Understanding Fire Risk Through Statistical Modelling

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Fire safety research is increasingly shaped by the availability of large and complex datasets. From residential incidents to industrial fire events, modern fire databases contain valuable information that can help researchers and policymakers better understand how, where, and why fires occur. However, extracting meaningful insight from this data is not always straightforward.

One of the key challenges in fire safety analysis is that fire incidents rarely behave in a simple or predictable manner. Many locations may experience no incidents at all, while a small number of sites account for repeated events. This uneven distribution means that traditional statistical approaches based purely on averages can struggle to capture the true variability present within fire data.

Within the eRISIKO project, statistical modelling plays an important role in identifying patterns of fire occurrence and supporting evidence-based risk assessments. That is, exploring methods designed specifically for *count data* - situations where the quantity of interest is the number of incidents occurring within a given period or environment.

A common starting point for analysing count data is the Poisson model, which assumes that events occur randomly and independently at a constant average rate. While this approach is mathematically convenient, real fire data often violates these assumptions. Fire incidents are frequently clustered, influenced by environmental conditions, human behaviour, building characteristics, and operational practices. As a result, the variability observed in practice can be far greater than predicted by simpler models.

To address this issue, one can apply negative binomial models, which are better suited to handling highly variable and overdispersed data. These models account for the fact that some environments naturally exhibit greater fire risk than others, even when average incident rates appear similar.

This distinction is important because understanding variability is often just as valuable as understanding averages. Two facilities may report the same average number of incidents over time, yet one may experience events in a highly predictable pattern while the other shows sudden clusters of activity. Statistical models capable of capturing this uncertainty can therefore provide more realistic representations of fire risk.

The practical applications of this work extend beyond academic analysis. Improved statistical modelling can support more effective resource allocation, inform fire prevention strategies, and contribute to the development of data-driven safety regulations. By identifying the factors associated with elevated risk, researchers and practitioners can better prioritise inspections, interventions, and mitigation measures.

As fire safety challenges continue to evolve, robust statistical methodologies will become increasingly important. Large datasets alone are not sufficient; meaningful interpretation requires models capable of capturing the complexity and variability inherent within real-world fire behaviour.

The eRISIKO project aims to improve the understanding of fire risk through both engineering and statistical innovation. By combining domain expertise with modern analytical tools, the project contributes towards safer, more informed, and more resilient fire safety practices for the future.

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