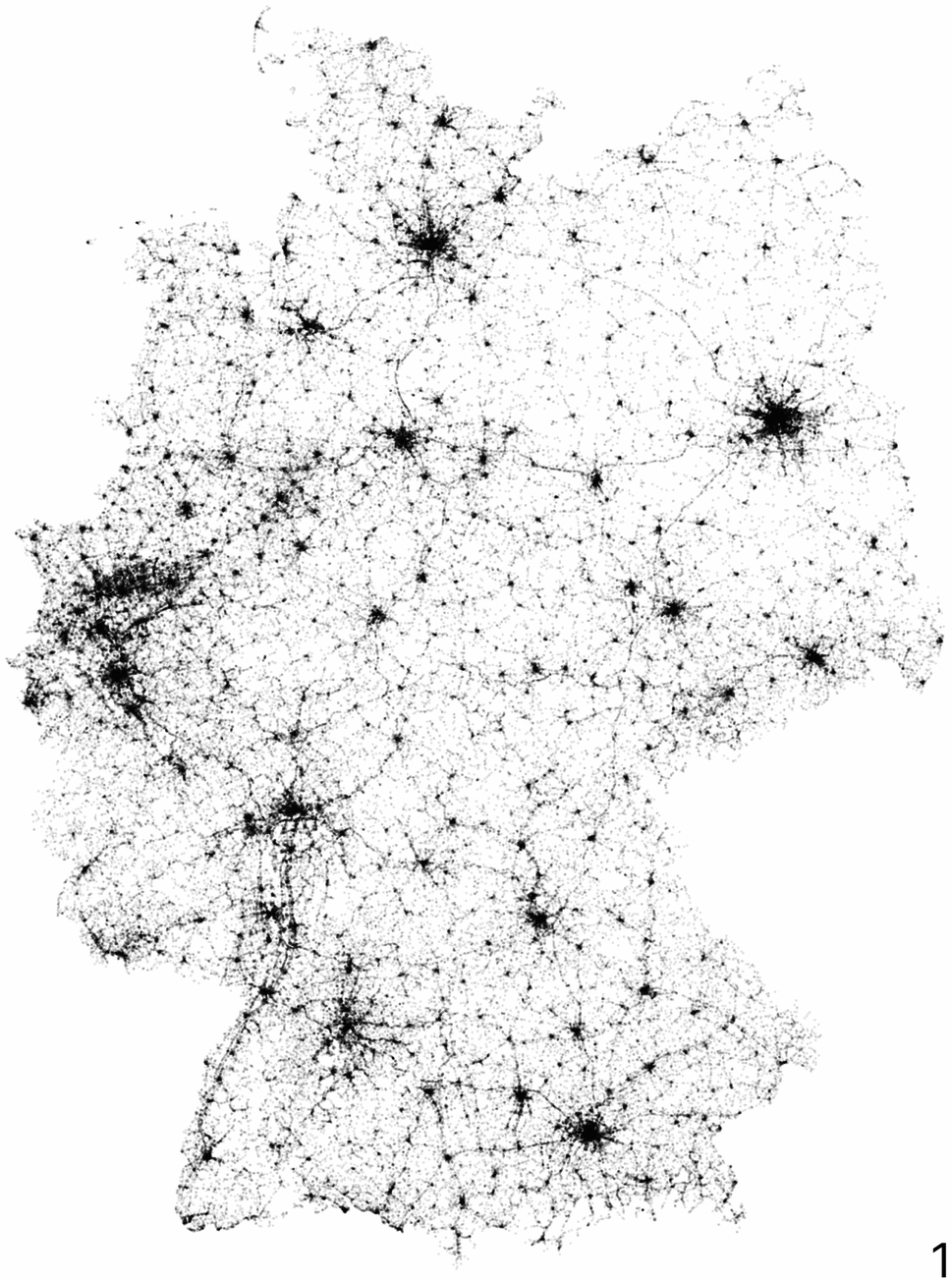
Urban Mobility Risk Analysis

Patterns and trends in urban road accidents across Germany



Michael Fryer **Adrian Frings** **Gaziza Janabayeva**

Agenda

1. Introduction
2. Dataset & Methodology
3. Research Question?
4. Findings for Germany
5. Findings for Frankfurt
6. Conclusion

Why is Analysis on Road Accidents meaningful?

1.20 million

Deaths annually due to road accidents

Nr.1 cause

Of Death among youth age 5-29

3% of GDP

lost in most countries as result of road accidents

🗺️ Data

- Traffic accidents in Germany that involve personal injury
- All German states since 2020
- Covers accidents involving cars, bicycles, motorcycles, pedestrians, and delivery trucks

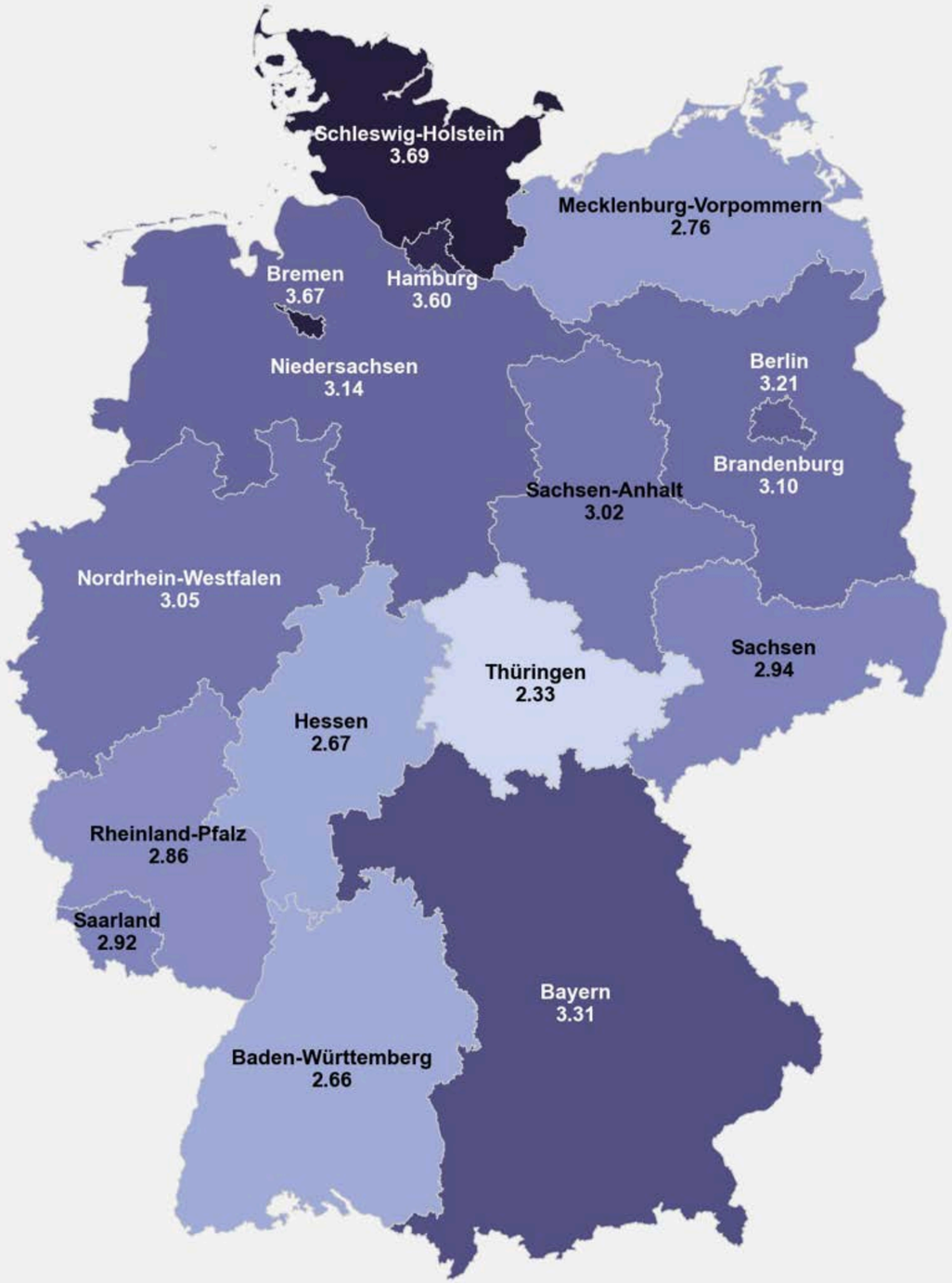
🚧 Limitations

- Personal injury accidents only
- No exact dates → time-series analysis not possible
- Unknown number of participants per accident
- Reporting periods differ slightly between states (NRW data missing for 2021)

📊 Data Source

- German Accident Atlas (Unfallatlas) from the Federal and State Statistical Offices
- GENESIS-Online from the Statistisches Bundesamt (Destatis)

How are traffic accidents with personal injury distributed in Germany?



Accidents per 1000 Inhabitants by State and Year (2020 - 2024)

Key Insights

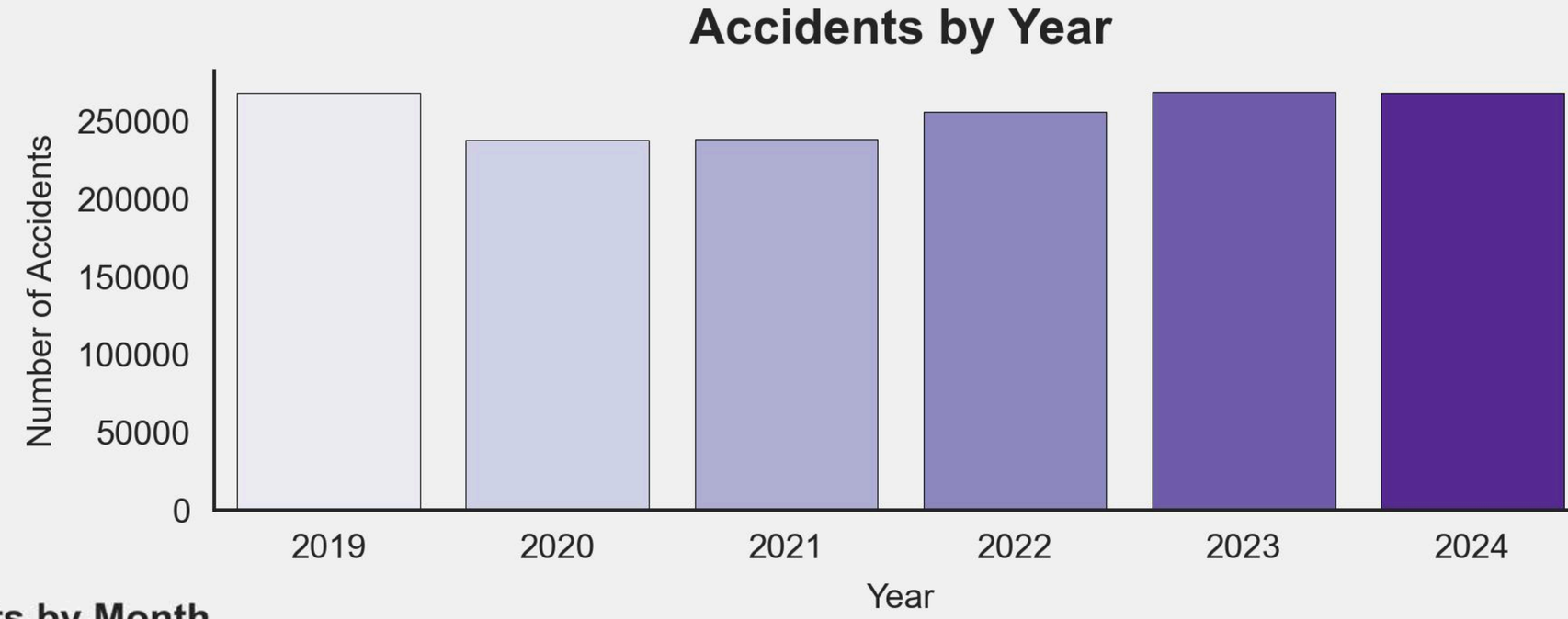
- Highest rates: Schleswig-Holstein, Bremen, Hamburg
- Lowest rates: Thüringen, Baden-Württemberg, Hessen
- Overall: North > South in accident frequency

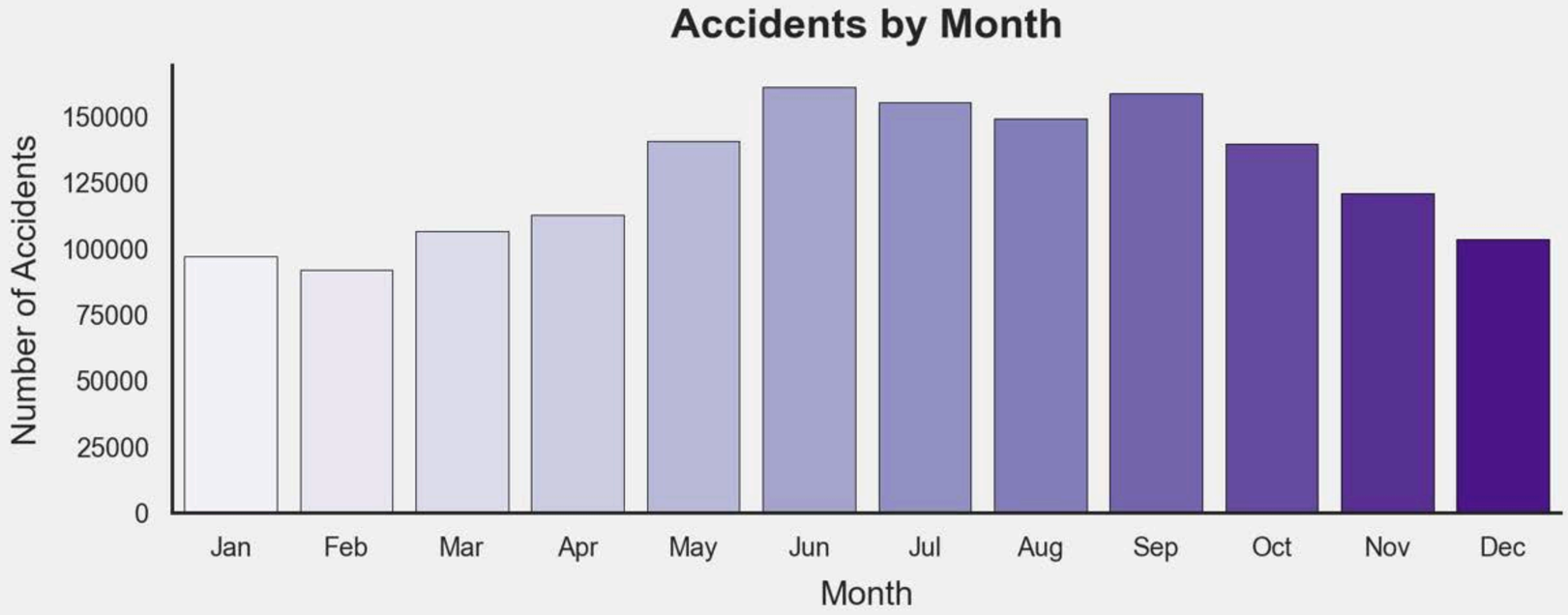
Regional Trends

- Urban and coastal states show higher accident frequencies.
- Central and southern regions (esp. Thüringen, Hessen, Baden-Württemberg) are safer overall.

Trends in Road Accidents by Year and Month

- Sharp drop in 2020 due to COVID-19 lockdowns.
- Steady rise from 2021–2023, peaking at 269K.
- 2024 stabilized, marking a post-pandemic plateau.

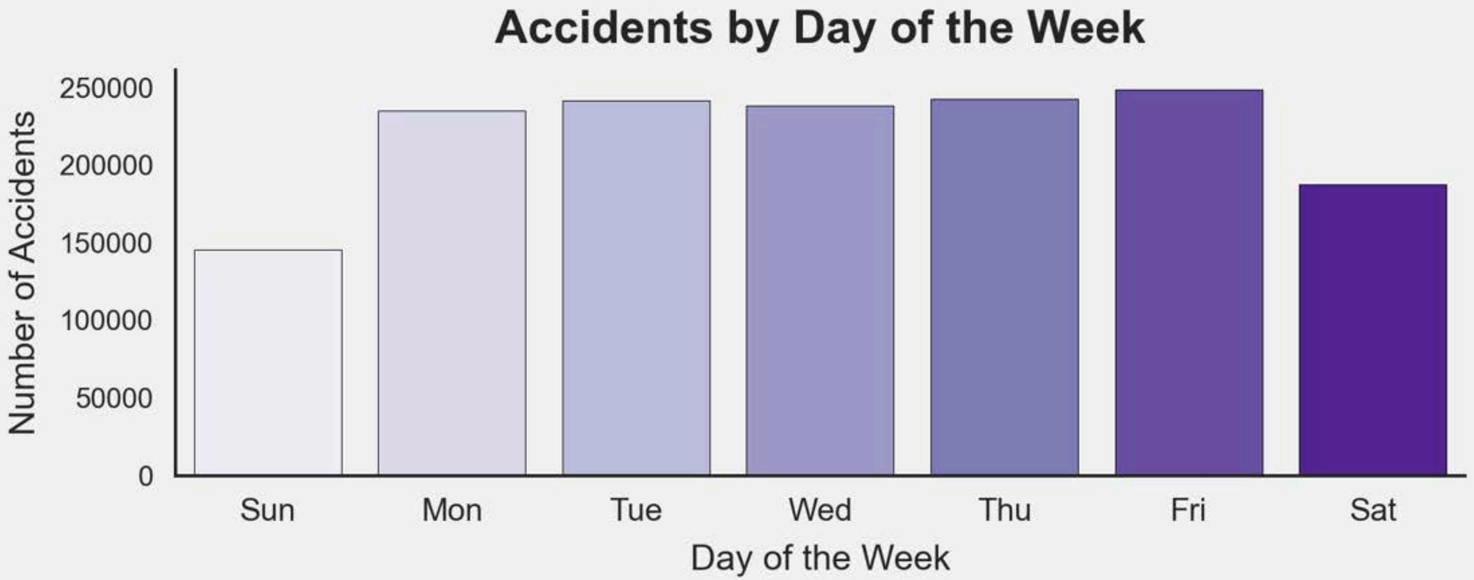


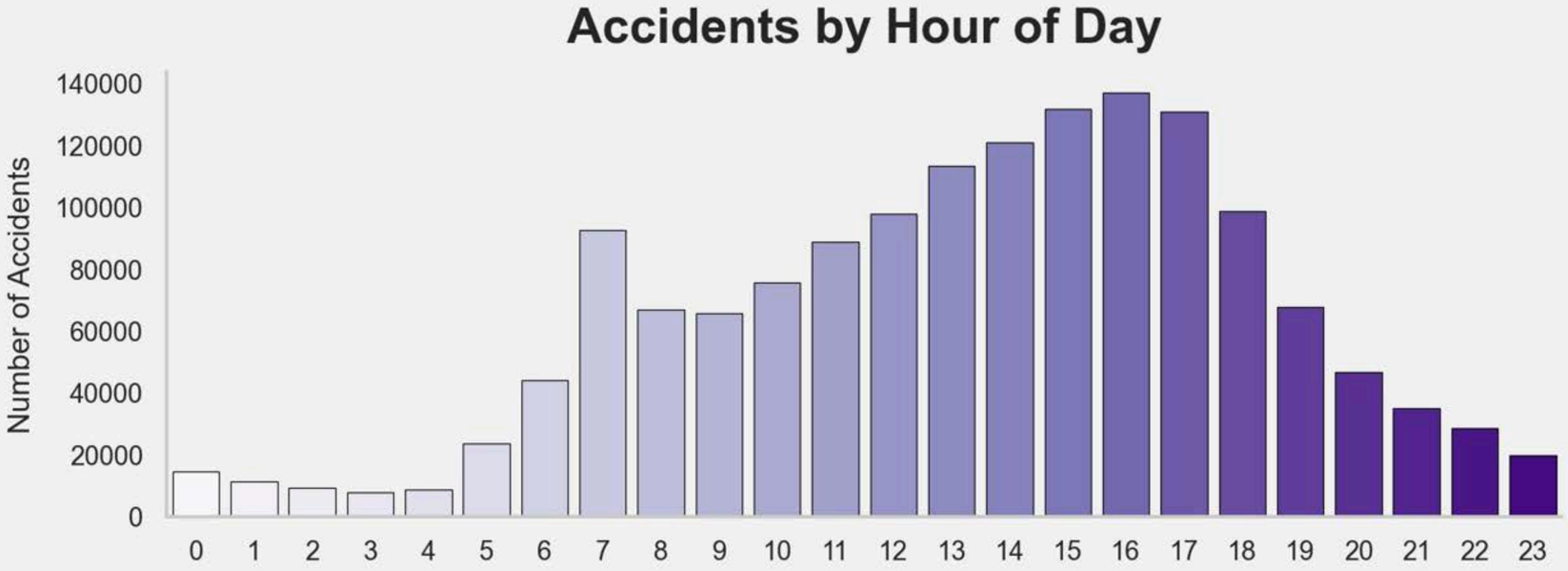


- Peak in June & September (travel season).
- Lowest in February & December (winter slowdown).
- Clear seasonal trend: more accidents in warmer months.

Trends in Road Accidents by Year and Month

- Peak on Friday (~250K).
- Lowest on Sunday (~150K).
- Accidents rise steadily through the week, reflecting higher weekday traffic and commuting activity.

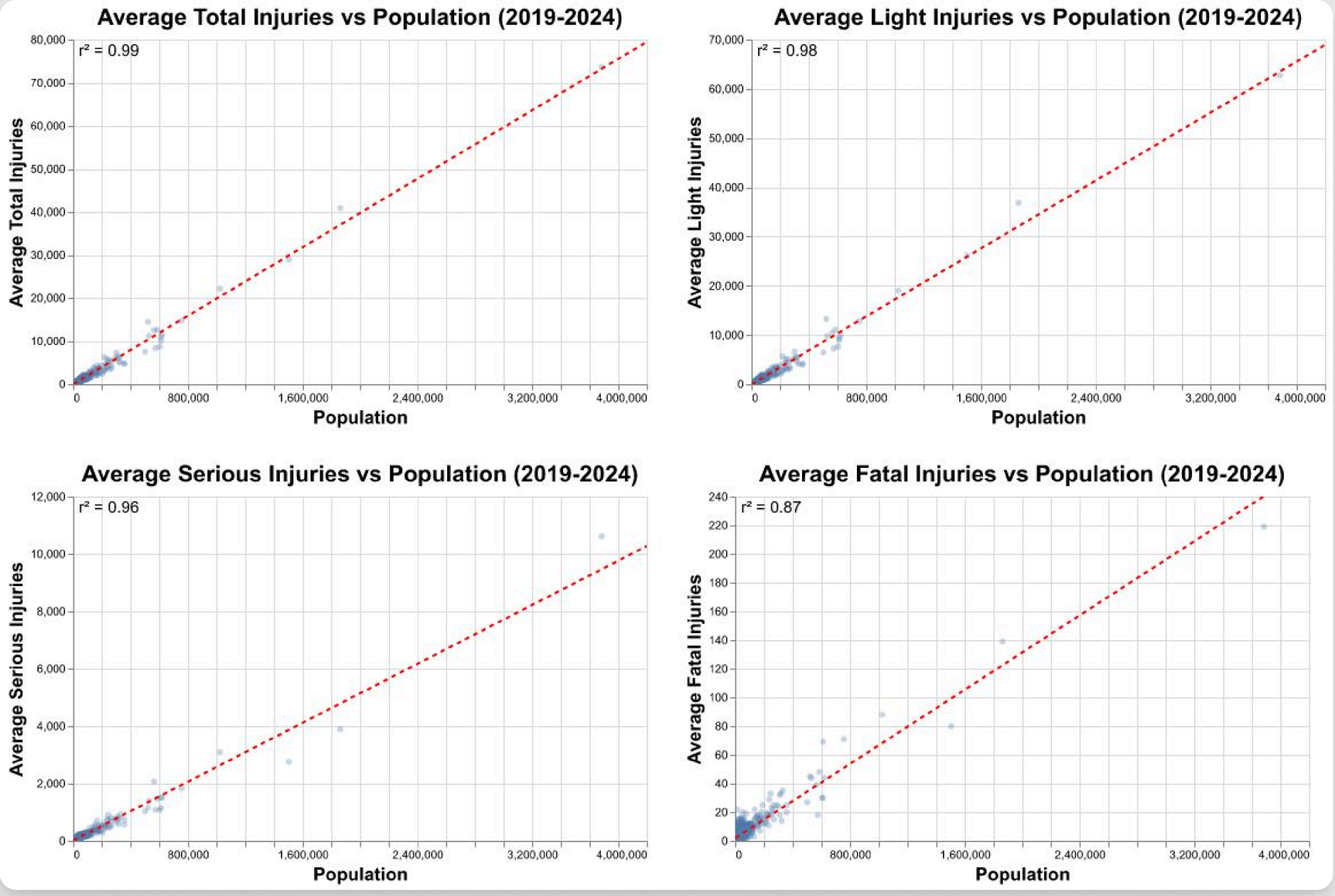




- Accidents rise sharply from 6–7 AM (rush hour).
- Peak at 4 PM (≈137 K accidents).
- Decline after 6 PM, lowest after 10 PM (≈15 K).

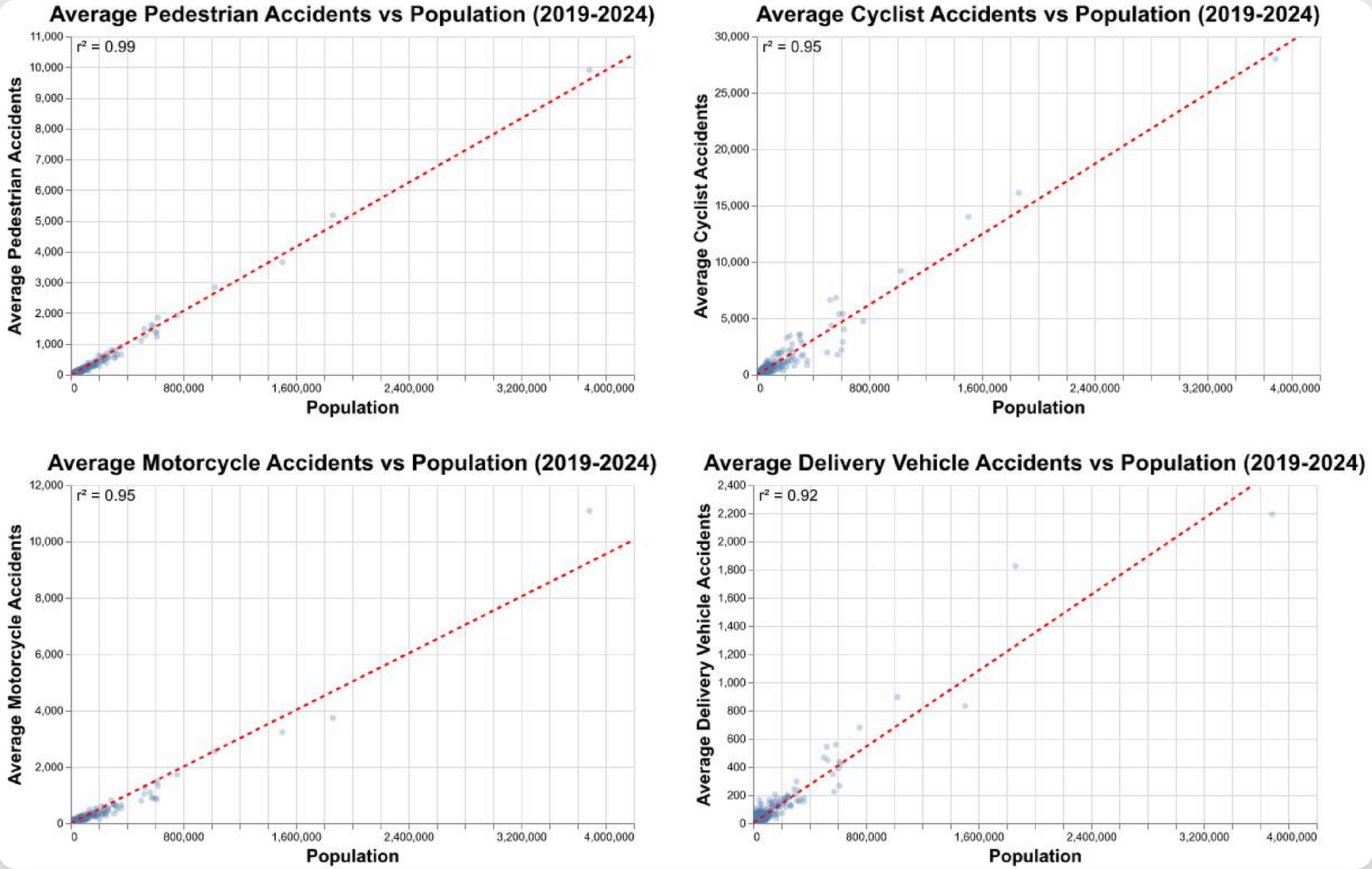
Accident Categories vs Population

- Averaged over 2019-2024
- Extremely linear
- Very high r^2
- Large cities relatively well predicted

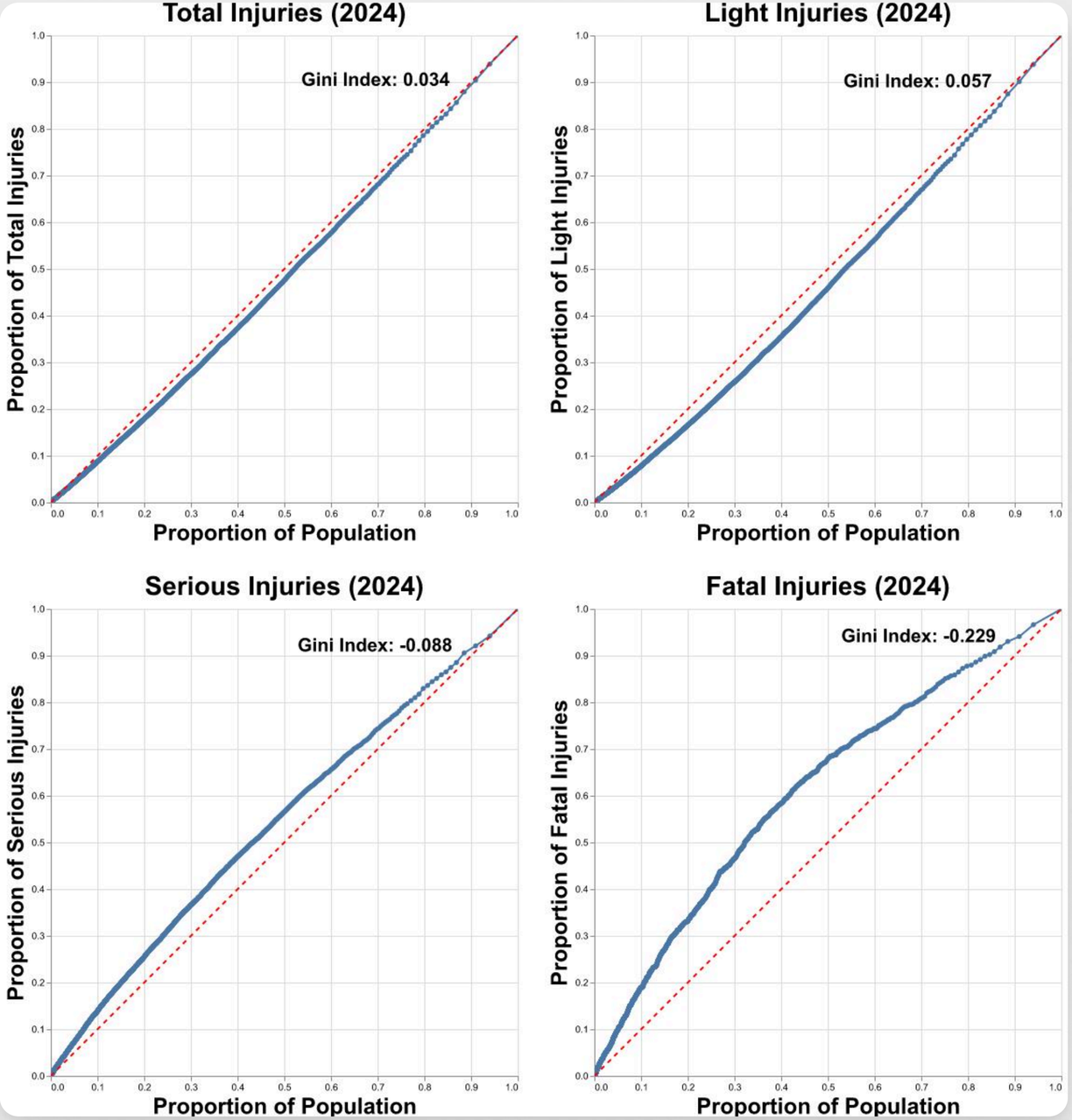


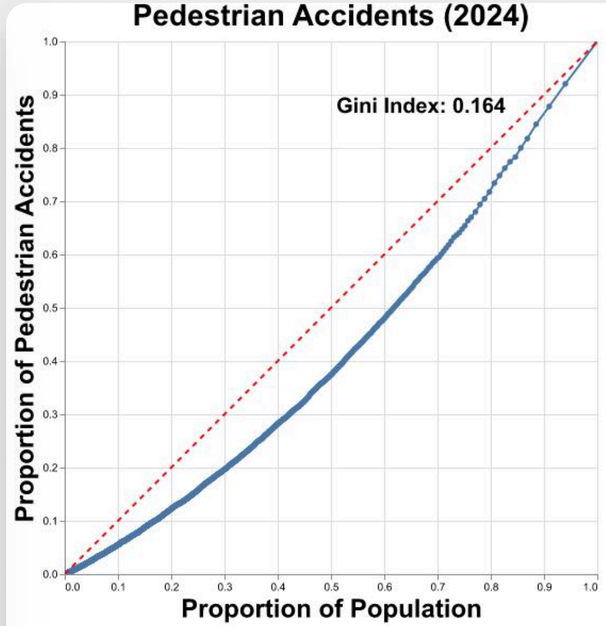
Accident Participants vs Population

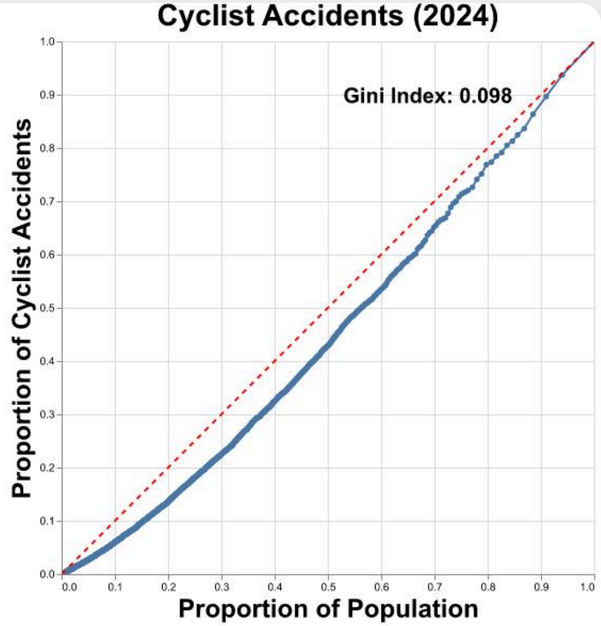
Similar results when comparing different types of participants.

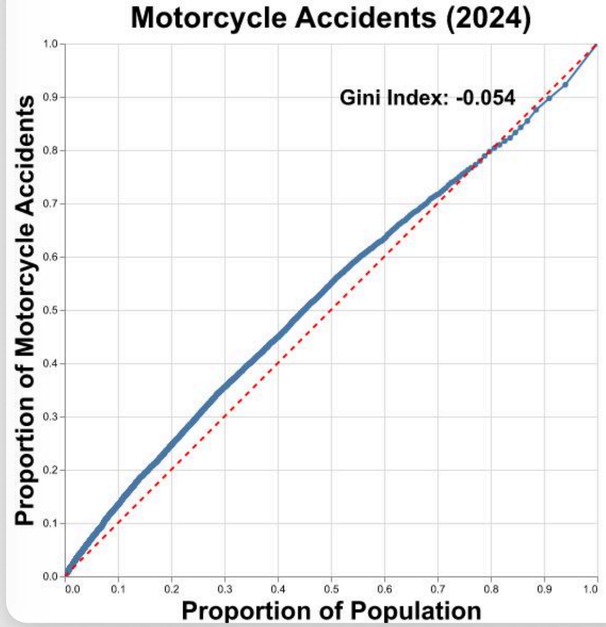


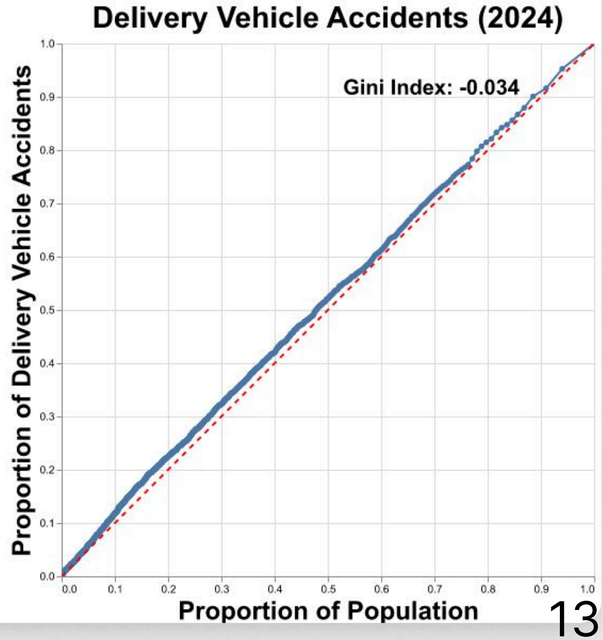
Accident Categories vs Population





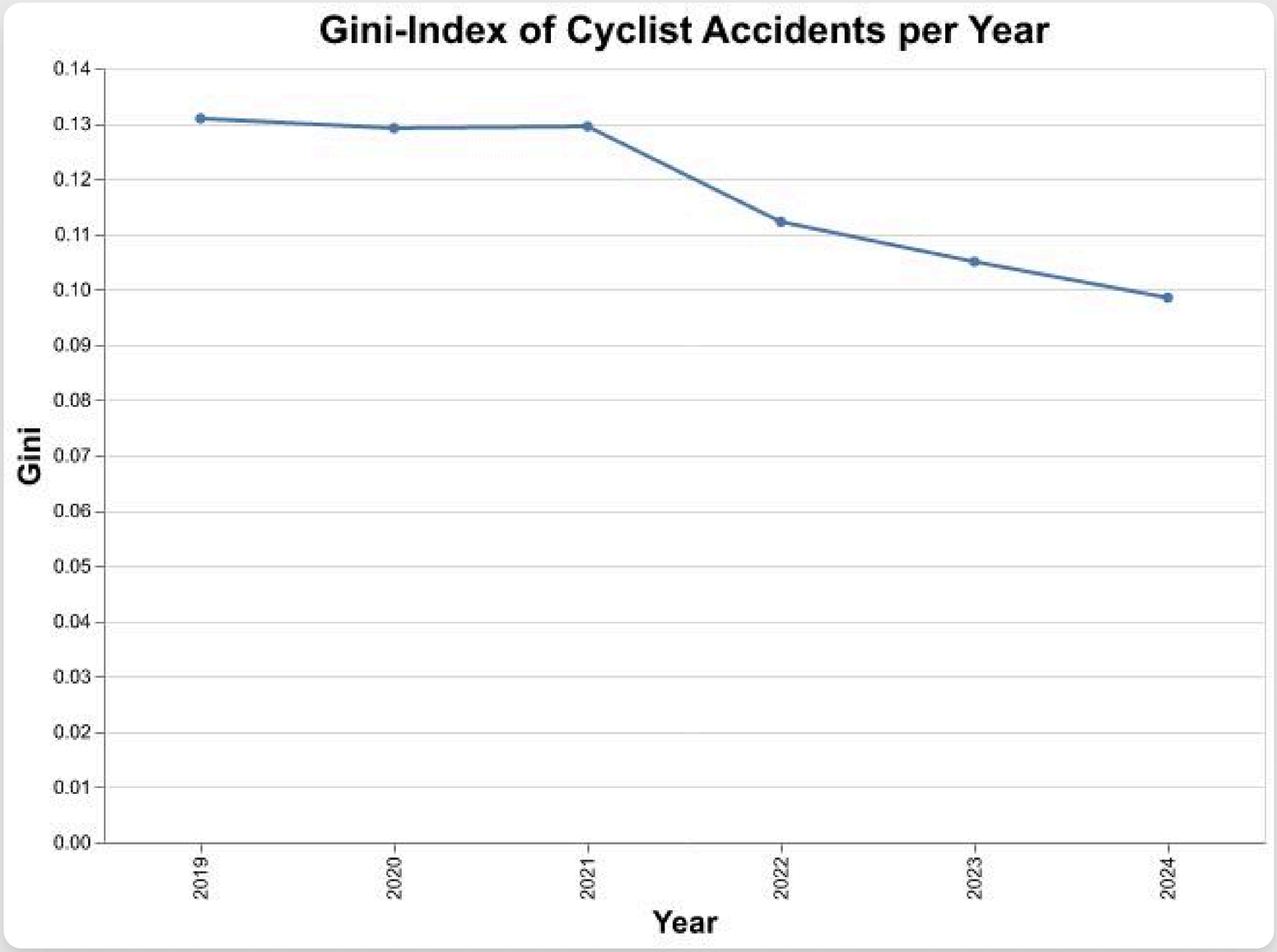




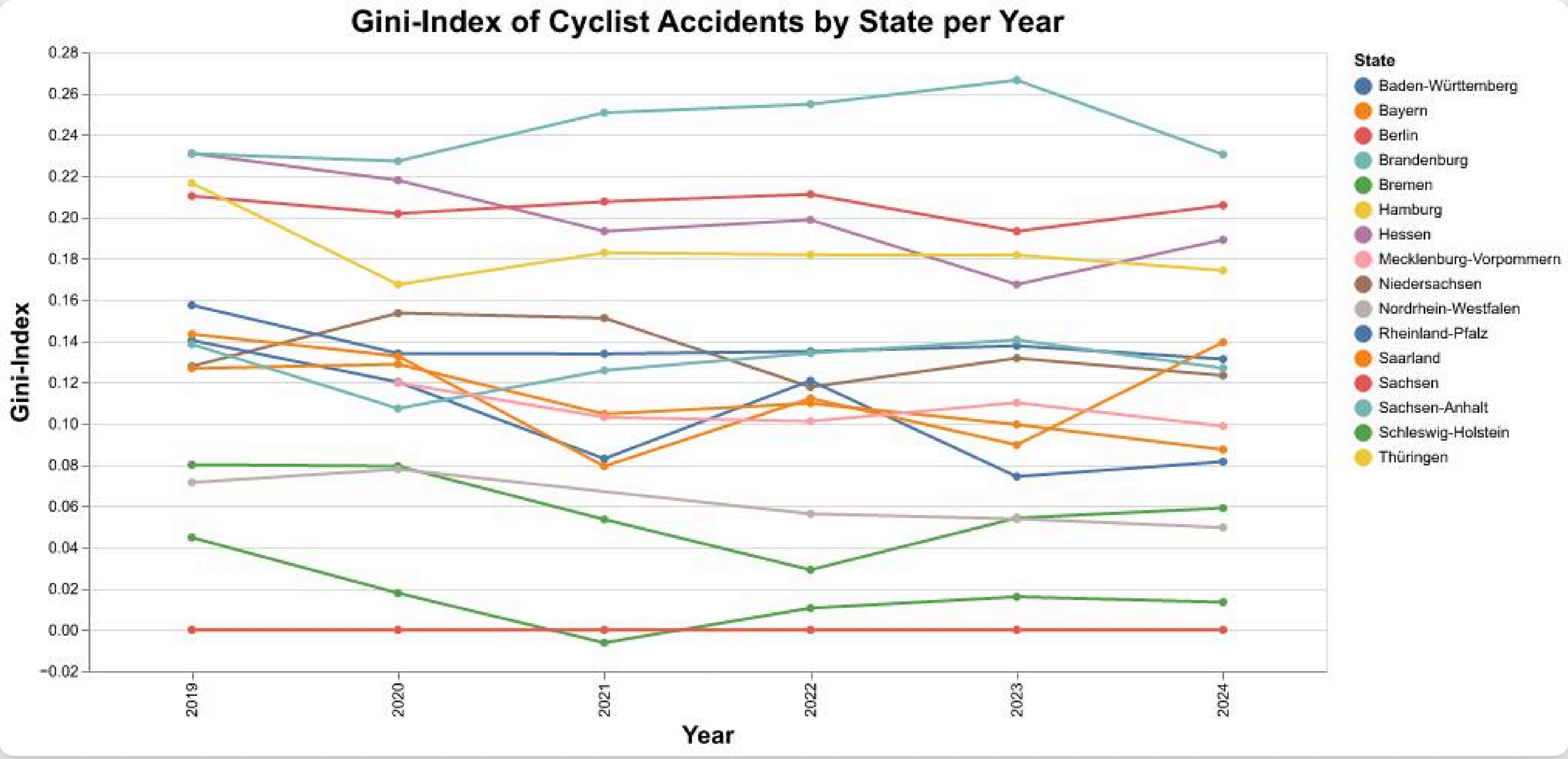


Gini-Index for Cyclist Accidents per Year

- Clear downward trend since 2019
- In theory, this means accidents involving cyclists are becoming more evenly distributes



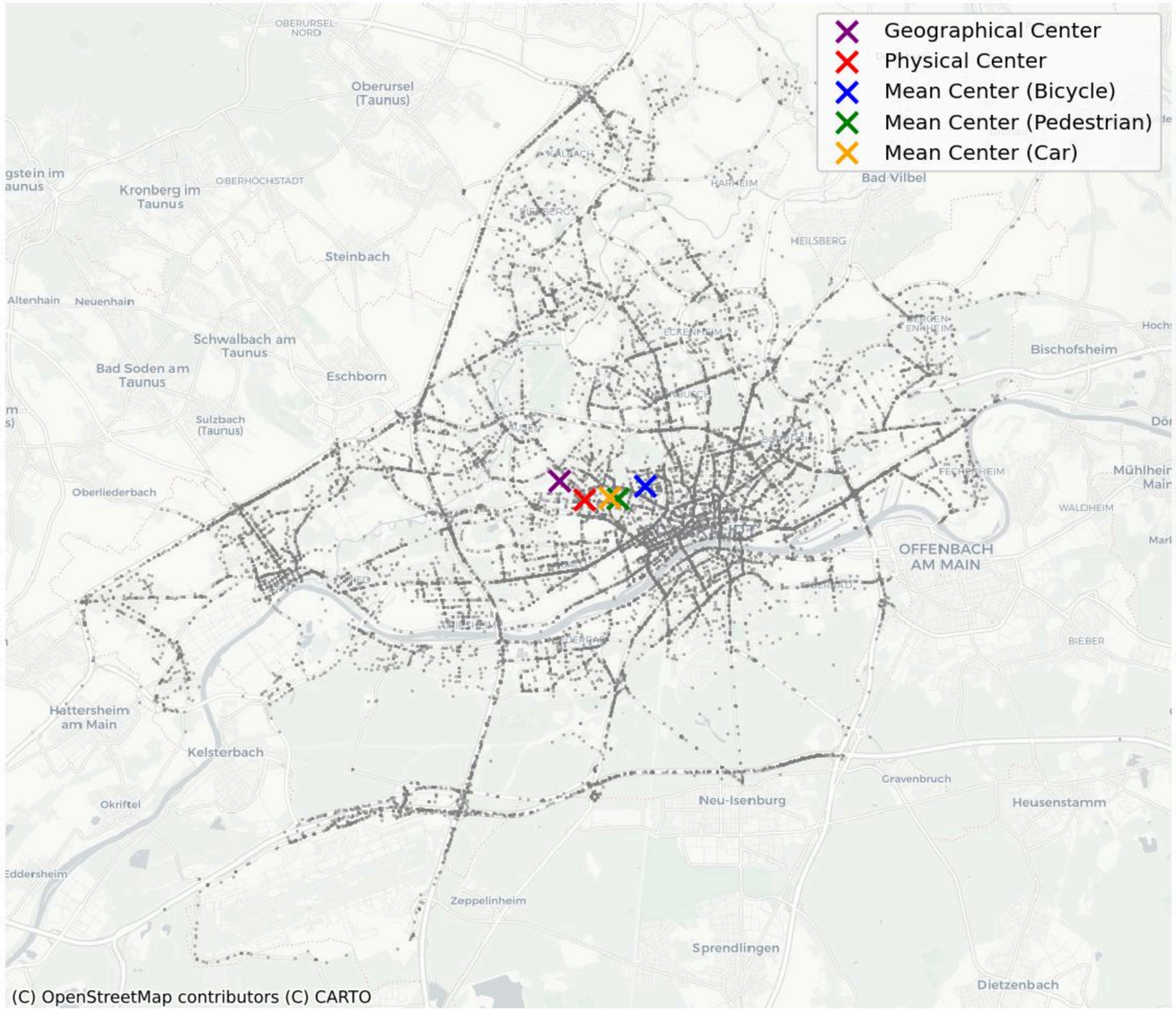
Gini-Index for Cyclist Accidents per State per Year



In reality, it’s much harder to see a trend when comparing on the state level.

How are traffic accidents with personal injury distributed in Frankfurt am Main?

Frankfurt Geospatial Accident Analysis



Frankfurt Accident distribution

Just from looking at this map, it is hard to identify clusters or special points of interest, we can merely guess

By calculating the mean Centres of different Accident types, we cannot derive much meaningful information either

Therefore, we have to use a clustering algorithm to determine points of interest for us

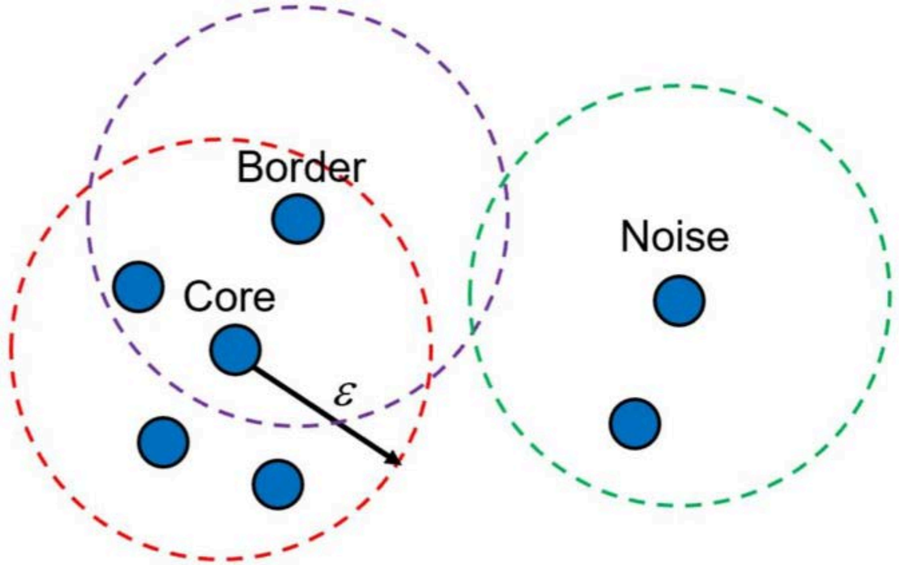
Frankfurt Geospatial Accident Analysis

DBSCAN algorithm (Density-based spatial clustering of applications with noise)

1. Find all points in the neighbourhood of every point within radius <= ε (eps)
   If minimum sample condition is met, the point is declared a core point

2. Find all connected components for core points, ignoring non core points.
   Core points touching each other build a joint cluster in this step

3. Assign each non core point to a nearby cluster if within radius ε.
   If no cluster is near enough, they point is declared as noise



Erich Schubert, Jörg Sander, Martin Ester, Hans Peter Kriegel, and Xiaowei Xu. 2017. DBSCAN Revisited,

Revisited: Why and How You Should (Still) Use DBSCAN. ACM Trans. Database Syst. 42, 3, Article 19

(September 2017), 21 pages. https://doi.org/10.1145/3068335

https://ai.plainenglish.io/dbscan-density-based-clustering-aaebd76e2c8c

Frankfurt Geospatial Accident Analysis

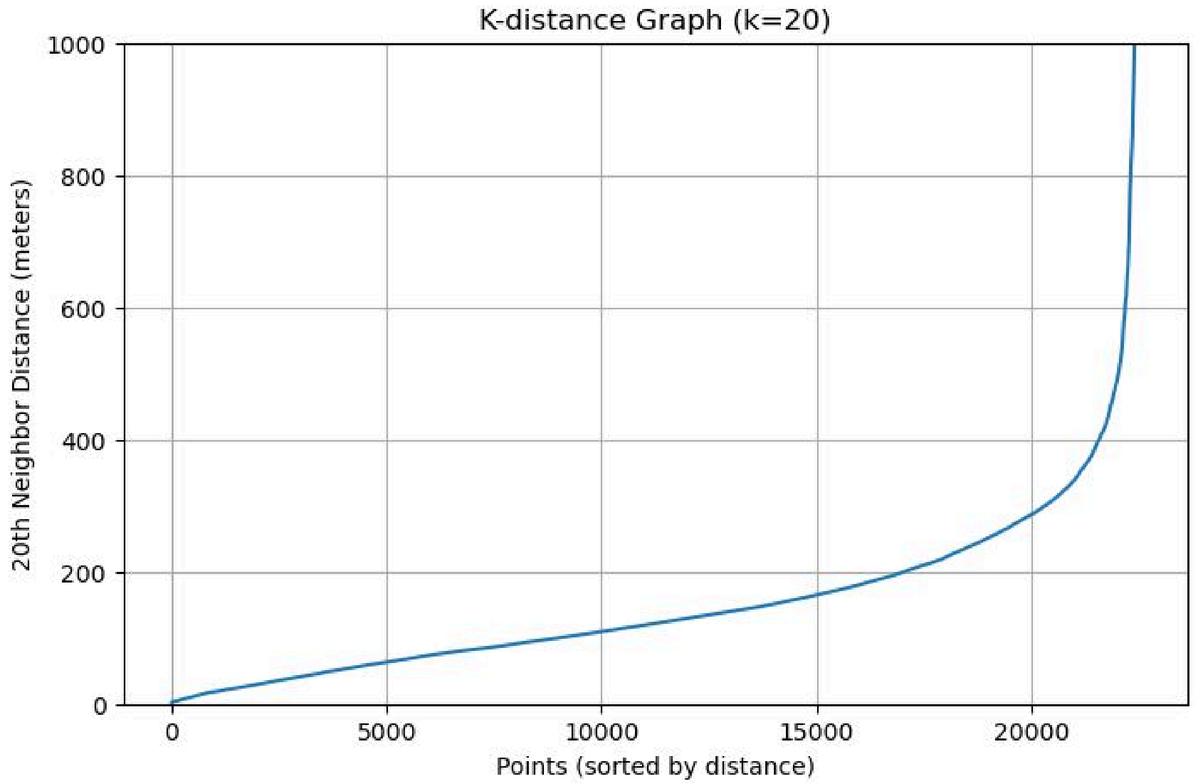
Finding suitable parameters for DBSCAN algorithm

One disadvantage of the the DBSCAN algorithm is, that it is hard to tune its parameters as we usually have no prior information about them.

There are 2 main parameters we have to tune:

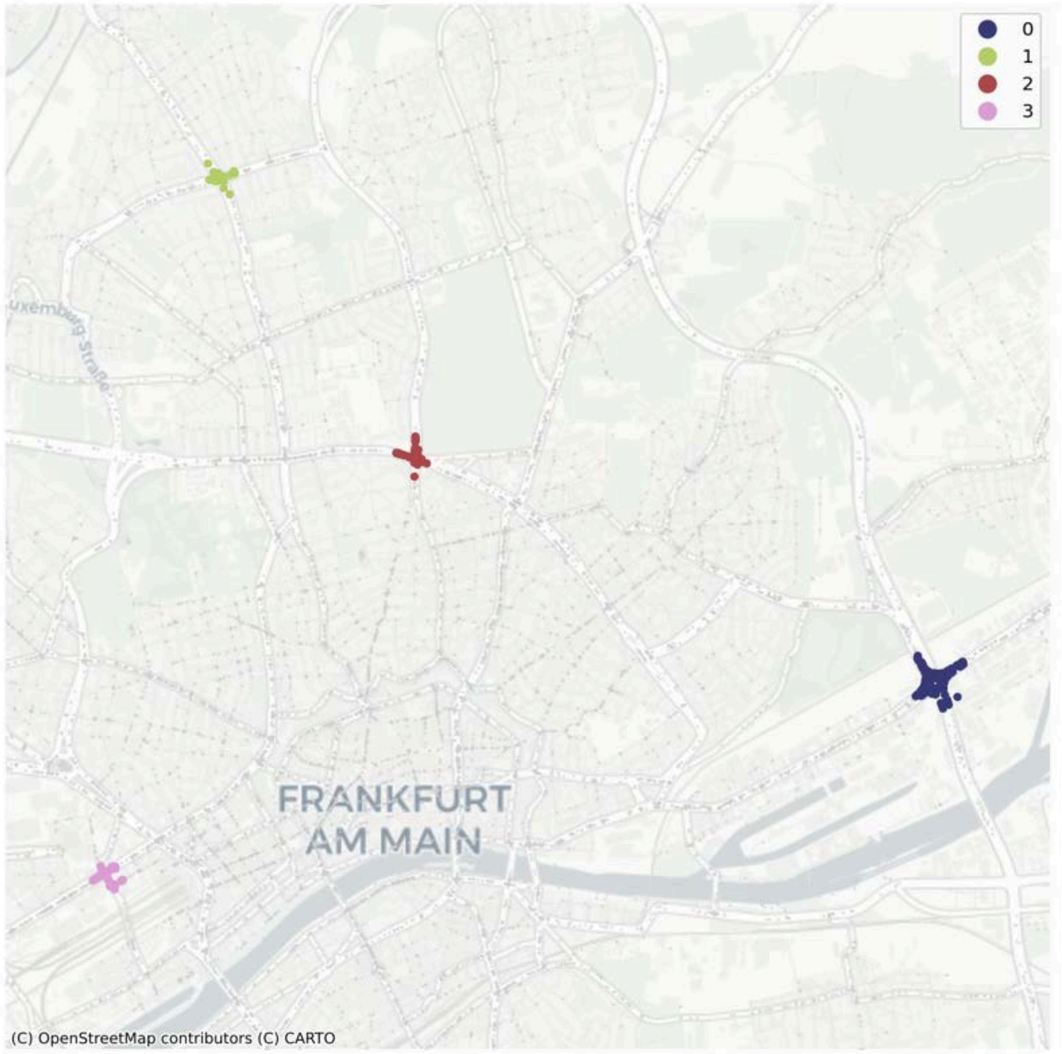
- ε/eps (distance around each point for counting)
- Minimum samples (amount of points within ε to be considered a core point)

To get a feeling for good parameter values, we create an elbow curve with the K-Nearest-Neighbours algorithm



Frankfurt Geospatial Accident Analysis

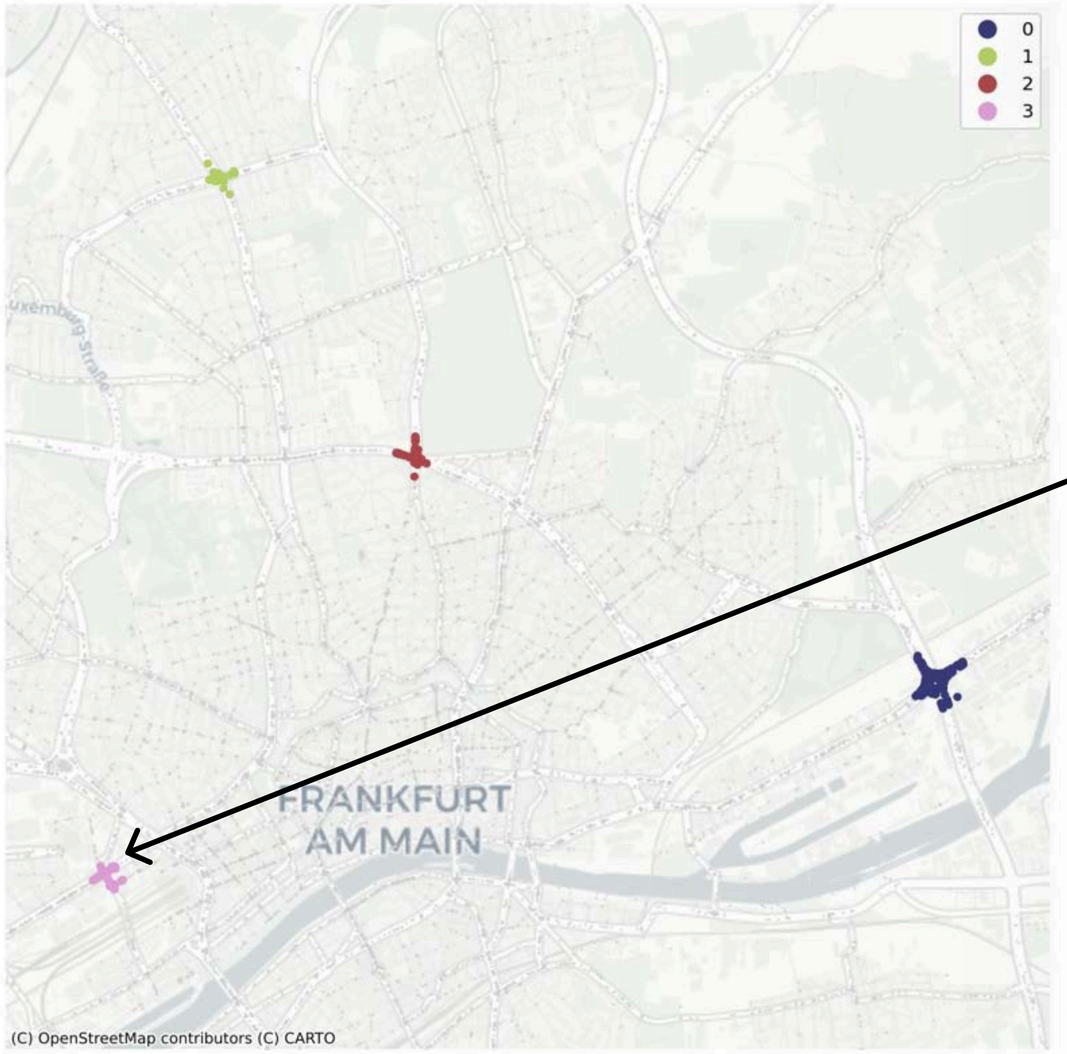
Accident Clusters (all accident events)



DBSCAN Cluster, EPS=100, Min Samples=85, Total Clusters found: 4

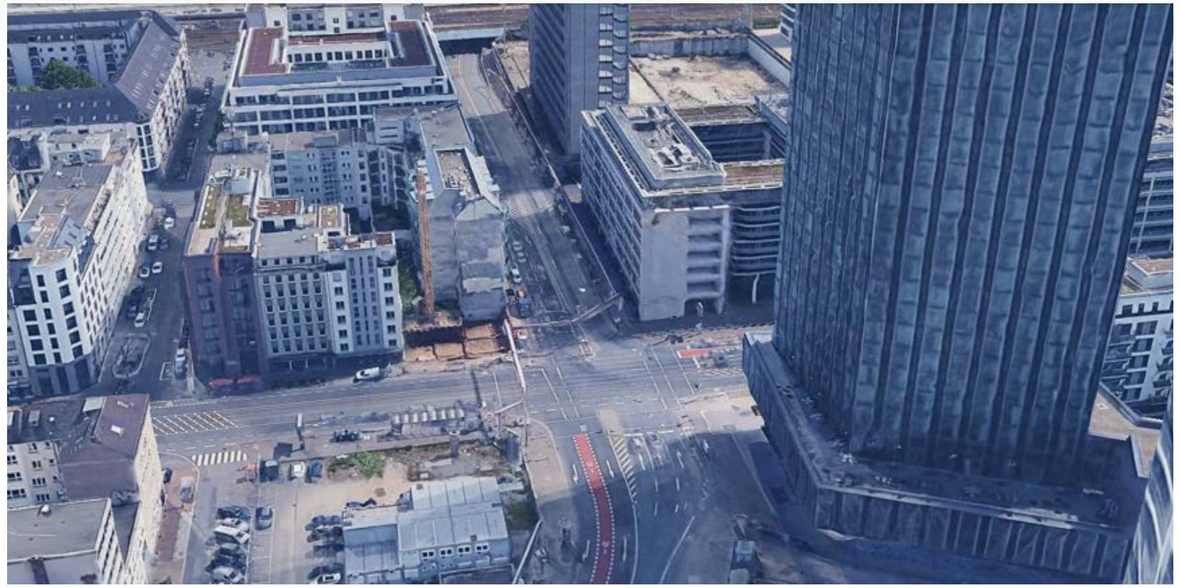
Frankfurt Geospatial Accident Analysis

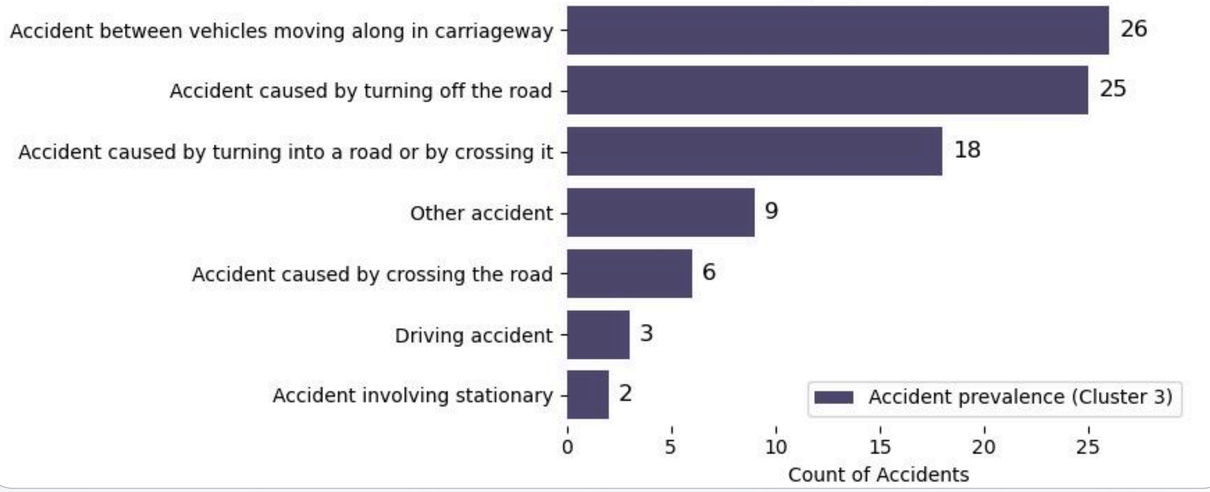
Accident Clusters (all accident events)



DBSCAN Cluster, EPS=100, Min Samples=85, Total Clusters found: 4

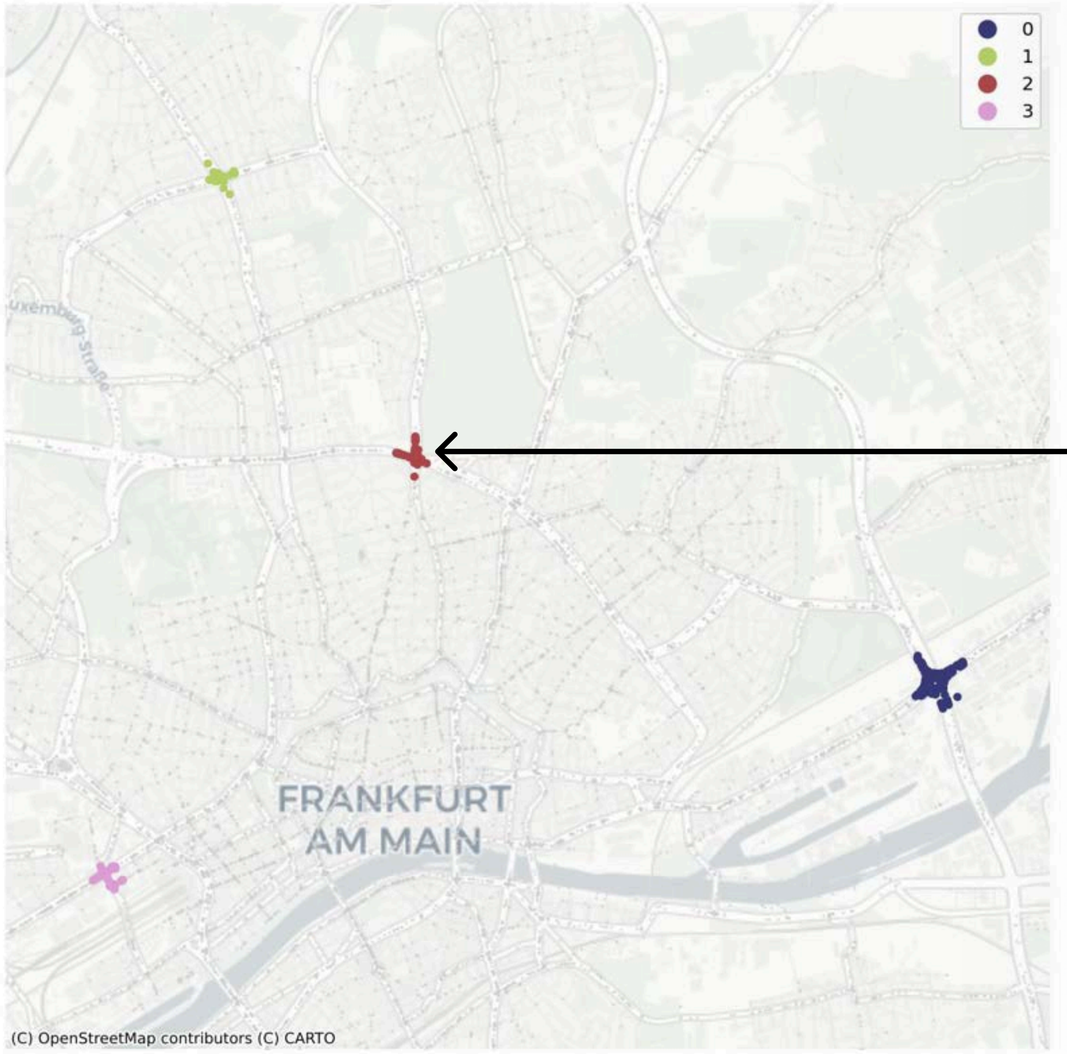
Cluster 3: Mainzer Landstraße X Hafenstraße





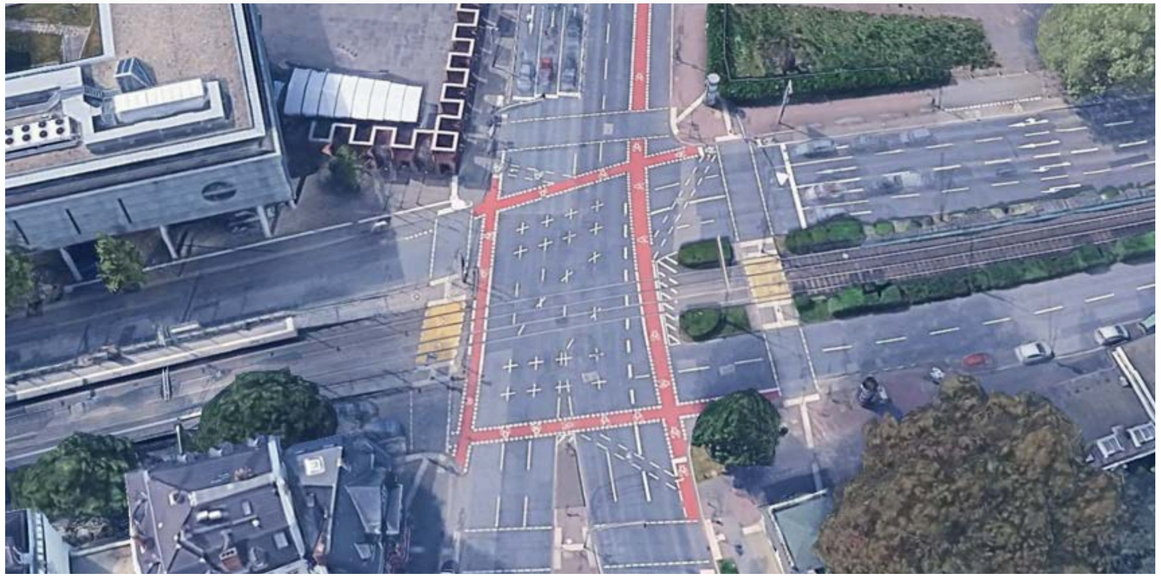
Frankfurt Geospatial Accident Analysis

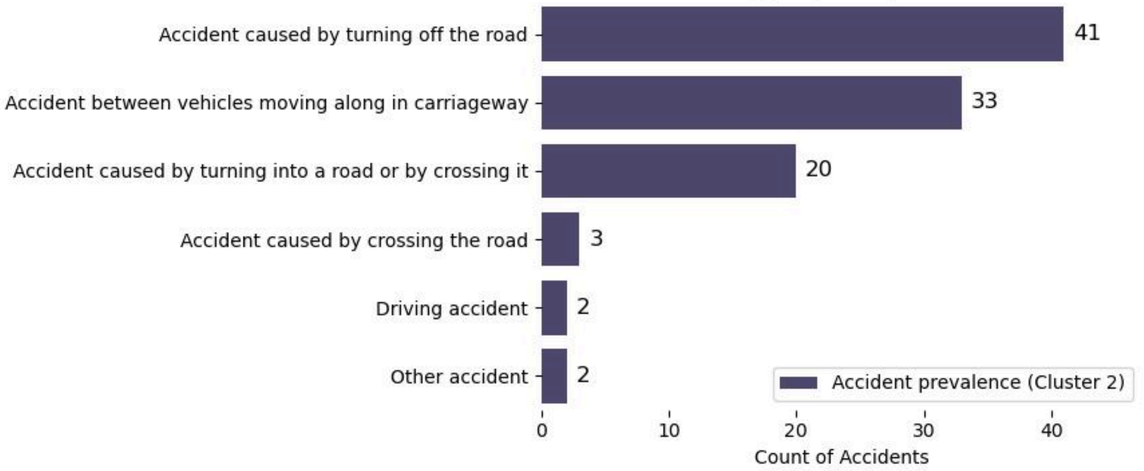
Accident Clusters (all accident events)



DBSCAN Cluster, EPS=100, Min Samples=85, Total Clusters found: 4

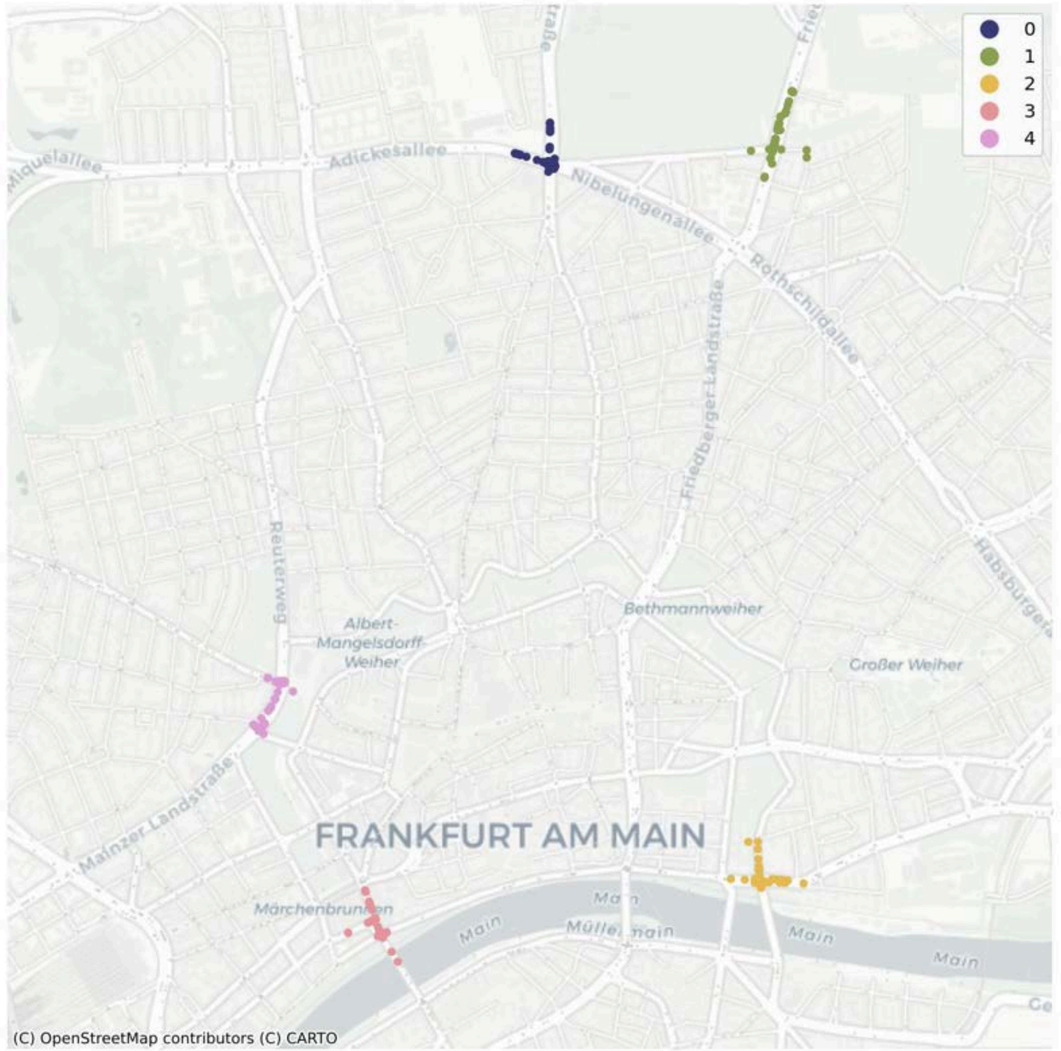
Cluster 2: Adickesallee X Eckenheimer Landstraße





Frankfurt Geospatial Accident Analysis

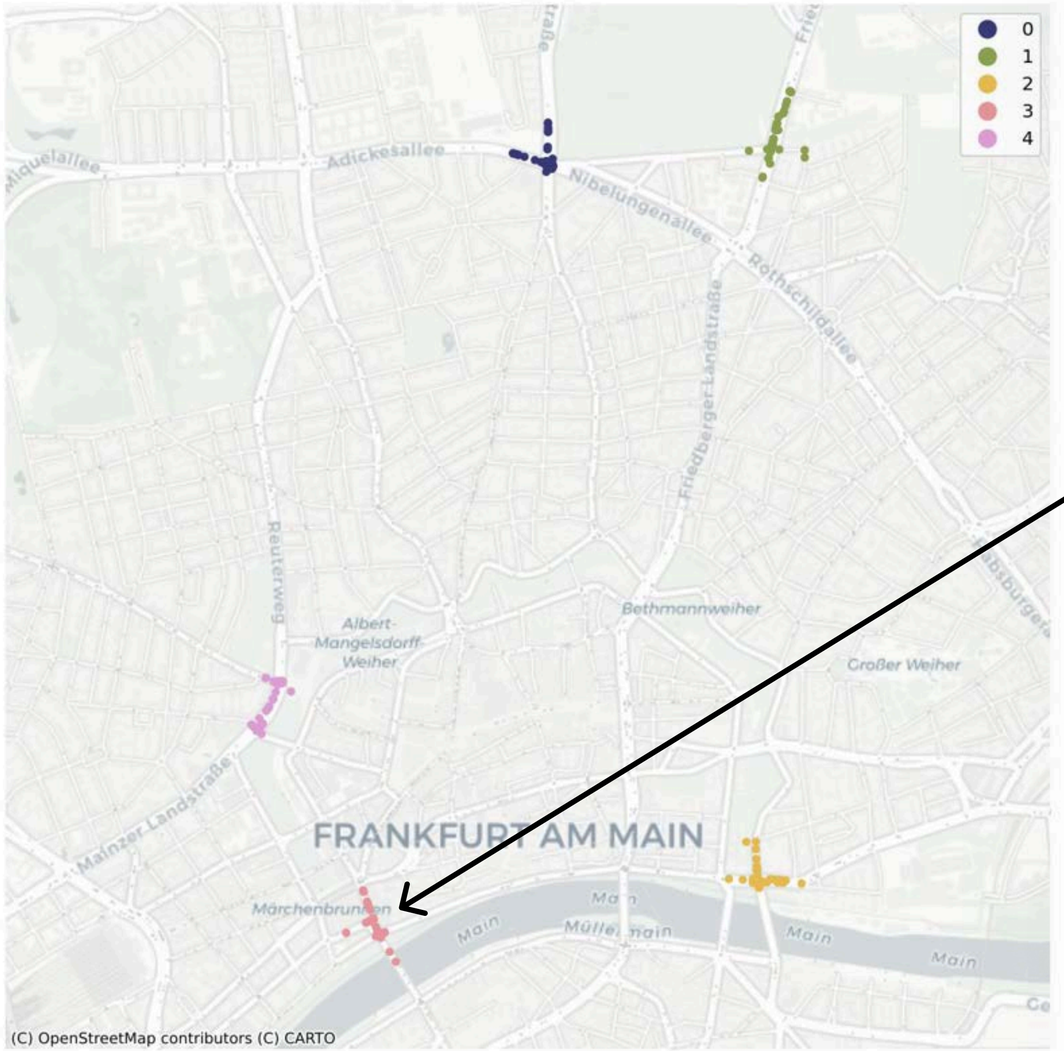
Accident Clusters (events incl. bicycles)



DBSCAN Cluster, EPS=100, Min Samples=40, Total Clusters found: 5

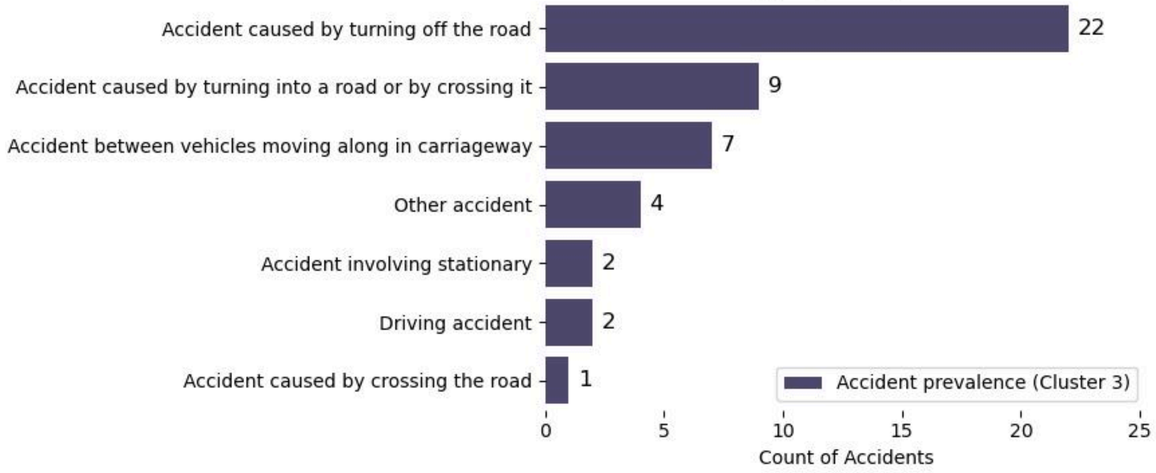
Frankfurt Geospatial Accident Analysis

Accident Clusters (events incl. bicycles)



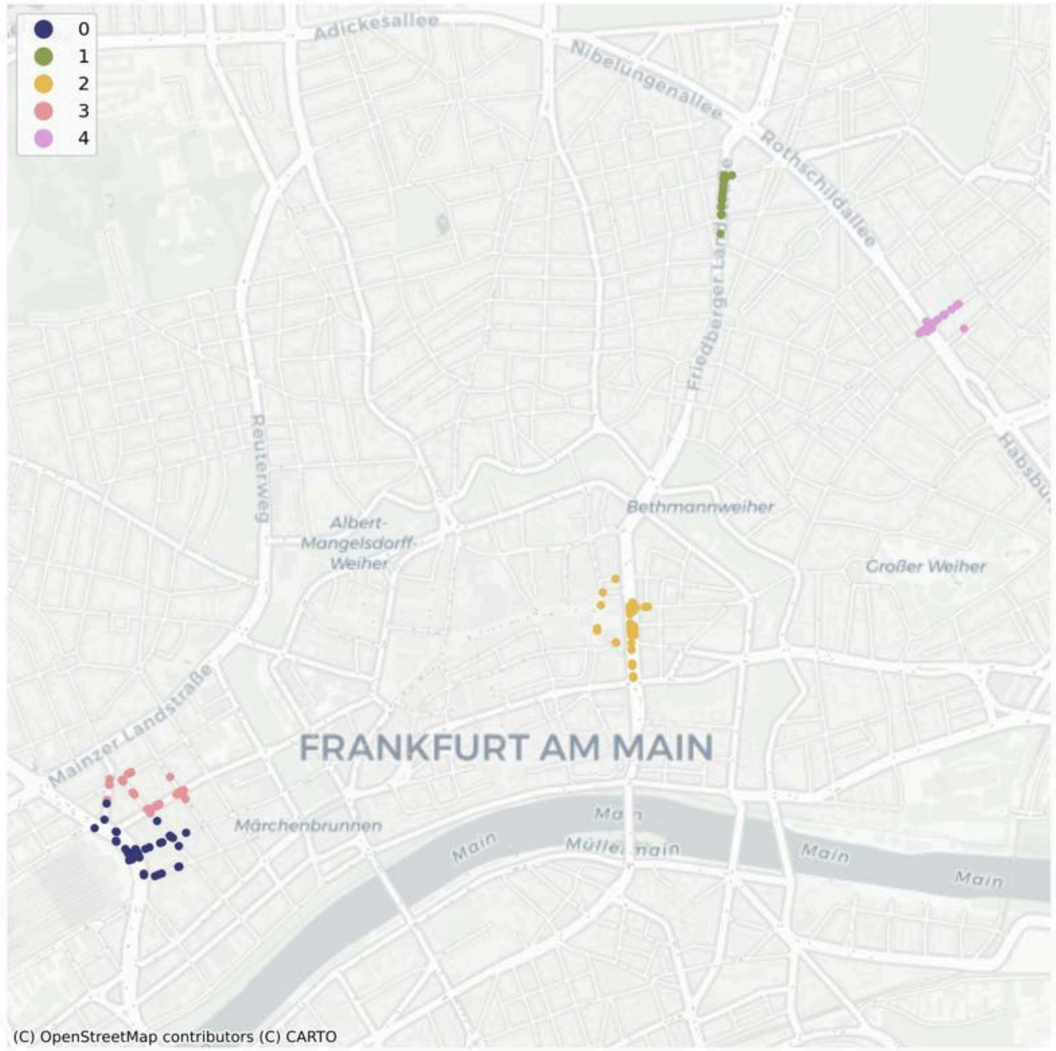
DBSCAN Cluster, EPS=100, Min Samples=40, Total Clusters found: 5

Cluster 3: Neue Mainzer Landstraße X Untermainkai



Frankfurt Geospatial Accident Analysis

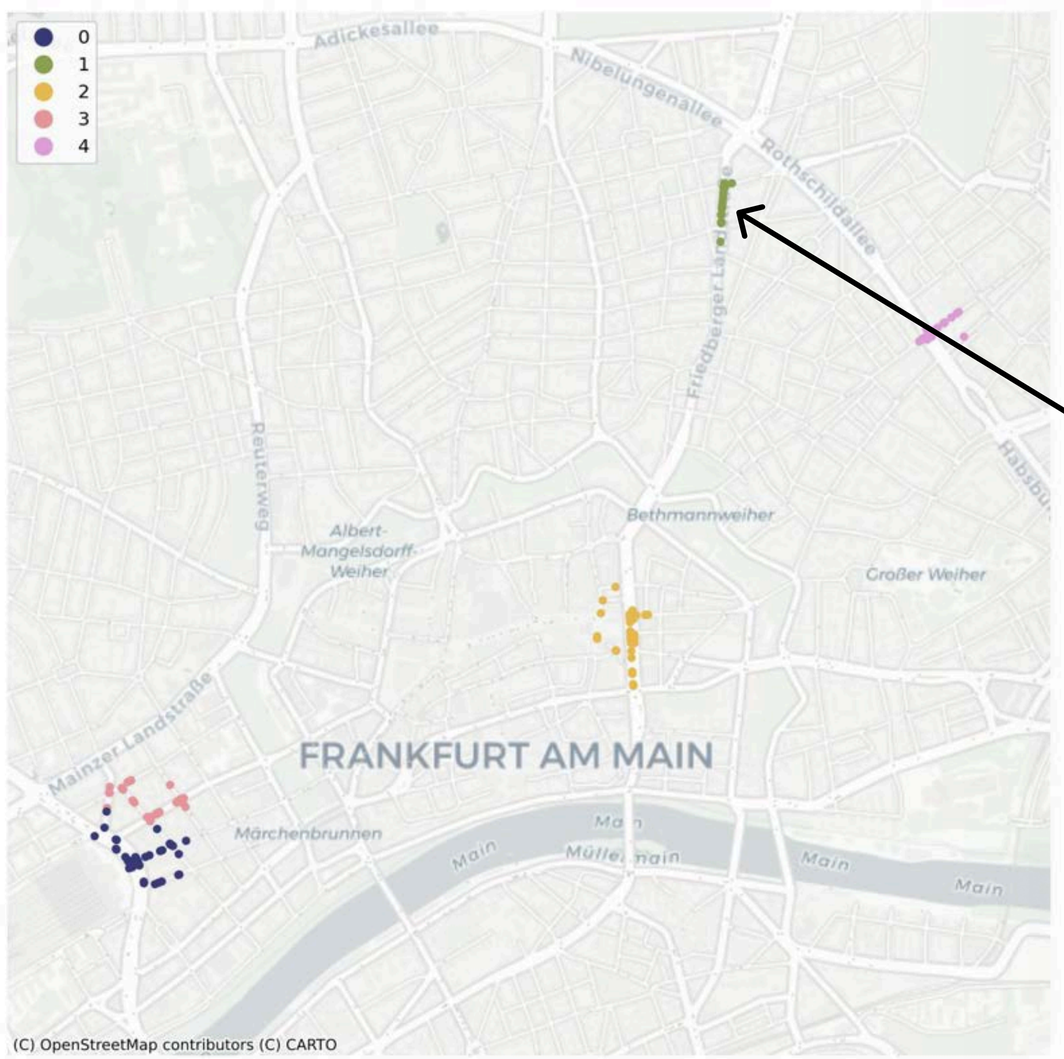
Accident Clusters (incl. pedestrians)



DBSCAN Cluster, EPS=100, Min Samples=40, Total Clusters found: 5

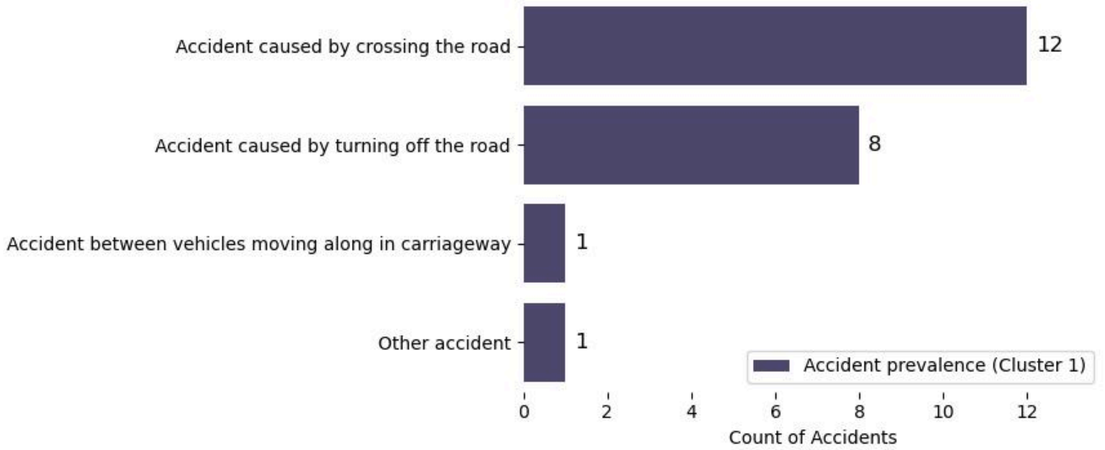
Frankfurt Geospatial Accident Analysis

Accident Clusters (incl. pedestrians)



DBSCAN Cluster, EPS=100, Min Samples=40, Total Clusters found: 5

Cluster 1: Friedberger Landstraße 114



🚦 Conclusion

- 📊 Accident events follow expected trends e.g. hour of the day, day of the week, month, etc.
- 📈 Clear linear correlation between population of a city and frequency of traffic accidents.
  - Not-necessarily equally distributed (gini-index)
- 🧭 DBSCAN identified key areas with high accident density.
- 🚶🚴🚗 Risk patterns differ for pedestrians, cyclists, and drivers.
- 🔍 Potential use case: Review identified high-risk road segments for safety enhancements or identify similar clusters in different cities

References

- “Data license Germany—Attribution—Version 2.0”. [Online]. Available: http://www.govdata.de/dl-de/by-2-0. [Accessed October 26, 2025]
- “Unfallatlas Deutschland”, 2025. [Online]. Available: https://unfallatlas.statistikportal.de/. [Accessed October 29, 2025]
- Sergio J. Rey, Dani Arribas-Bel, Levi J. Wolf, “Point Pattern Analysis”, 2020. [Online]. Available: https://geographicdata.science/book/notebooks/08_point_pattern_analysis.html. [Accessed October 26, 2025]