Organising the response to road traffic accidents for French Counties: does demand drive performance?

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Introduction

Reducing both mortality and morbidity from road traffic accidents remains a major objective of public policy across both high- and low-income countries (OECD, 2016). The social cost of these accidents continues to receive great attention (Bougna et al., 2022), suggesting that significant resources must be committed to reducing this phenomenon. Achieving such objectives can be done in two ways: better prevention of such accidents, or better response when they occur. This paper will focus on the latter, looking at the role of emergency services in the response provided to road-traffic accidents and their approach to post-crash interventions.

One of the most well-known principles with regards to the response to road-traffic accidents is the "golden hour" principle (Dinh et al., 2013; Newgard et al., 2010), meaning that the sixty minutes following an accident are the most important for the health state of victims. This naturally puts a lot of focus on the role of emergency services who will be the first to treat victims on arrival at the scene of an accident. In reality, there are many key factors in the post-accident phase that will impact survival (Peden et al., 2004) and whilst the effectiveness of emergency services in terms of patient survival remains a popular topic (Lucchese, 2020; Swan & Baumstark, 2022), the interest of this paper is first and foremost to explore the interactions between firefighter service supply and demand when a crash occurs and to investigate the organizational dimension for the provision of such a service.

When studying the role of emergency services, there are several key considerations to take into account relative to road-traffic accidents. Firstly, to the best of our knowledge, no country relies on a dedicated service – road-traffic accidents are just one of a number of missions that must be undertaken, either by emergency medical services or by fire and rescue services, with specific tasks for each organisation.

Secondly, it is important to highlight the specificity of such missions – responding to a road-traffic accidents involves traffic calming measures, an expertise with regards to potential hazards from explosions due to combustibles, specific material to extricate victims stuck in their vehicle, and of course first-aid to the victims themselves. The main takeaway from these tasks is that road-traffic accidents expose emergency services workers to several risks. They must take care at each stage, all the while going as quickly as possible. The skillset and experience required to perform these tasks will thus be different to other missions that only require the transport of a victim to hospital.

Thirdly, when responding to emergencies, time is always of the essence. The importance of response time for emergency services has been demonstrated repeatedly in the literature (Jaldell et al., 2014; Swan & Baumstark, 2022; Wilde, 2008) and often provides the main indicator of their performance in annual statistical publications of their activity (*Les Statistiques des Services d'Incendie et de Secours*

(édition 2022), 2023). There are therefore many reasons to consider response time as a reliable indicator of the performance of such services, and especially for firefighter' missions in the case of a car crash.

The final point to take into consideration is the nature of what is a public service, provided to all citizens without exclusion. Having said this, the element of urgency and thus the importance of response time prevents it from being a pure public good. Finite resources and the role of many exogenous factors (such as topography, urbanisation or road infrastructure) mean that it is impossible from a practical perspective to provide the same service to every citizen in a given geographical zone simultaneously. It is this "queuing" that can lead to disparities in the level of service provided (performance) which can in turn have possible consequences on victim morbidity and mortality.

The scientific literature regarding the organisation of emergency services relies largely on algorithmic "location-allocation" models (Larson, 1974), aimed at providing optimal geographic positioning of emergency medical service resources. There are many different approaches developed in this literature (Aleisa, 2018) but they generally rely on simplifying hypotheses such as the fact that only one emergency vehicle can be allocated to each station (Shetab-Boushehri et al., 2022). Such an approach does not seem to do justice to the intricacies in the provision of such a service.

We take the example of France – where response to road-traffic accidents is undertaken by fire and rescue services (FRS) - to demonstrate how different populations can be exposed to different levels of risk according to the response capacities of emergency services to road-traffic accidents. We will show how this capacity can be correlated to risk exposure levels, investigating the existence of potential inefficiencies on the supply-side that we may or may not be able to explain based on either observable factors (urbanisation, etc.) or unobservable ones (implicit organisational choices or constraints).

Methods

In order to understand how these services are provided to a population, we will look to provide the building blocks to a simple supply-demand model of these emergency services. The most important thing when defining such a model for a public service is choosing the correct input and output measures.

There are three main components to the production of emergency services: human personnel, emergency vehicles and related equipment, and emergency stations. Whilst these inputs are straightforward to define and measure, it is not so straightforward to do the same for the outputs produced. In the case of FRS, several types of output measure are presented in the literature: direct, intermediate and final (Jaldell, 2005, 2019). To ascertain an image of their performance, it is important to focus not on the number of interventions performed (direct output), but rather a measure of capacity, reflected in the "manning-level" or the response time (intermediate outputs that are in turn correlated to final outputs such as victim survival). All three inputs can contribute to increasing the "manning-level" or decreasing the response time for a given geographical area. These inputs are of course subject to a budgetary constraint, which will itself be correlated to population size (tax base).

The "true" demand for these services is unknown so we can only use proxy measures that can be deemed to be appropriate. We will suggest using several measures related to the accident rate based on official statistics. This measure can either be based on an overall rate of morbidity from road-traffic accidents (including all victims), only victims seriously injured, or simply the mortality rate. Whilst correlated, each measure may not interact in the same way with supply. For example, one could suppose that the mortality rate is more likely to lead to greater financial efforts and thus a greater supply and a higher level of performance measured by response time compared to other accident rates.

We will notably assume that performance (response time) can be interpreted as the ratio between demand and supply, meaning that increasing the budgetary constraint for a fixed level of demand should increase service performance as more inputs can be used to reduce response time.

Data and analysis

We use two datasets. The first is data from FRS in France. These FRS are organised at the *département* level of jurisdiction, corresponding to around 90 territories with surface areas ranging from 600km² to 10 000km² and populations of 75 000 persons to over 2 000 000. Without providing further detail at this stage, we can say that these territories are very heterogeneous and should display variability in service response levels and thus providing an appropriate case study for our research objectives cited in introduction. What is particularly interesting from an economic point of view is the autonomous nature of these jurisdictions in the financing of these services. Their budgets are primarily fixed through population-dependant variables (taxation on insurance contracts), but there is room for different strategies based on the priorities of local government.

The second source of data is the official statistics on road safety, which is based on data collected by police forces. This dataset includes both the number of accidents and the number of victims (including their health state: deaths, severe injury, slight injury). It is important to note that these two databases do not necessarily contain the same data. In particular, the official statistics tend to record a lower number of accidents than the FRS dataset.

Our data spans two decades from 2002 to 2022, it is thus possible to analyse the evolution of supply and demand across these territories over time. There is however already much to be said from a cross-sectional perspective. Figure 1 shows data from 2022 and shows the relationship between average response time for each Fire and Rescue Service (FRS) department along with the mortality rate from road traffic accidents. One can note that FRS departments are categorised by size (based on population – and thus on budget), creating three distinct groups. Mortality rates from road-traffic accidents are clearly higher when FRS departments are smaller, and these FRS often have longer response times.

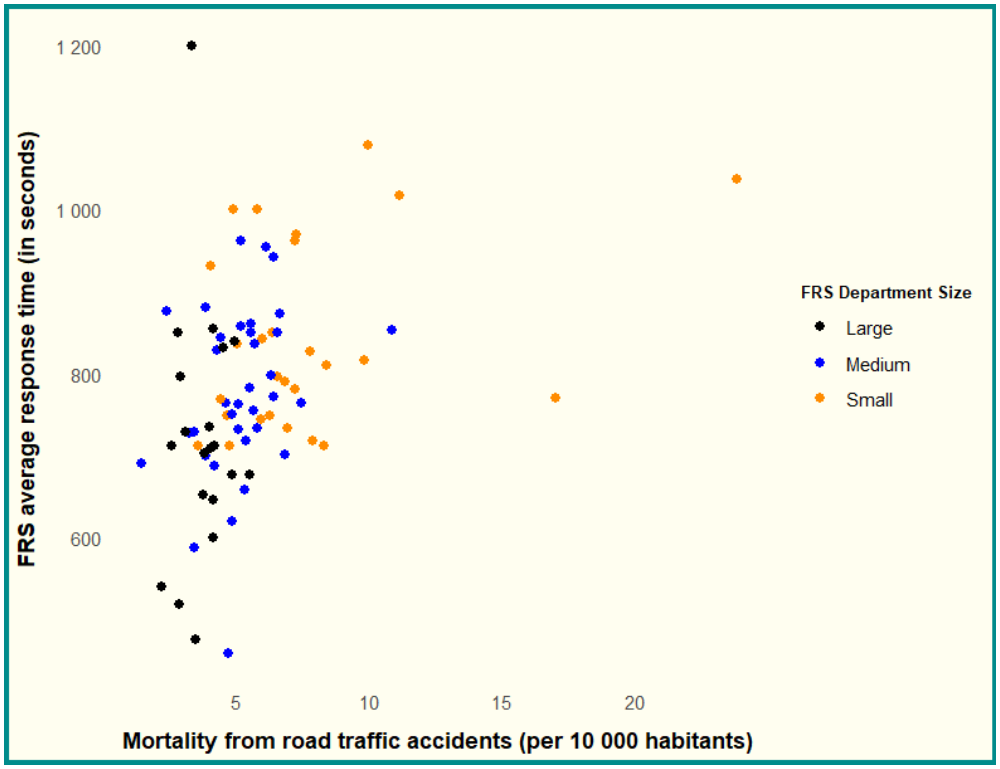

Figure 1: 2022 data showing the relationship between the performance benchmark (response time) and the proxy demand for rescue from road-traffic accidents (mortality rate)

If we take a quick look at what the panel data shows us in figure 2, we can see that the demand (measured by the mortality rate) varies greatly according to the size of FRS department. What was an extremely heterogeneous demand across the country in 2002 has nonetheless become more homogeneous over time. Most notably, we can observe that this evolution can be attributed to a reduction in mortality and thus in demand from small FRS departments, corresponding to less-populated and rural geographical areas.

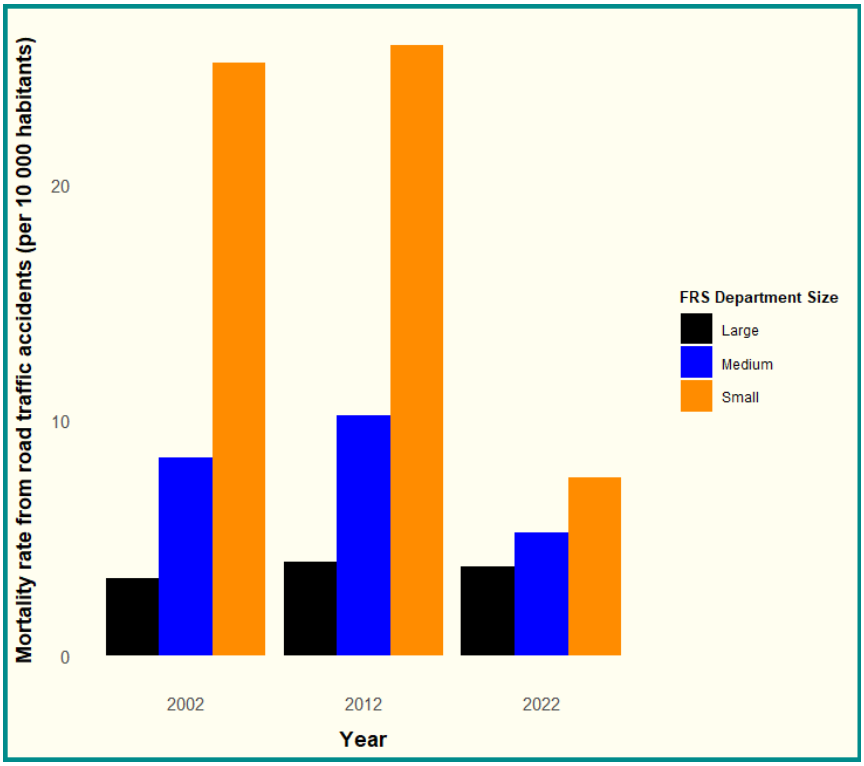

Figure 2: Data showing the evolution of the mortality rate from road traffic accidents according to Fire and Rescue department size from 2002 to 2022

Tentative conclusions and perspectives

The first analyses performed show that there is a clear heterogeneity in the supply of rescue services across France. Given the differing budgetary restraints of each *département* (ranging from 9€ million to 230€ million), there cannot be one unique approach to organising the response to road-traffic accidents. The question that we must answer is whether it is possible to explain the reasons for such different approaches, in order to understand the rationality of the decisions being made. These choices could come from factors linked to the characteristics of jurisdictions or from organisational constraints. We will thus look to comment on what could explain the fact that smaller *départements* would appear to have insufficient supply of rescue services, all other things being equal. Several variables could explain such a phenomenon, such as the proportion of operations dedicated to road-traffic accidents, or the proportion of volunteer personnel compared to full-time personnel.

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