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The Economic and Social Value of UK Fire and Rescue Services

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Foreword:

It is widely accepted that our Fire and Rescue Services play a central role in keeping our community safe, and reducing losses to the economy, resulting from fire, flood or collisions on our roads. Firefighters across the UK share a singular dedication to respond swiftly and effectively to emergencies of all types, at all times. This dedication is reflected in the publics' regard for firefighters, who continued to be trusted to act fairly, responsibly and in the public interest daily.

This project has examined ways in which we might quantify the value the Fire and Rescue Services make to our society, our communities, and the UK economy.

This work is not intended to replace or compete with any previous or future government produced estimates of the cost of fire. There are two aspects to evaluating the impact of fire: the cost of the event, and the economic and social impact of avoiding or resolving the event. In this sense, it can be considered a counterpart to the cost of fire estimates that have been published previously, providing complementary data on value instead of cost. This work is based on Fire Service incident data, and also considers the value the Fire and Rescue Services add to our society, our communities, and the UK economy. In addition, this report considers the value added to the economy of responses to fire incidents, non-fire incidents, and prevention and protection activities.

There has been significant input from groups of experts across the sector concerning the calculations used, and at every stage the most conservative values and ranges were applied to avoid overestimating the contribution made by Fire and Rescue Services. In addition, this report was subjected to an independent academic review which made recommendations to the method, but overall found it to be defensible.

Though it is worth noting, that even with the most conservative values used, the value of the service across these activities is substantial. More work is required, to look at a greater number of activities and to consider values for subsets of activity types, but the general result is clear – the UK Fire and Rescue Services represent a return in value to our communities that far outstrips their budgets.

I believe that this report represents the first time that our sector has had a definitive statement on the contribution that we make to society.

This report can be considered a baseline, the first step of a longer journey from which we can launch into future work that will see the inclusion of more incident categories, and following a national discussion on this work, further adaptation and finer detail. Future work will also see the creation of software that will allow services to examine their own activities and the value they bring to their communities, and support risk management planning activities.

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Part One:

Executive Summary

1.1 Introduction

Governments have always needed to demonstrate the value of public services, but current factors such as increasing budgetary pressures, impacts of a growing and ageing population, and rising unit costs have made this even more pressing.

The UK's Fire and Rescue Services (FRS) have also had to respond to changing demands: non-fire incidents are now taking up an increasing proportion of the FRS workload, while activities aimed at preventing fires and protecting citizens and property remain an important element of the services workload (Office of National Statistics, 2019).

The FRS has adapted its approach and focused the way it uses resources to address the risks faced by communities, while maintaining an important capability to respond to emergencies at both local and national levels (Chief Fire Officers Association, 2015).

The last national picture of the economic *cost* of fire was based on data for 2008 (Department for Communities and Local Government, 2011). The Home Office is currently working internally to refresh the figures, but by the very nature of the data under consideration (the *costs* of fire rather than the benefits of FRS work), any updated work will not aim to capture the wider social and economic value of the full range of activities that the FRS undertake.

Absence of a representative estimate of the social and economic value of the activities delivered by the FRS means there is a critical lack of a robust evidence base to inform (a) future funding decisions and (b) FRS Community Risk Management Plans (CRMP) and (c) evidence-based service developments.

The research team from Nottingham Trent University previously reported on a range of methods that could be used to provide an estimate of the economic and social value of the FRS (Hewitt and Biermann, 2020).

A second phase of work has followed to implement those methods. This report presents those findings, which are structured as follows:

i. The economic and social value of FRS emergency responses to fire incidents
ii. The economic and social value of FRS emergency responses to non-fire incidents
iii. The economic and social value of FRS prevention and protection activities.

The estimates of value have been informed by the analysis of routinely collected data, expert opinion, and with some use of reference values from the literature. The approach has been to calculate conservative but verifiable measures of value.

1.2. Methodology

The scope of the FRS Economic and Social Value Project was to estimate the economic and social value of FRS emergency responses in the three categories of activities that determine the abovementioned structure of this report, namely: fire incidents, non-fire incidents, and prevention and protection activities.

Assumptions

A number of assumptions had to be made in order to carry out the work. Factors that were specific to an individual fire response could mostly not be considered, because the value estimation included hundreds of thousands of incidents, and in some cases, the information required for a more detailed evaluation was simply not known, or not recorded. Overall, the research team faced a trade-off between the inclusion of details and the practicality of the approach. However, given the great number of incidents that were included, the actual bias induced by averaging is arguably very limited. This is due to the Law of Large Numbers, as explained below.

Law of Large Numbers

In statistics, the term Law of Large Numbers refers to the fact that if the number of experiments increases, the percentage difference between an observed mean and an actual mean (of some characteristic of a random process or a population) goes to zero. This effect emerges rather fast when sampling data. Sampling just a few hundred data points out of a very large population (or, if it is a repeatable random experiment, a potentially infinitely large population) may lead to differences between observed and actual means which, in percentage terms, are very small. All the covered incident types have samples that are so large that the law of large numbers applies.

In the context of this report, the specific economic value of individual incidents will almost always be either overestimated or underestimated, but these errors cancel out on average. As far as one is concerned with average values, as is exclusively the case in this study, the estimations of those averages can be very accurate, even if many specific characteristics of the incidents are not considered. The fact that a great number of incident records are included (e.g., 137,245 fire incidents for the econometric estimation of saved property and lives) means that also cases with rare characteristics are included in the sample in high absolute numbers, and the overall results therefore also reflect those rare cases.

Therefore, even with many outliers and non-standard cases, the average economic value derived from tens of thousands of incident records is likely to be a good representation of the actual average economic value (background on the Law of Large Numbers can be found in Rosenthal, 2006).

Likewise, the Law of Large Numbers means that the more often a question is answered from the non-fire incident expert questionnaire, the closer the average answer of the respondents will be to the average of *all* experts. Together with a phenomenon referred to in the literature as *Wisdom of the Crowd* (described in more detail in Section 2.2.1), this improves the reliability of expert surveys.

Standard of comparison

The economic contribution of the FRS must be gauged by comparing the situation in which the FRS does their work with a counterfactual situation where they do not. The counterfactual in case of incident response, is a scenario in which there simply were no incident response by fire services, and the counterfactual for the prevention and protection work, is a scenario where these activities were not carried out.

Indirect estimation strategies that exploit proxy variables and correlations are necessary for estimating the economic value of a service whose benefit is not directly measurable because the counterfactual is not directly observable. Moreover, being provided by the government, the service has no market price that would directly reveal a lower boundary of the willingness of private individuals to pay for its existence. These facts inevitably lead to uncertainty in the estimation of the economic value. Such caveats are not uncommon in economics and the social sciences, where also the best estimates of a figure that is not directly observable may still be uncertain to some degree.

In comparing the actual situation with a counterfactual scenario in which there were no fire services, we do not assume that in the counterfactual scenario there existed no “natural forces” or non-professional firefighting efforts that could end the fire. That is, for example, why we do not assume that a house would burn down entirely if there were no FRS or if the FRS did not respond (see the discussion in Section 2.1.3).

Selection of Incidents

For the estimation of the number of saved lives in non-fire incident responses, a "conservative approach" was adopted – only a small fraction of incidents was included, namely those where it was highly likely that lives had been at risk. This was done through the exclusion of entire incident categories (e.g., animal rescues) and through the application of a three-standard-deviations threshold. Details can be found in Section 2.2.

To be clear about this, "conservative" in our understanding of the term, means that if different assumptions can be made which are equally plausible, then we choose the one that will foreseeably lead to a lower estimate of the economic benefits. Our understanding of the term does not go beyond this, e.g., it does not imply that we refrain from using innovative methods to estimate the value of FRS activities.

Tapping expert knowledge

For non-fire incidents, we used a questionnaire to gauge something for which no statistical data exist, but which is arguably collectively known to experts, namely the relation between the severity of an incident and the resources needed to resolve it. An alternative way of tapping expert knowledge would be to run focus groups, but the qualitative character of the data obtained in focus groups requires extensive interpretation when these data are to be used in quantitative analyses.

This process of "quantifying" qualitative information leaves considerable interpretative latitude to the researcher and is a potential entry point for biases (e.g., confirmation bias). We believe that a questionnaire is a more solid approach to obtain expert data, as the responses come already in quantitative form and there is less interpretative scope.

Usage of existing research

Where possible, the values of parameters that could not be estimated from the data were informed by previous research, although in some cases, there was no such information available. When appropriate, a range of values has been produced to show upper and lower parameter results, but the final estimate was always based on conservative choice of parameters.

Measures of value

Various measures of economic and social value are used in the study, and these are introduced and defined below.

For responses to fires, the following two measures have been used, the first relating to the value of saved lives, and the second relating to the value of saved property:

(i) Department for Transport's (DfT, 2019) value of a road traffic fatality. This can be seen as a proxy for the cost to life (also known as the value of a statistical life) in fire. The published DfT value for a fatality (over a lifetime) is £2,146,852. These costs include lost output, human costs, and medical/ambulance cost; and

(ii) Value of property per sq. metre (based on Office for National Statistics, 2021 and GOV.UK, 2021 data). This value is different from that of those estimated on rebuild costs, the value of which has no official statistics.

For responses to non-fire incidents the value of (i) above was used.

For ***prevention*** activities, specifically targeted home visits, the average cost of a domestic fire is estimated to be £53,498 (Greater Manchester Combined Authority, 2021 Unit Cost Database). This comprises both costs as a consequence of fire, and costs in response to a dwelling fire, and it includes the average cost of fire setting. Costs in anticipation of fire are not included (e.g., the cost of installing fire protection in buildings). Costs as a consequence of fire include economic and social costs as well as fiscal.

For ***general prevention*** work such as fire, road, and water safety education and campaigns, and for the fire cadet schemes, the Social Value UK (2021a) definition of social value was employed (the quantification of the relative importance that people place on the changes they experience in their lives), and the proxy financial values as used by the National Social Value Measurement Framework database. For the fire setter and anti-social behaviour schemes, the social and economic benefits derived by Ward and Thurston (2009) are used. This includes financial proxies for reduced antisocial and dangerous behaviours, and improved behaviours at home and at school.

For ***protection*** activities (specifically audits/inspections of commercial properties) the average cost of a fire in a commercial building is estimated to be £91,177 (Greater

Manchester Combined Authority, 2021 Unit Cost Database). This comprises both costs as a consequence of fire, and costs in response to a commercial building fire, and it includes the average cost of fire setting. Costs in anticipation of fire are not included (e.g., the cost of installing fire protection in buildings). Costs as a consequence of fire include economic and social costs as well as fiscal.

Data sources

The data sources listed in Table 1.1 were used in the value calculations: details, including analyses and additional parameters can be found in Part Four, and a summary table of the statistical methods and data sources are included in Part Three.

It should be noted that this iteration of the report only considers English data. Phase II of this report will apply the same methodologies using data sourced from the devolved administrations of Scotland, Wales, and Northern Ireland. This will result in calculations for the entire UK being able to be generated.

Dataset	Source
The Incident Recording System for England. Anonymised incident data has been sourced from the Home Office's online Incident Recording System (IRS), which allows FRSs to complete an incident form for every incident attended, be it a fire, a false alarm, or a non-fire (also known as a Special Service) incident.	Home Office
Fire Statistics	Available from GOV.UK website
Dwelling Fires dataset and Other Buildings Fires dataset	Available from GOV.UK website
Non-fire incidents: medical and collaborating incidents dataset	Available from GOV.UK website
Flooding and water rescue incidents dataset	Available from GOV.UK website
Non-fire incidents: other non-fire incidents dataset	Available from GOV.UK website
Non-fire incidents: road traffic collision dataset"	Available from GOV.UK website

Table 1.1: Datasets and sources used.

1.3. Key Results

1.3.1 The economic and social value of FRS emergency responses to fire incidents

Two types of economic benefit have been quantified by econometric estimation (“econometrics” refers to a statistical toolkit that is frequently used for data analysis in economics and other fields).

Firstly, when the FRS respond, they prevent any further damage to commercial buildings, dwellings and associated property at risk.

Secondly, they prevent injuries and save lives. When applied to 137,245 fire incidents that occurred over the three years under consideration (2016/17– 2018/19) the value of saved property due to FRS intervention is estimated as **£13,353,474,801** and the value of saved lives is estimated as **£16,068,822,255**. This equates to an estimated average value per year of saved property as £4.45bn and an average estimated value per year of saved lives as £5.35bn.

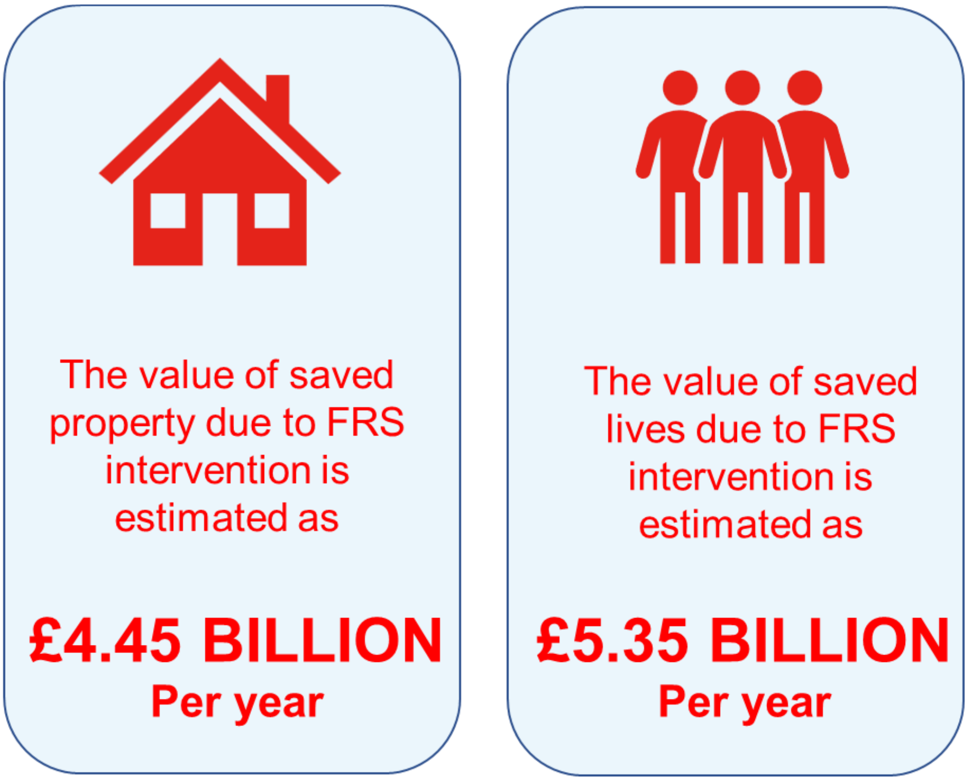


Figure 1.1: Estimated Values for fire incidents each year averaged across a three-year period 2016-2019

1.3.2 The economic and social value of FRS emergency responses to non-fire incidents

When the FRS respond to non-fire incidents, they may save buildings and property, but our analysis is restricted to the lives they save. They also prevent injuries. Over three years (2016/17 – 2018/19), the value of saved lives for the following response types is estimated as:

Incident type	Estimate total value of lives saved over 3 years	Estimated average value of lives saved per year
Rescue from water and flooding	**£3,209,570,576**	**£1.07 bn**
Making environments safe	**£2,635,829,746**	**£0.88 bn**
Spills and leaks	**£1,147,423,695**	**£0.38 bn**
Extrications	**£2,418,726,117**	**£0.81 bn**
Medical assistance	**£182,569,397**	**£0.06 bn**

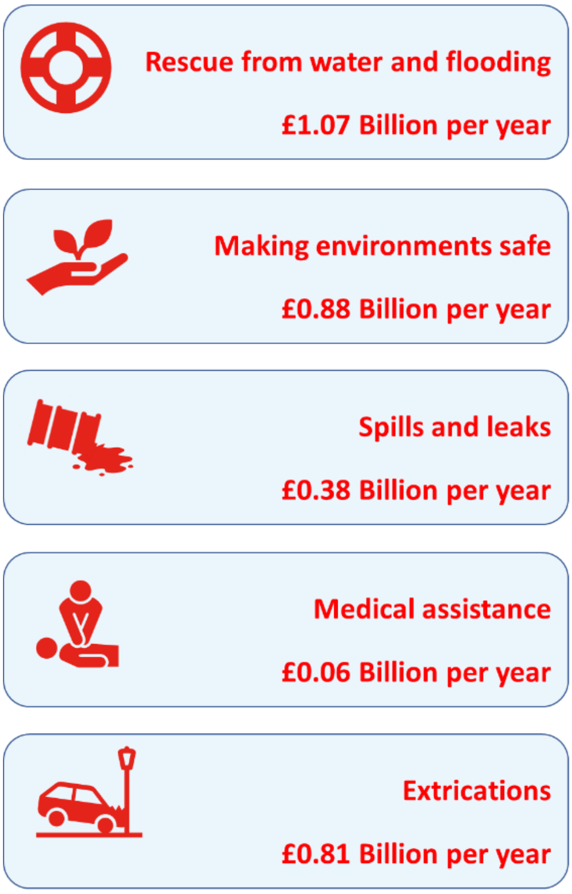


Figure 1.2: Estimated Values for Non-fire Responses each year averaged across a three-year period 2016-2019

1.3.3 The economic and social value of FRS prevention and protection activities:

Economic and social value methods have been applied to several FRS prevention and protection activities. In general, these methods compare the benefits of an intervention relative to the costs and are often expressed as a return on investment (£'s benefit for each £1 invested). These returns on investments are calculated by dividing total benefits by total costs. They represent the average benefit generated through each pound of existing funding, not the additional impact of increasing or reducing the funding by one pound. A summary of findings is presented below, with further details presented in Part Two of this report.

Home Fire Safety Checks / Safe and Well Visits.	Our analysis shows that, on average, a targeted home visit contributes to a reduction in the incidence of accidental dwelling fires. The gross return on investment for this activity is **£2.67** for each £1 spent.
Audits/Inspections of commercial premises.	Our analysis shows that, on average, the number of hours employed on unsatisfactory audit outcomes and follow-up actions are associated with a reduction in the incidence of fires in business/commercial buildings. The gross return on investment for this activity is **£4.15** for each £1 spent.
Fire setter and antisocial behaviour schemes.	Using previously published data the social return on investment of these interventions is **£3.30** for each £1 spent.

When applied to FRS data over the three-year period 2016/17 to 2018/19 a total benefits value of FRS prevention and protection activities is estimated as **£328,115,818. The average per year is estimated as £0.11bn.**

The benefit to cost ratio of the FRS activities evaluated in this report is estimated to be about 6.17, that is for every £1 that are currently invested, economic and social benefits valued at £6.17 are returned.

Home Fire Safety Checks/ Safe and Well Visits. £2.67 for each £1 spent.

Audits/Inspections of commercial premises. £4.15 for each £1 spent.

Fire setter and antisocial behaviour schemes. £3.30 for each £1 invested.

Figure 1.3: Estimated Values across a three-year period 2016-2019 for prevention and protection activities

1.3.4 Overall Cost Benefit of FRS Activity

Figure 1.4: Total benefit cost ratio estimation

A full breakdown of the inputs and calculations for the cost benefit analysis can be found in Part Three, but the calculations are relatively straight forward. The total benefit cost ratio is found to be 6.17. The comparative figures come from the combined FRS budgets for England and the combined value calculations, described briefly in this section, and in more detail in Part Three.

1.4 Conclusions and Lessons Learned

Conclusions

To avoid over-estimation and over-valuation, throughout this work conservative estimates have been used where possible. For example, only the most severe non-fire events were included, accounting for less than 1% of all non-fire incidents. Nonetheless, the value estimates for the impact of the FRS are very high.

Despite the use of conservative estimates of value, it is clear that through their routine activities the FRS provides significant value to the United Kingdom. Although only data for England is analysed in this report, it is fair to assume that the Devolved Administrations would perform at a similar level, and this will be demonstrated when Phase II of the report using data supplied by the Devolved Administrations to provide a similar Economic and Social Value Analysis.

In addition, FRS activities provide a significant contribution to society, and the resulting positive impact on communities represents a healthy social return on investment.

As to be expected, some activities generate greater return on investment than others, and knowledge of this this provides the sector with the intelligence required to improve or tailor future activities.

This report represents for the first time a definitive and robust statement of the contribution of the UK Fire and Rescue Services, and it has the potential to initiate a wider discussion on the value of FRS activities. In forthcoming phases of the project, individual services may be able to calculate the value of their own activities with increasing detail, and in turn this will enable them to understand the impact of those activities. This intelligence will form part of strategic and financial planning and the Community Risk Management Planning process.

From our experience of developing this report we have identified gaps in available data that would inform future work. It is for the NFCC to prioritise and resource any specific future work it funds relating directly to this project, but that is not in itself a barrier to other agencies or organisations initiating further work in the field.

Lessons Learned

As an outcome of this work, we have identified a number of potential workstreams that could make future iterations of this project more accurate and less reliant on assumptions.

The number of saved lives is estimated in this report, and one of the largest drivers of value. Further research that aims to better calculate, or collect, the number of saved lives at fire and non-fire incidents would improve the accuracy of the report.

Due to a lack of data, not all types of incidents have been included in this report. Any future phases of Economic Value research should consider all categories of fire and non-fires responses and create specific value formulae for each. For example, wildfire and crop fires have not been included in this phase, but these fires do certainly represent an economic cost.

Such work as we have undertaken would have benefited from there being a research unit at a national level, in addition to the national research conducted by central government, to conduct national-level research for the sector and exploit the advantages brought by improvements in collection and curation of national FRS data. This matter is already under consideration, both through the establishment of the Academic Collaboration, Evaluation and Research (ACER) Group and via the Home Office Fire Reform White Paper which proposes the creation of a College of Fire and Rescue. It would be beneficial if the new National Fire Data Collection System can develop the definition of a life saved and record the number of immediate saved lives for each incident.

Future Work

The priority for any future work is the acquisition and analysis of data from the devolved administrations, which is being processed to form Phase II of this report. An addendum that includes the remaining data will be published to give a full UK value calculation. There is also other potential work outside the current funded project which would benefit this and related projects.

It is recommended that additional work is conducted on incident types that have not been included in this initial study. The incident types analysed were those that are most common, and therefore can reasonably be used in a global value calculation, but without more detailed analysis the sector will be unable to determine the nature of the value of all its activities.

In addition to the consideration of more incident types, work should also be conducted to ensure the currency of any value formula. To achieve this, a plan of project maintenance should be established, running in conjunction with any implementation plan.

In addition, the review of the assumptions and resulting valuations should continue, possibly leading to the establishment of a specific Value Contribution Technical Working Group.

The implementation phase of this project will be centred around the development and dissemination of bespoke software allowing Fire and Rescue Services to generate their own value estimations. Clearly, issues of currency, consistency, and completeness will be significant factors in the success of this phase. To this end, there are a number of aspirational pieces of work that would improve the field of economic and social value calculations, as well as other related Community Risk Programme projects.

For example, an update of the national template for incident recording should be in the focus of future work, e.g., regarding the recording of lives saved. In addition, work to implement a systematic and comprehensive method of recording and evaluation safety campaigns is required.

The re-estimation of the fire service “Family Groups” has been requested from several stakeholders, and a pilot study has been conducted by the NFCC. The value to this project would be the ability to report aggregated data that neither identifies individual services, nor is aggregated to a national level. Data sources, method, and the ideal number of clusters has been identified, and approval to continue the project is being sought from the NFCC. Currently, using the raw data collected, each FRS will receive a list of the FRSs with whom they hold shared characteristics. Future work could look to incorporate this into this report with value calculations made across family groups.

Part Two:

Project Report and Results

2.1. The economic and social value of FRS emergency responses to fire incidents

2.1.1 Scope of estimated economic benefits

Fire and Rescue Services provide a unique service: they are on standby 24 hours a day, ready to rapidly respond to a wide range of emergencies. In fact, the average response time for fire incidents in the year 2018/19 was 8.5 minutes (computed from the Dwelling Fires dataset). This provision creates psychological and emotional benefits beyond the immediate protection of life and property. It provides community and individual confidence and a positive experience of safety, even by those not actually affected by fire.

The commercial success of insurance products shows that, if provided by private companies, "peace of mind" is something people are willing to pay considerable amounts of money to secure. On average, insurance companies pay out less to insured persons than they receive from them as premia (otherwise, insurance could not be a profitable business model). The fact that people nevertheless buy insurance products demonstrates their desire for risk reduction, even if they must pay for it in terms of reduced expected net wealth. It is a well-established fact that such preferences, known in economics as *risk aversion*, are prevalent within most economic contexts (see the empirical survey in Guiso and Sodini, 2013).

Nevertheless, the psychological and emotional benefits that manifest themselves in this willingness to pay are difficult to assess reliably. While one could consider how much people are willing to pay for private fire insurance, in the UK such insurance is only taken out in a situation where Fire and Rescue Services already operate. Consequently, the willingness to pay for fire insurance in the UK only reflects a marginal benefit *on top of public fire protection*.

Moreover, insurance merely yields an *ex-post* compensation for the fire damage, and this compensation will, from the perspective of the insured person, not fully reflect the benefit of Fire and Rescue Services that can prevent the losses of life and property before they occur. Even from the perspective of the insurer, it may be more efficient to prevent fire damage instead of letting it happen and then pay compensation. This is hinted by the fact that in the past, fire insurance companies operated their own fire brigades in London (see Carlson, 2005). These additional advantages of fire protection over mere insurance would be neglected if one would use insurance premia as a proxy for the societal benefits of Fire and Rescue Services.

What is to be estimated instead is the willingness to pay for fire protection in a hypothetical situation without Fire and Rescue Services. This could be done empirically if there was a country where fire protection was provided only by private companies, and their services were only available to those who paid for them.

Yet, while Fire and Rescue Services in London were run privately for about 200 years, and privatisation of Fire and Rescue Services has occasionally been proposed in the economic literature (see the survey in Carlson, 2005), there is currently no country in the world where fire protection is based on contracts between private individuals and commercial Fire and Rescue Services. (Note that it would not be enough to find a country where public fire protection is outsourced to private companies, which indeed sometimes happens, like the Ministry of Defence aspiring to outsource the fire protection for its facilities, cf. Plimmer, 2019). Consequently, there is no empirical data on the willingness to pay for Fire and Rescue Services that can be directly used as an estimate of their value for society.

To avoid these intricacies, we disregard psychological and emotional benefits generated by a fire service that is permanently on standby and restrict analysis to the economic benefit that arises from emergency responses that *took place*. However, in doing so, it is important to keep in mind that the estimated benefits only represent a lower boundary of the actual benefits because the psychological benefits are not included.

2.1.2 Estimates of economic benefits of FRS interventions in fire incidents

In this report, a fire intervention is characterised as an action taken by a FRS in response to a call for assistance, where firefighters travel to, and spend time at the scene of the emergency, conducting firefighting or rescue activities that may involve the treatment of casualties.

As previously mentioned, the average response time is 8.5 minutes and on average, in 2018/19, the length of time the Fire and Rescue Services remained on scene was 83 minutes (calculated from the Dwelling Fires dataset).

What is the economic benefit of an FRS incident response?

Our analysis considers two types of economic benefits. Firstly, when the FRS respond, they prevent further damage from a building and the property that is at risk. Secondly, they prevent injuries and save lives.

However, injuries will not be explicitly estimated but are indirectly included, as a prevented injury could be interpreted as a "partially saved life". If anything, we believe that this leads to a lower estimate of the economic value of FRS services than if we would explicitly attach a benefit to the avoidance of injuries based on, e.g., hospital costs.

Initially, we expected response times to be one of the central explanatory variables for the outcomes of FRS interventions, yet it turned out that for fire and non-fire incident responses, response times did not have high explanatory value. The reason appears to be that response time are consistently very good in all incident categories and all FRSs. Therefore, response times do not change much between incidents with similar characteristics, and the variable does not have enough range to explain the overall variance of the outcomes of 'saved lives' and 'saved property'.

2.1.3 Damage to Buildings and property

In the hypothetical situation that there were no Fire and Rescue Services, a house that caught fire would not necessarily burn down entirely. In many cases, the inhabitants would successfully take measures against the spread of the fire, and the fire would be restricted to a sub-unit of the house (such as a room or a flat).

To take this into account, we use the midpoint between two estimates of likely damage (16% and 70%). These estimates were published by the UK Audit Commission (1995) and the UK Home Office (2019a). This gives us a value of 43% of a domestic property being destroyed.

A few more detailed justifications of this percentage may be in order at this point. The full quote on page 28 of the 1995 publication is: "For instance, of 107,437 fires recorded in occupied buildings in the UK in 1992, nearly 30% were extinguished without the use of any firefighting". In the 2019 publication, the value of 16% comes from the following statement: "In 2018/19, the proportion of fires affecting the 'whole building'… was 16 per cent".

The choice of 43% results from the following considerations:

1) If we assume that a fire that affects the whole building is always a fire that destroys the whole building, then the statement in the 2019 report implies that even with FRS intervention, 16% of the buildings were completely destroyed. Therefore, without intervention, the percentage of buildings that get completely destroyed must be higher than 16%. Consequently, the average share of destruction without intervention must be higher than 16%. It follows that 16% is a lower bound of the average percentage of destruction.

2) If we assume that "extinguished without the use of any firefighting" in the 1995 publication means that the fire was extinguished without the building being damaged, then the statement in the 1995 report implies that 30% of affected buildings were not damaged even if a fire broke out and nobody reacted. Therefore, even in the unrealistic scenario that all buildings that did not remain entirely without damage were completely destroyed, the average destruction share would be just 70%. In reality, the buildings which were damaged by a fire were not entirely destroyed, so that the actual average destruction share must be below 70%. It follows that 70% is an upper bound of the average percentage of destruction.

43% is then the midpoint between the lower and upper bounds of the possible range of the true value.

Our percentage assumption directly impacts the estimated value, as the estimated saved property value is a linear function of the percentage of a building we assume to survive in a fire if there was no FRS intervention. However, this would still be true if we would choose a different percentage. As some assumption about this percentage has to be made, picking the midpoint between an upper and lower bound of the possible values seems to be the best option.

Using this percentage then allows us to estimate this component of the benefit as follows:

(*0.43 * average house size in a region – m^2 affected by the fire) x price of a sq. metre in that region*.

The square metres that were affected by a fire are recorded for each fire incident through the IRS system. The damage that may result from the FRS intervention (usually through water) is included in the definition of damage that results from the fire.

Region	Average house price (£)	Median size (sqm)	Price per sqm
East	327,982	93.7	3,501.85
East Midlands	231,318	95.2	2,429.17
London	507,253	73.4	6,907.10
North East	152,776	92.1	1,659.11
North West	203,661	93.3	2,182.08
South East	370,886	94.3	3,931.86
South West	301,327	95.1	3,167.36
Wales	196,216	98.8	1,986.54
West Midlands	231,501	93.8	2,467.15
Yorkshire and The Humber	192,354	93.2	2,063.04

Table 2.1: Average house sizes and values per square metre by region

The Office for National Statistics (2021) publishes data on house sizes in different regions of the UK, and there is also data available on the average house prices per region (GOV.UK, 2021). Using these sources, an approximation for the average price per square metre was calculated for each English region (Table 2.1). Other data could have been used and this was considered, for example rebuild costs as opposed to house prices, but this data was not available for the whole of the UK in a usable form. Future work may allow that to be considered and compared.

This method was applied to 137,245 cases recorded in the IRS, Dwellings Fire dataset and in the Other Buildings fire dataset across the range 2016/17-2018/19. These years were chosen to provide a typical recent range of years, but without the impact of the COVID-19 pandemic being a factor. The analysis of this range provides the following evaluation of saved property values:

Total	2016/17	2017/18	2018/19	Average per year
£13.35 Billion	£ 4.46 Billion	£ 4.54 Billion	£ 4.34 Billion	£4.45 Billion
(£13,353,474,802)	(£4,466,310,189)	(£4,542,911,110)	(£4,344,253,503)	n/a

Table 2.2: Value of saved property: fire incidents

To illustrate the impact of our assumption that without FRS intervention, 43% of a house would be destroyed, the following table presents the same numbers as above, calculated based on the lower estimate of 16%:

Total	2016/17	2017/18	2018/19	Average per year
£4.97 Billion	£ 1.66 Billion	£ 1.69 Billion	£ 1.62 Billion	£1.66 Billion
£4,968,734,810	£1,661,882,861	£1,690,385,529	£1,616,466,420	£1,656,244,936.68

This is the table based on the higher estimate of 70%:

Total	2016/17	2017/18	2018/19	Average per year
£21.74 Billion	£ 7.27 Billion	£ 7.40 Billion	£ 7.07 Billion	£7.25 Billion
£21,738,214,794	£7,270,737,517	£7,395,436,691	£7,072,040,586	£7,246,071,597.98

2.1.4 Lives Saved

An econometric estimation was carried out to determine how the number of saved lives of an incident depends on the number of deployed resources. As a proxy for the resources, the number of firefighters present at the scene was used.

The variable “Lives saved” takes on the value 1 if in the course of an incident, lives were rescued by the FRS, and 0 otherwise. People who were merely evacuated were not counted, as many evacuees leave premises without help of the FRS. By contrast, people that are recorded in the IRS system as rescued are those actually saved by firefighters from a usually life-threatening situation.

The model has two covariates, namely the number of fire alarm systems that were installed at the premise, and a variable that indicates the spread of the fire upon arrival of the FRS. Details of those variables are provided below.

Using IRS incident data for dwelling fires for the years 2011 to 2019 (about one million incidents in total), the econometric model we estimate is the following:

$$\text{L}ives\ \text{saved} = \alpha + \beta_1 \cdot firefighters + \beta_2 \cdot firealarm + \beta_3 \cdot firesize,$$

where:

- α is a constant
- 'firefighters' is the number of firefighters that present at the scene
- 'firealarm' is the number of fire alarm systems installed at the premises. In most cases, this variable has the value 0 or 1
- firesize' is the size of fire or time at the time of arrival. 'Firesize' can assume one of 5 values, ranging from no fire at all (0) to the roof being on fire (5).

This yields the following estimates for α and the coefficients β_1, β_2 and β_3:

Variable	Estimated coefficient
Constant (α)	-0.015
firefighters ($\beta 1$)	0.005
firealarm ($\beta 2$)	0.029
firesize ($\beta 3$)	0.004

Table 2.3: Estimated Regression coefficients. Dependent variable: lives saved

The variable 'firesize' may have a positive effect because if the fire is more advanced when the Fire Service arrives: it may be more likely that people must be rescued, while in situations where the fire has not progressed greatly, rescues may not be needed.

All variables are significant >99%.

A Variance Inflation Factor test was carried out and did not flag a collinearity problem. The reason for a low correlation between the explanatory variables firefighters and firesize might be that the fire size on arrival will in many cases not be known when firefighters are initially dispatched so that there is no (strong) correlation at this point.

Often, the initial despatch will be the only despatch, but if there will be subsequent despatch of firefighters, the number of additional firefighters may primarily depend on the subsequent course of events, not the fire size on arrival.

The R^2 is just a bit higher than 2%, which is low, but this is not surprising, given that the number of saved people depends on many other factors, many of which are not even included in the IRS records. A low R^2 shows that a model has overall a low predictive power, which may be a problem in other contexts, but it does not invalidate the estimates for individual explanatory variables, which is what we are interested in establishing in this document.

Using this model, we calculate the number of expected lives that were saved through the FRS intervention for each fire incident in the IRS dwellings fire database. This yields the following results:

Total lives saved	2016/17	2017/18	2018/19
7,485	2,516	2,508	2,461

Table 2.4: Lives saved: fire incidents

Multiplying these numbers with the value of a statistical life of £2,146,852 (Department of Transport, 2019 Tag Data Book, May, v1.12, Table A4.1.1, adjusted for inflation), we get the “lives saved” component of the expected economic value of an incident. Summing up over all incidents 2016/17-2018/19 yields:

Total economic value	2016/17	2017/18	2018/19	Average per year
16,068,822,255	5,400,824,842	5,384,283,347	5,283,714,066	£5.36 Billion

Table 2.5: Value of lives saved: fire incidents

The methodology applied in this section may require some additional explanation of rationale.

Firstly, it should be noted that the dependent variable is a binary 0-1 variable, but we interpret it as a variable “lives saved”. This means that if the variables assume the value 1, we interpret this as if exactly one person was saved whenever anyone was rescued. Consequently, whenever more than one person was saved in an incident, the additional people are not taken into account. The problem arises because the data we used do not allow us to discern how many people were rescued.

Secondly, a straightforward question is: why is the benefit of the FRS intervention not just calculated as the total number of people who were rescued in an incident? This is because not all lives that are saved through FRS interventions are actually rescued lives. Consider the case that a fire in a kitchen is put out by the FRS before the fire could spread to any other rooms in the apartment and any other apartments in the block. This FRS intervention, which solves the problem at its very initial stage, may be undertaken without anyone being rescued. The situation was brought under control before any lives were threatened. However, if the fire had not been put out, it could have spread over to the whole apartment, the apartment block, and maybe to surrounding buildings, a development which could have led to many rescues and potentially deaths. The intervention may therefore have saved many lives, even though there were no actual rescues. Yet, if only the rescued people had been counted, the intervention would not have contributed any economic value.

In more general terms, an econometric approach is required because the number of interest is counterfactual and non-observable, namely the difference between the number of people who actually died in an incident, and the people who would have died without FRS intervention. What can be estimated econometrically is how this unobservable number *changes* as a function of the deployed resources. More specifically, the change in the likelihood of being in a situation where at least one additional life is saved can be estimated as a function of those explanatory variables.

This is, strictly speaking, what is estimated in the econometric model outlined above: the estimated coefficient β_1 is to be interpreted as the change in the likelihood of moving from a situation where nobody is rescued (lives rescued = 0) to a situation where at least one person is rescued (lives rescued = 1) which come about through each additional firefighter. Under some simplifying assumptions, this value coincides with the expected/average additional lives saved through the deployment of one additional firefighter. This value can then be used to estimate the impact of the intervention on lives saved, based on the number of firefighters that were deployed in the incident.

Thirdly, what is the role of the covariates? The covariates were included to improve the quality of the econometric model. The estimated coefficients of the covariates are not required for the actual calculation of the economic benefit, which is only based on the number of firefighters deployed.

2.2 Non-fire incidents

In this section we consider how many lives are saved through an individual FRS response to a non-fire incident such as rescuing people from water or extricating someone trapped in a car after a road traffic collision. The answer depends on many parameters, some of which will be specific to the incident and its context. For example, the level of danger of a flooding event will depend on the age and mobility of those who are affected – if a care home is exposed, more lives may be at risk than if the building is a secondary school. Likewise, if a road traffic collision involves a bus and a road tanker, there may be more lives at risk than if two passenger cars collide. In the traffic example, the speed of the involved vehicles is another important factor, as is the exact location of the event (which may determine the risk of follow-up accidents).

Obviously, not all relevant details can be captured in the FRS Incident Report that is created after the event. However, even if a comprehensive description of every incident could be obtained, it would be a practical impossibility to base an individual estimation of the lives that were saved through each incident response on all information that is available. This is due to the great number of such incidents, e.g., between 2011 and 2019, the FRS responded to almost 1.1 million non-fire incidents in the UK.

Therefore, instead of basing our estimate on a comprehensive description of an incident, this evaluation considers the resources deployed by the FRS – summarised by the number of firefighters mobilised to the scene. This parameter has two crucial properties: it is known with a high degree of certainty for *every* incident, and it is *correlated* with the number of saved lives.

To elicit this correlation, a questionnaire was designed with the goal of establishing the correlation between deployed firefighters and saved lives. The association between deployed resources and saved lives was quantified using a linear regression model. On this basis, the value of the FRS intervention could be estimated using this information in conjunction with the value of a statistical life (VSL, for more information see Kniesner and Viscusi, 2019).

2.2.1 Methodological considerations

The Law of Large Numbers

Any estimate of the saved lives which is based only on the parameter “deployed personnel” will frequently be inaccurate. This is not a problem if the statistical analysis will be based on a very large number of cases. It is sufficient if the estimate is correct on average.

Consider an incident to which 10 firefighters were mobilised. Such an incident may sometimes be very serious, with a great number of people at risk, but in other cases, it may not yield harm to anyone. Therefore, whatever number of saved lives are estimated for this incident, in most cases such estimation will be wrong. However, should there be a great number of such cases, then the errors that were made in estimating the number of saved lives of each individual case will cancel out – they will be overestimated and underestimated to the same extent. If we can establish that on average, in the given example 1.2 lives are saved, then, based on a statistical regularity called the Law of Large Numbers, we will (in terms of percentage terms) be very close to the true value if we state that in 400 such cases the number of saved lives is 480 More specifically, with this sample size and normally distributed data, we achieve a Margin of Error of less than 5% at a 95% confidence level. This means that with 95% probability, the true number of saved lives will be between 456 and 504.

Underestimations and overestimations cancel out if we know the true average and our sample becomes large. This does not require a specific distribution, e.g., a normal distribution, but what constitutes “large” *does* depend on the distribution. However, we will not further delve into the statistical details here.

The Wisdom of the Crowd

A questionnaire was designed to elicit expert opinions on how many vehicles and personnel are required to resolve incidents of different levels of severity. The respondents may have very different views on the resources that will be needed, particularly because the information provided on the incidents was extremely scarce, confined to the numbers of people who are in different risk categories.

From a methodological perspective, this is not a problem. The large number of responses that were received led to a phenomenon known as the Wisdom of the Crowd, which has been shown to exist in a great number of academic studies (see, for example, Mannes et al., 2012, Epp, 2017, and Da and Huang, 2020). It relates to the empirical finding that when people must estimate the size of quantitative variables on which they get “noisy signals”, for example as in the case of estimating how many jellybeans are in a jar, how heavy a certain object is, or the value of an object that is to be auctioned, etc., usually each individual estimate is substantially incorrect, but the average estimate is very close to the true value.

In the context of our project, this means that each individual expert may have an incorrect opinion on the resources that are needed to resolve a certain incident, but we can expect that the average estimate will be close to the true value.

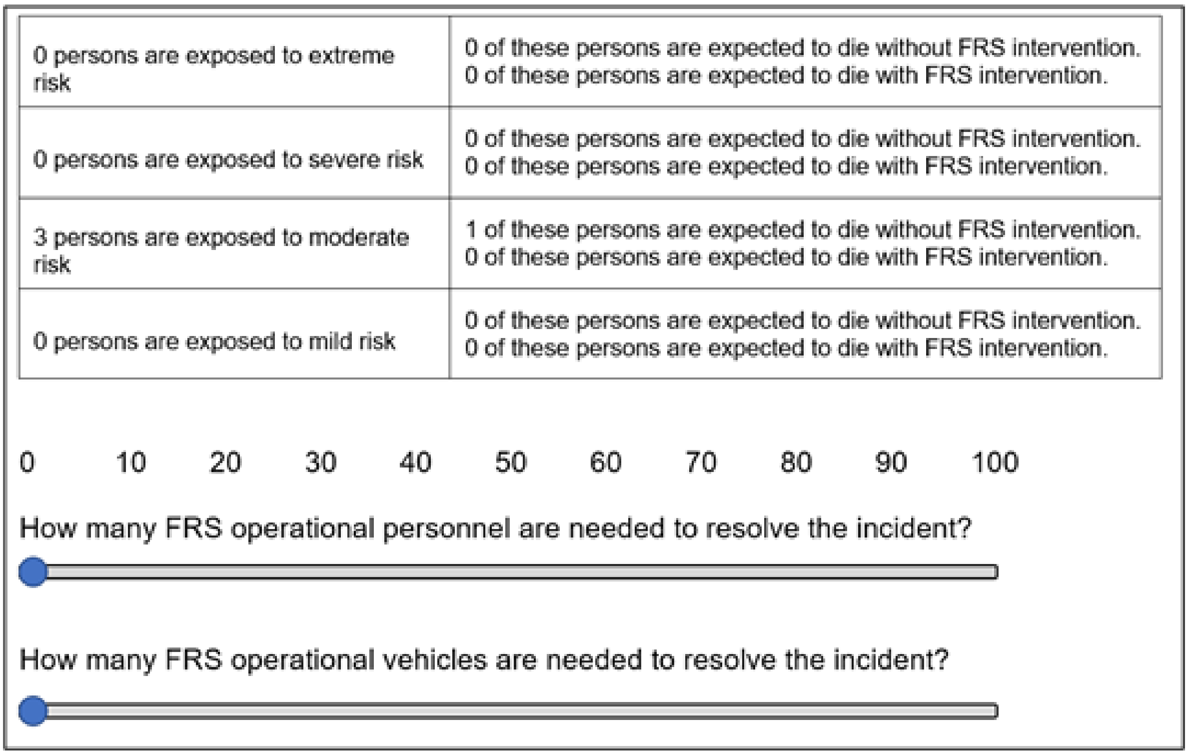
For estimations of simple quantities, the “Wisdom of the Crowds” phenomenon suggests that there should be no systematic errors in a huge number of expert estimations (see the references above). While there are many examples where peoples’ judgments fall victim to systematic biases, these typically refer to statistical reasoning (e.g., the Gambler’s Fallacy), not to the simple estimation of quantities, and therefore do not refute the Wisdom of the Crowds.

2.2.2 Questionnaire design

The questionnaire focused on responses to non-fire incidents in five categories: flooding and rescue from water, making environments safe, spills and leaks, extrications, and medical assistance. These were chosen in consultation with Project Board members, technical Working Group and FRS Single Points of Contacts (SPOCs), in conjunction with the analytical capacity within the project team.

Within each incident category, respondents were presented with ten different, randomly generated scenarios. Each scenario described only the number of persons expected to die without FRS intervention and the number expected to die with FRS intervention. An example is shown below.

An incident has occurred in the category Flooding and rescue from water. The following information is known:



0 persons are exposed to extreme risk	0 of these persons are expected to die without FRS intervention. 0 of these persons are expected to die with FRS intervention.
0 persons are exposed to severe risk	0 of these persons are expected to die without FRS intervention. 0 of these persons are expected to die with FRS intervention.
3 persons are exposed to moderate risk	1 of these persons are expected to die without FRS intervention. 0 of these persons are expected to die with FRS intervention.
0 persons are exposed to mild risk	0 of these persons are expected to die without FRS intervention. 0 of these persons are expected to die with FRS intervention.

0 10 20 30 40 50 60 70 80 90 100

How many FRS operational personnel are needed to resolve the incident?

How many FRS operational vehicles are needed to resolve the incident?

Figure 2.1: An excerpt from the non-fire risk & resources questionnaire

In this flooding and rescue from water scenario, the left-hand column gives the number of persons involved in the incident and their relative level of life-threatening risk (extreme to mild). The right-hand column shows the numbers of persons at each risk level that are expected to die without FRS intervention and with FRS intervention. In the scenario shown in Figure 2.1, no persons are exposed to extreme or severe risk, but one person is exposed to moderate risk and three persons are exposed to mild risk; one of those is expected to die without FRS intervention but none are expected to die with FRS intervention.

The task for each scenario was to estimate the resources that would need to be deployed by the FRS to resolve the incident. The response was made both in terms of FRS operational personnel and FRS operational vehicles, including those riding on the vehicles, but the response showed that the correlation between the two parameters was so high that not both could be explanatory variables in the same linear model. For that reason, only the data on the number of deployed personnel was used for the econometric estimation, which is the parameter that has higher explanatory power. The responses were made by the responder adjusting the slider bars (as shown in the above example) to record the numbers.

Of course, it is unlikely that someone would call the emergency services and describe an incident in terms of the number of people at risk and the likelihood of one of them dying if there is no response.

The information provided by the caller will be likely be far less structured and probably contain ambiguities. The control room operator who makes the decision about which resources to deploy must transform that messy information into an estimate of the severity of the incident, which may include how many people are at risk at different risk levels, and how many of them may die if there was no intervention.

In response to a call for input, many FRS experts were willing to participate (see details in 2.2.3, below), and from the following involvement the feedback was generally positive. Notably, nobody mentioned that they perceived the scenarios presented in the questionnaire to be overly artificial or distant from reality, which suggest that practitioners decode real-world incident information in a similar way as was presented in the hypothetical scenarios of the questionnaire.

It is possible that a scenario could occur where, in reality, no one is at risk, but there may still be an emergency call and resources deployed to resolve the incident so that a positive number of personnel and vehicles may be deployed. However, respondents were asked to make an honest estimate of the resources that they believe are needed to resolve an average incident that *has the given parameters*, not an incident that initially appeared to have those parameters but then turned out to be harmless. If they answered the questions in line with these instructions, they would not include “safety margins” to account for uncertainty.

While respondents were asked to choose the optimal combination of FRS personnel and vehicles that would realistically resolve the incident, this does not mean that there is just one such combination. If the respondent believed that there were multiple best combinations (for example, the same case may be resolved with one vehicle and twenty firefighters or with two vehicles and ten firefighters), they were directed to choose any of the optimal combinations. The highly positive correlation that was found between the estimated needs for both vehicles and personnel indicates that most respondents considered these to be complementary resources – the case of multiple best combinations would then not occur.

The types of the vehicles to be mobilised were not specified in the scenarios. In the questionnaire, all vehicles were considered equal. For example, if respondents required two fire engines and one Command Unit at an incident then then answer should be "three vehicles". However, as the responses on vehicles were finally not used in the econometric estimation, this simplification has no impact on the estimation.

2.2.3 Questionnaire implementation and econometric strategy

The questionnaire comprised ten different scenarios of increasing risk for each of the five incident categories. The number of persons at risk and the number expected to die without FRS intervention, and the number expected to die with FRS intervention, were randomly generated within a set of parameter values. Hence, each respondent was likely to receive somewhat different numbers in the scenarios presented.

The questionnaire was successfully piloted with two experienced FRS personnel who deemed the task and numbers of persons described in the scenarios to be realistic and appropriate. The final questionnaire was implemented in Qualtrics survey design software (Qualtrics, 2021). The link to the online survey was distributed to all NFCC single points of contact in all FRSs for onward distribution to FRS staff with level 1 and 2 command roles as well as control room staff. Data collection took place between the 1st and 20th of July 2021.

After incomplete responses were removed, 168 complete responses were retained for the analysis. At least one response to the questionnaire was received from each of 30 different FRSs, representing 60% of all FRSs in the UK. Five different control centres also responded. Overall, nearly 40% of responses were submitted by staff in Level 1 Command roles, 32% from staff in Level 2 Command roles, 25% from staff in Control roles, and 3% from Others.

Data was downloaded from the Qualtrics website into Microsoft Excel and then configured for the analysis. Specifically, each response to the 10 scenarios per incident category per respondent was treated as an individual case, so that 1680 datapoints were obtained. These were transferred to the statistical package SPSS (IBM Corp., 2019).

A stepwise multiple linear regression procedure was adopted to investigate the contribution of the two explanatory variables ‘vehicles’ and ‘personnel’ in the regression equation, and to provide the optimum statistical model from the data. In all five incident categories, the regression analysis found significant collinearity between the number of personnel and the number of vehicles deployed. The procedure suggested to exclude the number of vehicles from the final models.

Therefore, for each of the five incident categories, we estimated a linear regression model of the form:

$$\textit{Saved lives} = \alpha + \beta \cdot \textit{per}$$

where:

- α is a constant – the number of survivors if there were no firefighters whatsoever
- β per are the number of personnel deployed

For further clarity it is worthwhile to mention that the assumption of a linear relationship between the explained and the explanatory variables is but an approximation, but one that is often made in empirical research. As we work with large samples, we believe that this approximation is unlikely to lead to great errors in the estimations of the final values.

The linearity of the model has the advantage that future estimations of the economic value, possibly by individual FRS, can be done without the use of sophisticated software.

2.2.4 Findings

The results below show only the beta coefficients for the number of personnel. The model parameter estimates were constructed in SPSS with robust standard errors to overcome heteroskedasticity in the data.

Incident category	Model constant (α)	Beta coefficient (β): Number of personnel
Rescue from water	1.121	0.097
Making environments safe	1.411	0.105
Spills and leaks	1.267	0.088
Extrications	1.070	0.199
Medical assistance	1.853	0.106

Table 2.6: Estimated regression coefficients: non-fire incidents

A regression coefficient is to be interpreted as the number of saved lives per deployed firefighter. The value is highest for extrications, a finding that was confirmed to be reasonable by FRS practitioners.

The interpretation of the coefficients can be illustrated with an example. Consider road traffic incident where people were trapped in their cars and exposed to risk of death. If no FRS assistance would arrive, on average 1.070 people would *survive*. Each firefighter who would come to the rescue and extricate people would, on average, increase the number of saved lives by 0.199. Thus, if four firefighters would be at the scene, the expected number of survivors would be $1.070 + 4 * 0.199 = 1.87$. The saved lives through the intervention would be $4 * 0.199 = 0.8$. Based on the Department of Transport 2019 Tag Data Book, May, v1.12, Table A4.1.1 (adjusted for inflation), the value of a statistical life is estimated to be £2,146,852 (a value used throughout this study). Therefore, the intervention in this hypothetical case would have an economic value of about £1.7 million.

When using these coefficients for estimating the economic value of past interventions, two caveats must be addressed:

1. Whenever an emergency call is received, firefighters will be mobilised, even if there is no chance whatsoever that there are lives at risk. In many incidents, lives are very unlikely to be at risk, for example, this is the case in the flooding category when cellars have been filled with water that needs to be pumped out; in the medical assistance category, when handcuffs must be removed; or in any category when just advice was given. However, in the questionnaire on the impact of FRS interventions that was distributed among FRS experts, *all* described cases had the potential for life being lost (by the way in which the cases were constructed, i.e., respondents were given the information how many people would die with and without FRS intervention). This means that the estimated saved lives coefficients are only accurate for a (small) share of the incidents. If this was ignored and the number of mobilised firefighters were multiplied with the coefficient in *every* incident, the number of saved lives would be grossly overestimated.
2. Given the uncertainty of the information, a “safety margin” will often be added to the resources that will be mobilised in *reality* (not in our hypothetical examples in the questionnaire). In many cases, these firefighters will not be needed to resolve the incident, but their attendance is still recorded in the IRS system. Also, for this reason, a mere multiplication of the deployed firefighters with the coefficients would overestimate the impact of the intervention.

To take these caveats into account, the study took the following approach: (a) We apply the method only to certain categories of cases where it is likely that people are at risk; and (b) we only look at the most severe cases in terms of *deployed personnel* and *time at the scene*.

Regarding (b), the study only considers cases where the number of firefighters is three standard deviations higher than the average number of personnel deployed in that category of incidents. In addition, the time at the scene also must be three standard deviations higher than the average time at the scene in that category of incidents. Assuming that the two parameters are roughly Gaussian distributed (which is truer for some incident classes and less true for others), the distance from the mean implies that only cases that are in both dimensions more severe than 99.7% of all cases will be considered. Most importantly, all cases where no lives are at risk will be among those which remain below this threshold.

To avoid misunderstandings, it should be noted that restriction to the most severe cases cannot lead to an overestimation of numbers, because we do not estimate averages or regression coefficients, but 'saved lives' in absolute terms (using the coefficients that we had estimated before). If we would not focus on the most severe cases, the absolute numbers would be unambiguously higher because in addition to the severe cases, we would also include all the other cases.

This means that our estimation is very conservative, and if the real values would be different than what we estimate, we expect the deviation to be towards a *higher* number of saved lives.

The threshold of three standard deviations leads to the dismissal of many incidents that otherwise would be assessed to have considerable economic value. Nevertheless, this threshold was chosen because, as explained above, the values that were obtained from the experts are only relevant for a subgroup of real-world cases, namely those where lives were at risk. From discussion with experts, the conclusion was that this is the case only in a small share of incidents, and a threshold of three standard deviations was considered appropriate against the backdrop of the conservative approach of the study. To show how this choice affects the results, a table with the alternative values for two and one standard deviations thresholds is included at the end of this section.

The analysis covers the years 2016/17 to 2018/19. Table 2.7 shows which incident types we have included in our analysis and to which category we have assigned them:

Incident category	Included in category
Breathing difficulties / impairment / Respiratory arrest Removal of objects from people Medical assistance only (RTC) Chest Pain / Cardiac Arrest / Heart condition Assistance to other agencies (unspecified) Other assistance to police/ambulance - Other Unconscious, fitting or unresponsive Collapse Threat of / Attempted suicide Shock / Anaphylactic shock Choking	Medical assistance
Floodings Rescue or evacuation from water	Rescue from water
Spills and Leaks (not RTC) Hazardous Materials incident	Spills and Leaks
Making safe (not RTC) Make scene safe (RTC) Wash down road (RTC)	Making environments safe
Other rescue / release of persons Evacuation (no fire) Extrication of person(s) (RTC) Release of person(s) (RTC)	Extrications
Other assistance to police/ambulance - Bariatric person Lift release No action (not false alarm) Good Intent False Alarm Animal assistance incidents Advice only Other transport incident Stand by Malicious False Alarm Water provision Make vehicle safe (RTC) Stand by - no action (RTC) Other RTC Advice only (RTC) Effecting entry No action required (medical assistance) Other medical assistance (unspecified) No persons involved Suicide Civil Disturbance	Not Included in this Phase

Table 2.7: The assignment of non-fire incidents to classes

As shown in Table 2.7, some incident categories were not included. This was the case whenever it was considered to be highly *unlikely* that human lives would be saved. For example, animal rescues were not included, even though there *are* cases where an animal that is in danger can cause its owner to engage in risky behaviour. While these exclusions will lead to an underestimation of the economic value, the general guideline of the analysis is to calculate the economic value conservatively instead of engaging in speculating where reliable data is not available. However, these choices should be kept in mind when the final values are interpreted.

i. Flooding and rescue from water incidents

For incidents in the categories "Flooding" and "Rescue from water", the average number of deployed firefighters per incident was 5. These attended a scene on average for 47 minutes. Because we only consider cases which are three standard deviations higher than the mean, we only included incidents attended by at least 16 firefighters for a minimum of 200 minutes.

The following table shows the economic benefits for this category if the value of a statistical life is assumed to be £2,146,852 (inflation-adjusted value from the Department of Transport 2019 Tag Data Book, May, v1.12, Table A4.1.1):

	2016/17	2017/18	018/19	Total	Average value per year
Number of incidents	15,095	16,692	14,373	46,160	n/a
Number of saved lives	449	536	510	1,495	n/a
Economic value (£)	962,923,234	1,150,864,025	1,095,783,317	3,209,570,576	£1.06 bn

Table 2.8: Value of saved lives: Flooding and rescue from water incidents

ii. Making environments safe incidents

For incidents in the category "Making environments safe", the average number of deployed firefighters per incident was seven. On average, these attended a scene for 48 minutes. Because only cases which are three standard deviations higher than the mean were considered, only incidents attended by at least 22 firefighters for a minimum of 190 minutes were included.

The following table shows the results for this category:

	2016/17	2017/18	2018/19	Total	Average value per year
Number of incidents	12,720	13,112	14,071	39,903	n/a
Number of saved lives	548.94	399.735	279.09	1,227.77	n/a
Economic value (£)	1,178,492,937	858,171,884	599,164,925	2,635,829,746	£0.88 bn

Table 2.9: Value of saved lives: Making environments safe incidents

iii. Spills and leaks incidents

For incidents in the category "Spills and leaks", the average number of deployed firefighters per incident was seven. These attended a scene on average for 63 minutes. Because we only consider cases which are three standard deviations higher than the mean, we only included incidents attended by at least 25 firefighters for a minimum of 251 minutes.

The following table shows the results for this category:

	2016/17	2017/18	2018/19	Total	Average value per year
Number of incidents	5,880	6,113	6,312	18,305	n/a
Number of saved lives	238.70	139.26	156.51	534.47	n/a
Economic value (£)	512,453,572	298,970,610	335,999,513	1,147,423,695	£0.38 bn

Table 2.10: Value of saved lives: Spills and leaks incidents

iv. Extrication incidents

For incidents in the category "Extrications", the average number of deployed firefighters per incident was 10. These attended a scene on average for 75 minutes. Because only cases that are three standard deviations higher than the mean are considered, only incidents attended by at least 28 firefighters for a minimum of 242 minutes are included.

The following table shows the results for this category:

	2016/17	2017/18	2018/19	Total	Average value per year
Number of incidents	11,925	11,841	11,465	35,231	n/a
Number of saved lives	466.26	406.66	253.73	1,126.64	n/a
Economic value (£)	1,000,984,773	873,031,320	544,710,024	2,418,726,117	£0.81 bn

Table 2.11: Value of saved lives: Extrication incidents

v. Medical assistance incidents

For incidents in the category "Medical assistance", the average number of deployed firefighters per incident was four. These attended a scene on average for 47 minutes. Because only cases that are three standard deviations higher than the mean are considered, only incidents attended by at least 14 firefighters for a minimum of 187 minutes are included.

The medical assistance dataset contains primarily incidents where the FRS were co-responders or assisting other agencies. The calculation of the economic benefit that follows from an unmodified application of the method to the dataset ignores this fact. The overall economic benefit of the intervention would be computed as if it was generated by the FRS alone, and therefore be strongly exaggerated.

As the data does not allow to distinguish whether a life was saved by the FRS or by one of the other agencies that were involved in the response, the best approximation seems to be an attribution of the total economic value to the FRS which corresponds to the share of FRS medical assistance responses among all medical responses (FRS and ambulances).

This share is calculated based on 2015/16 data:

Incidents attended by ambulances in England in 2015/16 (source: National Audit Office report on NHS Ambulance Services 2017): 6,600,000

Medical assistance incidents attended by FRS in England in 2015/16 (IRS data): 57,306

The share of FRS interventions corresponds to 0.9% of all interventions.

The following table shows the adjusted values for this category:

	2016/17	2017/18	2018/19	Total	Average value per year
Number of incidents	47,535	42,698	34,501	124,734	n/a
Number of saved lives (share of FRS)	27.36	28.02	29.67	85.04	n/a
Economic value of the FRS share (£)	58,740,441	60,143,387	63,685,570	182,569,398	£0.06 bn

Table 2.12: Value of saved lives: Medical assistance incidents

Sensitivity analysis

To show the impact of choosing the threshold of three standard deviations, the Table 2.13 presents the economic values for different categories if alternative thresholds of one standard deviation and two standard deviations are used (in £, total value for 2016/17-2018/19).

Under the assumption that the data are normally distributed (which is generally not fulfilled with empirical data, but some empirical distributions may have a similar shape and thus similar characteristics as the normal distribution), the threshold of one standard deviation removes incidents that are not among the 31% most extreme incidents (with respect to personnel deployed and time attended), and the threshold of two standard deviations removes all incidents that are not among the 5% most extreme.

The threshold of three standard deviations, which was applied in the analyses above, removes all incidents that are not among the 0.3% most extreme.

Incident Class	1 SD	2 SD	3 SD
Flooding and Rescue from water	11,499,165,119	10,384,015,051	3,209,570,576
Making env. safe	29,497,038,019	2,635,829,746	2,635,829,746
Spills and leaks	11,677,329,147	4,817,913,734	1,147,423,695
Extrications	15,230,305,874	15,230,305,874	2,418,726,117
Medical assistance	227,215, 859	182,569,397	182,569,397
Total	**£68,131,054,018**	**£33,250,633,802**	**£9,594,119,531**

Table 2.13: Saved lives sensitivity analysis

2.3 The economic and social value of prevention and protection activities

This section considers the methods and results of the estimation of economic and social value of FRS prevention and protection activities. It is structured as follows:

First, a consideration of the literature on the effectiveness of home fire safety checks is followed by an estimation of value resulting from home visits undertaken by FRS staff.

Secondly, an estimation of the value derived from FRS audits/Inspections of non-domestic (commercial) properties. This is followed by consideration of FRS prevention education and campaigns including fire safety, road safety, and water safety. In this section the application of social value approaches are used to derive value from these activities.

Finally, a model to demonstrate how the approaches can be implemented is presented in a tool using MS Excel.

2.3.1 Evaluations of the home fire safety check initiatives

A range of studies using different approaches and methods has found that the presence of a functioning smoke alarm in residential properties reduces the frequency and severity of house fires. Interventional studies that incorporate a smoke alarm check (or installation if required), are invariably coupled with some degree of fire prevention education for the recipients. The intervention, whether in a research setting or in practice, are commonly referred to as Home Fire Safety Checks (HFSCs). Here, research evidence of the effectiveness of HFSCs was reviewed to inform and rationalise the approach in the current project in determining the economic value of HFSCs.

Williams et al. (2009) evaluated a HFSC initiative introduced by the Department of Communities and Local Government (CLG) for FRSs across England. The initiative promoted the use of targeted approaches to implementation e.g., delivery to those considered high-risk based on incidence or demographic data. Different approaches were taken by different FRSs, with most taking some targeting approach. However, no precise data were collected on this during the implementation phase. The study concluded that the initiative had been beneficial and relationships between the installation of smoke alarms and reductions in dwelling fires and non-fatal casualties had been found.

The benefits of the initiative were found to far outweigh the revenue and capital costs of the initiative, giving a benefit-cost ratio in the range of £14-£30 per £1 invested.

Clare et al. (2012) evaluated the effectiveness of a fire prevention information package delivered to homes in the city of Surrey, British Columbia, Canada. A sample of high-risk homes (based on incident data) was assembled and blended with geographical location and demographic data to form several distinct high-risk zones within the city.

These zones were then randomly allocated to two groups, one to receive the fire prevention intervention package, and the second to serve as control areas. The intervention, delivered by on-duty career fire fighters, covered a range of prevention-related topics, including:

- smoke alarm checks or installation
- home fire escape plans
- children and fire
- senior fire safety
- kitchen fire safety

The frequency and severity of fires pre- and post-intervention were compared in the two groups (intervention and control). Severity was measured by the percentage of fires that were confined to the object of fire origin. The study found a reduction in the frequency of fires in the intervention group areas that was significantly larger than that for the control group areas (63.9% reduction in the rate of fires per 1,000 properties per year in the intervention group compared to 14.6% reduction in the control group). When fires did occur in the intervention areas, smoke detectors were activated more quickly and the fires were confined to the object of origin more often, post visit. The costs of the intervention were not reported in the study; hence a cost-benefit ratio is not reported.

Greenstreet Bergman (2013) evaluated the implementation of a HFSC initiative in Wales. The main findings were related to process measures, rather than outcomes. The association between HFSCs and outcomes such as the number of fires, fatalities and injuries was investigated, but no firm conclusions drawn.

Arch and Thurston (2013) evaluated the impact of targeted home safety assessments on fires and injuries in Cheshire FRS. The visits included a multifaceted fire risk and needs assessment tailored to each specific household. Data were compared to a control group comprising 37 English FRSs. They demonstrated that their highly targeted and tailored home safety visits were successful in reducing accidental dwelling fires and related injuries between 2002 and 2011.

Tannous et al. (2018) present an economic evaluation of a pilot scheme of home fire safety checks in New South Wales, Australia. Detailed costs for the scheme were derived including staff costs (hourly wage and on-costs), smoke alarms and materials, and travel costs. Benefit analysis was given as cost savings from an increasing percentage reduction in the average number of residential structure fires (in 3 scenarios: 0.25%, 0.5% and 0.75% reduction) and associated injuries and fatalities. The savings per Australian dollar ranged from $4.20 to $12.51 for every dollar spent on deployment to 1% of homes.

Reinhardt and Chatsiou (2019) reported a significant reduction in the number of accidental dwelling fires (by 0.58 per month) in homes in Essex that had received hour long fire safety check visits, compared to homes in (no visit) control areas.

Taylor et al. (2019) studied the effectiveness of fire prevention activities in one FRS over a period of 10 years. They concluded that the spend per head on fire prevention appeared to have been effective in reducing the number of fires.

Sund et al. (2019) evaluated the cost-benefit ratio of a home fire safety check programme in southern Sweden. The programme included a safety check, education, and a smoke alarm check or installation, with between 90-95% of the home visits delivered on on-duty firefighters. The intervention was not randomly distributed between FRSs but implemented in a region covered by one FRS. Statistical methods were employed to compare the change in the trend of fires in the treated area before and after implementation of the programme to the same change in the untreated regions. The costs of the intervention were based on the labour to deliver the intervention, namely the gross wage per hour for one firefighter adjusted for the time and number of firefighters needed to deliver the intervention to 25 households. Benefits were calculated as saved damage costs and saved lives. Overall, the intervention had positive economic effects with the benefits estimated to be maximum 8-11 times higher than the costs.

It is recognised that the literature above relates to this work at times, but not always directly, and as such that some interpolation is required to apply it to UK FRS data. Furthermore, data on FRS activities are often collected for different reasons, and not collected in a consistent or universal manner, so the resulting research is required to retrospective and based on imperfect data. To address this, the NFCC Community Risk Programme has recently established a project to review and revise evaluation methods across all FRS activities: this will reduce uncertainty in future iterations of this work.

Evaluation rationale and methods

There is evidence in the above literature to suggest that smoke alarm checks (or installation) with fire prevention education are effective in reducing the number of fires, particularly those residencies deemed to be at high risk. There is a smaller evidence base for the effectiveness of home visits in reducing injuries, fatalities, and severity of domestic fires. The attribution of the home visit to outcomes such as injuries and fatalities is possibly more problematic, as a second intervention i.e., the response of the fire service and other agencies, will likely be a dominant factor in determining these outcomes.

The UK FRSs carry out mainly targeted Home Fire Safety Checks to check smoke alarms and deliver preventive education. Targeting is commonly based on identified risk factors such as age, disability, and deprivation indices. The study evaluated the association between the number of targeted home visits and the number of fires across all 45 FRSs in the England. The aim is to identify the contribution of targeted home visits to any reduction in the number of fires. The method used is similar to that of Williams et al. (2009) in their evaluation of the Home Fire Risk Check grant programme. Our analysis has focussed on the value of targeted home visits (both home fire safety check visits, (Home Office, 2021a, Fire Statistics Table 1201) and the number of accidental dwelling fires (Home Office, 2021b, Fire Statistics Table 0202).

Through the examination of the variation in targeted home fire safety checks and accidental dwelling fires across the 45 FRS in England the analysis sought to quantify the ‘average’ association between targeted home visits and number of fires using the linear regression method. The aim was to identify the contribution of a targeted home visits to any reduction in the number of fires.

The benefit of targeted home visits in an index year (for example 2018/19) is shown, on average, to reduce the number of fires in the index year +1 (e.g. 2019/20). Both the intervention (that is, the targeted visit) and the outcome (number of fires) are highly influenced by the preceding year's data (in fact, both have been on a year-by-year downward trend over the past 10 years). The analysis controls for these trends in the form of a conditional change score regression model (Berrington et al., 2006), with the key model coefficients estimated by linear regressions shown in the benefit:cost analysis outlined below.

Benefits

The analysis shows that, on average, a targeted home visit contributes to a reduction in the incidence of accidental dwelling fires. The coefficient from the conditional change regression model for this predictor variable is equal to -0.00422. That is, each targeted home visit, on average, contributes a 0.00422 reduction in the number of accidental fires.

The average cost of a domestic fire is estimated to be £53,498 (Greater Manchester Combined Authority, 2021 Unit Cost Database). This figure comprises both costs as a consequence of fire and costs in response to fire; it includes the average cost of fire setting. Costs in anticipation of fire are not included (e.g., the cost of installing fire protection in buildings). It should also be noted that costs as a consequence of fire will include economic and social costs as well as fiscal. Hence, for each fire prevented the economic and social benefit is calculated as £53,498 x 0.00422 = £225.76 (i.e., the benefit value per targeted visit).

Costs

Estimates of the cost of a Home Fire Safety Check are given below. The first method takes the cost from a Home Office Impact Assessment Consultation document (Home Office, 2022). The second method is based on summary reports from FRS returns of Home Fire Safety Checks data (calculated from Home Office, 2021a, Fire Statistics Table 1201). The approach taken is to calculate the costs using both methods and the apply the higher cost to the Benefit: Cost calculation. This then provides the more conservative estimate of the Benefit: Cost ratio.

Cost method A

Following the method given by the Home Office (2022) the central estimate of a Home Fire Safety Check is £72. This is based on an average scenario of two firefighters (each with a salary of £17.96 per hour) each one on site for two hours per visit. Multiplying these salary assumptions with the time required, and the number of individuals, gives an average cost of £71.84.

Cost method B

The average time per targeted home visit has been calculated from routinely collected data to be 2.11 hours. This represents the average duration of targeted home visits in 2017/18 to households where a resident had a disability (calculated from Home Office, 2021a, Fire Statistics Table 1201). The average hourly rate of FRS personnel is £19.00 (Greater Manchester Combined Authority, 2021 Unit Cost Database). This is the average cost per hour of fire safety labour plus a 30% overhead to account for fixed administration costs such as expenses for premises (rent or building depreciation), telephone, heating, electricity, IT equipment, etc.; the overhead also included absence owing to illness. On-costs at 45% (31.2% pension and 13.8% national insurance contributions) are added to this to give a total cost per hour of £27.55. Hence, the cost of a targeted visit is 2.11 x £27.55= £58.13.

A smoke alarm may be fitted during the home fire safety check visit. The cost of an alarm is estimated to be £10. Based on data reported in FRS annual reports, on average, one alarm is installed in approximately every other visit. Therefore, the cost of smoke alarms per visit is 0.5 x 10 = £5.00.

The total cost of a typical home fire safety check visit is estimated to be £58.13 + £5.00 = £63.13.

Given the economic and social benefit and cost estimates calculated above, the gross Benefit:Cost ratios for Cost methods A and B are:

Cost method A: £225.76 / £71.84 = £3.14

Cost method B: £225.76 / £63.13 = £3.58

The more conservative value of the Benefit:Cost ratio is calculated using Cost method A and will be used here. A final adjustment factor (of 0.85 of the benefits value) is applied following the recommendation by HM Treasury (2014) given that the analysis is based on routinely collected data. Hence the final Benefit:Cost ratio is £3.14 x 0.85 = £2.67.

Figure 2.2 presents a simple infographic of the return-on-investment analysis of targeted home fire safety checks.

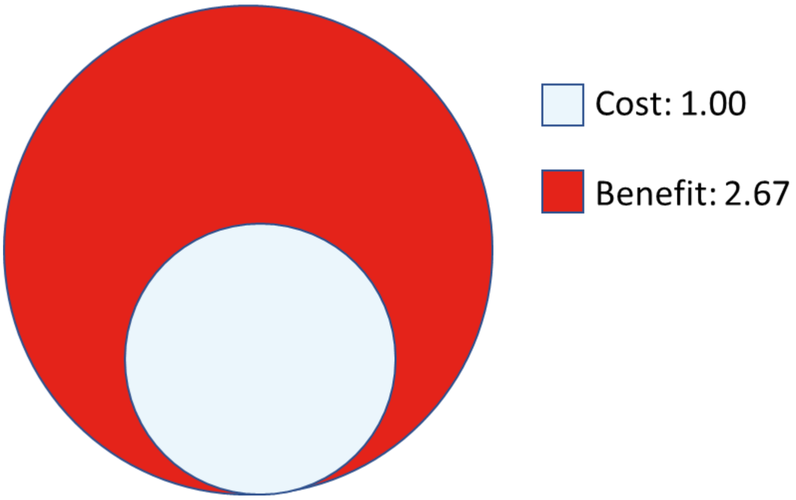


Figure 2.2: Infographic of the relative cost and benefits of targeted home fire safety checks.

It is noted that this return on investment is slightly lower than figures published in the literature but would not be considered an outlier.

The two most recent studies which used reasonably robust methods yielded benefits in the range of approximately 4-12 times the input (Tannous et al., 2018) and 8-11 times the input (Sund et al., 2019). The later study derived their figure from a setting where they compared an area with no intervention with an area receiving the intervention. The potential for a higher benefit value would have been greater in that scenario compared with method used by this study, where we evaluated

2.3.2 Audits/Inspections of non-domestic properties

Fire safety audits/inspections are visits made by FRS personnel to carry out a comprehensive assessment of the level of compliance with the requirements of the Fire Safety Order regulations (FSO, 2005). FSO regulations cover most non-domestic premises and communal areas in residential buildings. Each FRS audits a sample of the known premises each year, informed by risk profiles.

Greenstreet and Bergman (2010) considered several potential outcomes for evaluation in relation to audit/inspection activities including number of fires, lives saved, and property saved. This study evaluated the association between the number of hours FRSs employed on unsatisfactory audit outcomes (and follow-up actions) and the number of fires in public-sector/commercial properties. Audit activity in the following premise types were considered: Care homes, Factories or warehouses, Further education, Hospitals, Hostels, Licensed premises, Offices, Other premises open to the public, Public buildings, Schools and Shops.

The number of fires in public-sector/commercial properties occurring in the following premise types were considered: Agricultural premises, Education premises, Food and Drink premises, Hospitals and medical care, Hotel, boarding houses, hostels etc., Industrial premises, Offices and call centres, Other public buildings and Retail premises.

This achieved an alignment between the reported categories of audits (i.e., by building types) and reported fires (premises types) to ensure a match between intervention and outcome. As a result, some categories were omitted from the analysis where it was unclear e.g., reported fires such as those in the kitchen in purpose-built flats were very often within an individuals' flat that would not have been part of an FSO audit inspection. Hence, data on fires in all purpose-built flats and certain other premises (specifically houses of multiple occupancy, houses converted to flats, and other sleeping accommodation) and audit data on the same categories of premises were omitted.

Overall, across 45 FRSs the number of hours on unsatisfactory audit outcomes in these premises accounted for 24.4% of total activity. Of these, Greater London accounted for 24.6% of audit hours resulting in unsatisfactory audits. Audits in flats and similar properties and the association with reduction in fires, particularly in London, is an area for further research.

Through the examination of the variation in audit activity and fires in public-sector/commercial properties across the 45 FRS in England the analysis sought to quantify the 'average' association between the audit activity and number of fires using the linear regression method. The aim was to identify the contribution of an unsatisfactory audit outcome and follow-up actions to any reduction in the number of fires.

An unsatisfactory audit is required following an inspection if further action is required to bring the premises up to compliance. The number of hours recorded includes the time taken to complete the original audit and the total time spent on all the subsequent enforcement activity and any follow-up visits. The approach is very similar to that proposed by Greenstreet and Bergman (2010) for analysis of fire protection activities and is consistent with the analysis approach taken with home fire safety checks in the earlier section of this report.

This analysis used publicly available data on audits/inspections (Home Office, 2021c, Fire Statistics Table 1204) and the number of fires in public-sector/commercial properties based on individual anonymised incident data reported in the Incident Recording System supplied by the Home Office.

The benefit of an unsatisfactory audit outcome and follow-up actions in an index year (e.g., 2018/19) is shown, on average, to reduce the number of fires in the index year +1 (e.g., 2019/20). Both the intervention (i.e., unsatisfactory audit outcome and follow-up actions time in hours) and the outcome (number of fires) are highly influenced by the preceding year's data (in fact both have been on a year-by-year downward trend over the past 10 years). The analysis controls for these trends in the form of a conditional change score regression model (Berrington et al., 2006), with the key model coefficients estimated by linear regression. The benefit:cost analysis is outlined below.

Benefits

The analysis shows that, on average, the number of hours activity on unsatisfactory audit outcomes and follow-up actions is associated with a reduction in the incidence of fires in business/commercial buildings (for the purposes of this report an 'unsatisfactory audit' included audits at all levels of concern) The coefficient from the conditional change regression model for this predictor variable is equal to -0.02. That is, each targeted visit, on average, contributes a 0.02 reduction in the number of fires each year.

The average cost of a fire in a commercial building is estimated to be £91,177 (Greater Manchester Combined Authority, 2021 Unit Cost Database). This figure comprises both costs as a consequence of fire and costs in response to fire; it includes the average cost of fire setting. Costs in anticipation of fire are not included (e.g., the cost of installing fire protection in buildings). Note that costs as a consequence of fire will include economic and social costs as well as fiscal. Hence for each fire prevented the economic and social benefit is calculated as £91,177 x 0.02 = £1,823.54.

Costs

The average time per of an unsatisfactory audit and follow-up actions has been calculated from routinely collected data to be 5.58 hours. Specifically, this represents the average duration of an unsatisfactory visit and associated follow-up work across the following categories of premises: Agricultural premises, Education premises, Food and Drink premises, Hospitals and medical care, Hotel, boarding houses, hostels etc., Industrial premises, Offices and call centres, Other public buildings and Retail premises (Home Office 2021c, Fire Statistics Table 1204). The average hourly rate of FRS personnel is £19.00 (Greater

Manchester Combined Authority, 2021 Unit Cost Database). This is the average cost per hour of fire safety labour plus a 30% overhead to account for fixed administration costs such as expenses for premises (rent or building depreciation), telephone, heating, electricity, IT equipment, etc.; the overhead also included absence owing to illness. On-costs at 45% (31.2% pension and 13.8% national insurance contributions) are added to this to give a total cost per hour of £27.55. Hence the cost of an average inspection visit is 5.58 x £27.55 = £153.73.

Given the economic benefit and cost estimates calculated above, the gross Benefit:Cost ratio is: £1,823.54/ £153.73 = £11.86.

As this is the first study to publish a benefit:cost ratio in this area of activity the degree of attribution to other factors influencing the outcome must be considered. Following guidance by Steed and Nicholles (2011) and in the absence of other evidence an appropriate attenuation or attribution factor is 0.5. This value represents a potential scenario whereby "Other factors (people/organisations) have a significant role in generating the outcome" (Steed and Nicholles, 2011). In addition, a further attenuation factor is applied given that the analysis is based on routinely collected data (and set at 0.15, following the recommendation by HM Treasury, 2014). Overall, the attribution of the intervention to the outcome is set at a conservative value of 0.35 (1.0 - 0.5 - 0.15). Hence the final benefit:cost ratio is £11.86 x 0.35 = £4.15.

Figure 2.3 presents a simple infographic of the return-on-investment analysis.

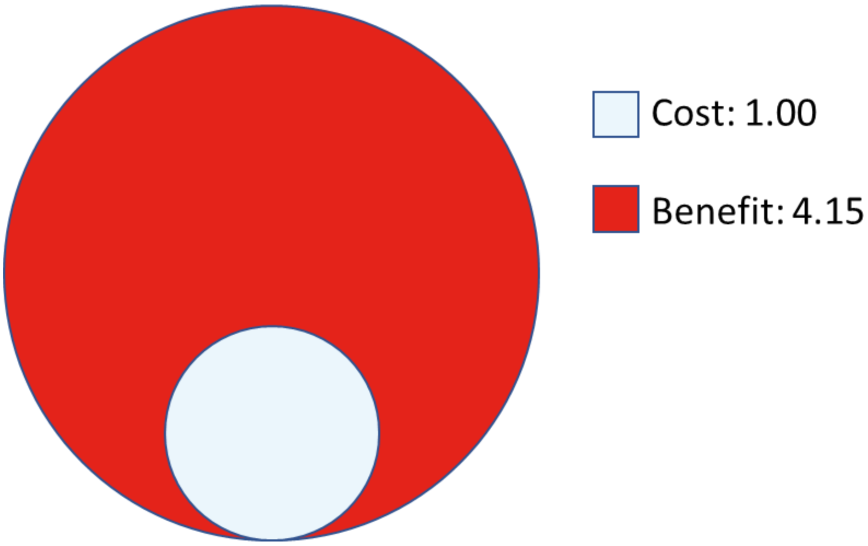


Figure 2.3: Infographic of the relative cost and benefits of audits/inspections of commercial properties.

2.3.3 Prevention education and campaigns including fire safety, road safety and water safety

This section considers three key areas of prevention activities: fire safety, road safety, and water safety education and campaigns. Publicly available data published by the Home Office (2019, Fire Statistics Table 1203) provided a potential source of data for analysis, which was investigated by the evaluation team. The HO summary report presents data for each FRS in England under the headings shown in Table 2.14.

All campaigns and initiatives[1]		of which: Firesetter and anti-social behaviour schemes and other youth diversion[2]		of which: Other youth fire safety programmes [3]	
Number of visits	Hours	Number of visits	Hours	Number of visits	Hours

2.14: From Fire Statistics Table 1203.

The footnotes given are

[1] Including: youth diversion, young fire setter schemes, schools' education activity (nursery to key stage 5), arson prevention initiatives, and other fire prevention campaigns/initiatives (Road safety campaigns etc).

[2] Initiatives designed to divert young (aged 18 and under) people from offending, or those at risk of offending. This category includes Local Intervention Fire Education (LIFE) and Cadets schemes.

[3] Other youth fire safety programmes include information on FRS involvement with schools, including visits to fire stations, or school talks.

In addition, the following comment is given in the table footnotes: “Home Office statisticians considered the future collection of the ‘campaigns and initiatives’ information in 2019 with regards to the burden of collection and the use made of the data given its known limitations and it was decided to not collect this information.”

As can be seen from the Table 2.14, the data is not segmented by the three specific activities of fire safety, road safety, and water safety as ideally required. Instead, it is collated under broad categories.

The evaluation team issued a questionnaire (distributed via the NFCC single points of contact from the UK FRS) to supplement the publicly available data. The questionnaire was designed to see if FRSs could give further information on the relative time spent (on average) on the three named activity areas. The intention was that this could be applied to publicly available data to evaluate a link between input hours on the three activities and relevant outcome measures. The economic and social benefit would then be estimated using methods similarly and previously applied to the home visits and audit/inspection data. However, responses to the questionnaire demonstrated that many of the education and campaign hours delivered are not readily separable in this way e.g., an education activity may cover encompass all the areas.

However, the respondents were able to estimate, on average, the relative split of hours delivered to each of the three separate activities. The results are shown in Table 2.15.

Prevention activity area	Estimated percentage of time delivered
Fire safety (excluding home/safe and well visits)	87.0%
Road safety	8.1%
Water safety	4.9%

Table 2.15: Relative split of hours spent on fire, road and water safety education and campaigns.

In addition, there are other issues to consider with these forms of activity. The research literature on education interventions highlights the difficulty in achieving attribution of outcomes to the inputs.

For example, interventions to reduce risky driving behaviour in young adults and their effects on the incidence of road traffic collisions in that age group (summarised in Cutello et al., 2020). There is increasing confidence in attribution when significant periods of time are given to the educational input, or the inputs lead to a formally recognised qualification. In general, research studies in this area often demonstrate short-term increases in knowledge following an educational intervention, but very often do not find any longer-term impact in outcomes or find it difficult to demonstrate attribution of the education to the outcome measure.

Taken together, the factors above regarding the data available, the mix of interventions and the difficulty in attributing interventions to outcomes, the evaluation team sought a different approach. The team investigated the potential of applying the method of social value to these activities.

Social value refers to the wider financial and non-financial value created by an organisation through its day-to-day activities. Social value is the quantification of the relative importance that people place on the changes they experience in their lives (Social Value UK, 2021a). Social value might be the value someone experiences from an increase in knowledge or skills or an increase in confidence following an intervention for example.

This was deemed a more appropriate approach to the prevention education work of the FRS, and the analysis and results can be communicated in a return in investment framework like that used for the analysis of the home fire visits prevention work. The framework in this case is known as a Social Return on Investment (SROI). Moreover, there is a validated database of social values (monetary proxies) that can be applied to a number of relevant interventions that FRSs deliver. This is known as the National Social Value Measurement Framework (abbreviated to National TOMs).

The National TOMs is a framework to measure, manage and maximise the delivery of Social Value. This framework has been endorsed by the Local Government Association and recognised as one of the principal ways of measuring Social Value by Crown Commercial Service. The National TOMs Framework has been developed as a way to report and measure social value to a consistent standard.

The TOMs proxies (Social Value Portal, 2021) are developed from adaptations of benefit analysis techniques as outlined in the HM Treasury Green Book and other relevant public sector and impact assessment guidance documents. To ensure transparency, the sources for each proxy are made publicly available and detailed in the guidance available with the Framework.

Sources of data include:

- the HM Treasury Green Book and supplementary guidance
- the Greater Manchester Combined Authority (2021) Unit Cost Database

- Office of National Statistics data
- data published by other ministerial departments

The social value approach is applied below for the prevention education activities of the FRS.

Going forward, the method assumes that FRSs record data on hours of input delivered on the three main areas of fire, safety, road safety and water safety as accurately as possible. This would provide the cost element of an intervention (measured in hours at a given average pay rate) and an outcome, that is based on a relevant social value proxy. There are some more specific activities, described below, that could be separately recorded, as they deliver specific and relevant social value proxies from the TOMs database.

Application of the method to prevention activities

As noted above, there are several levels of provision and outcome that could be applied in practice.

i) Fire setter and anti-social behaviour schemes

For such schemes the relevant TOMs is: NT24 Initiatives aimed at reducing crime.

Costs:

Number of staff hours of staff time spent on the activity. This is number of hours multiplied by the average cost of fire personnel time per hour at £19.00 (Greater Manchester Combined Authority, 2021 Unit Cost Database). On-costs at 45% (31.2% pension and 13.8% national insurance contributions) are added to this resulting in a total cost per hour of £27.55.

Benefits:

For this activity the study used the Social Return on Investment calculation from a study that evaluated a similar intervention (this is known as benefits transfer). Ward and Thurston (2009) report the evaluation of a targeted intervention for young people aged 11 to 16 years and who were disaffected and/or displaying antisocial behaviour. The intervention was mainly delivered by fire service personnel working with other agencies. It aimed to build resilience and encourage the children’s participation in positive, rather than negative activities and to reduce involvement in the targeted behaviours of fire setting, hoax calls, and dangerous driving. Typical activities centred on team building, fire awareness and hoax calls, and road traffic collisions. The value of the intervention included financial proxies for reduced antisocial and dangerous behaviours and improved behaviours at home and at school. The social return on investment of the intervention was calculated to be £3.70 for each £1 invested (minimum £3.30

per £1 invested). For this analysis we will use the more conservative value of £3.30.

To calculate the total costs and benefits across 45 FRSs in England, the study referred to data provided in the existing publicly available Home Office reports (Home Office, 2019, Fire Statistics Table 1203). On this basis, the FRSs in England in 2017/18 fire setter and anti-social schemes generated £15,955,400.67 benefit at a cost of £4,834,969.90 (benefit:cost ratio, or social return on investment, is £3.30). Figure 2.4 presents a simple infographic of the return-on-investment analysis.

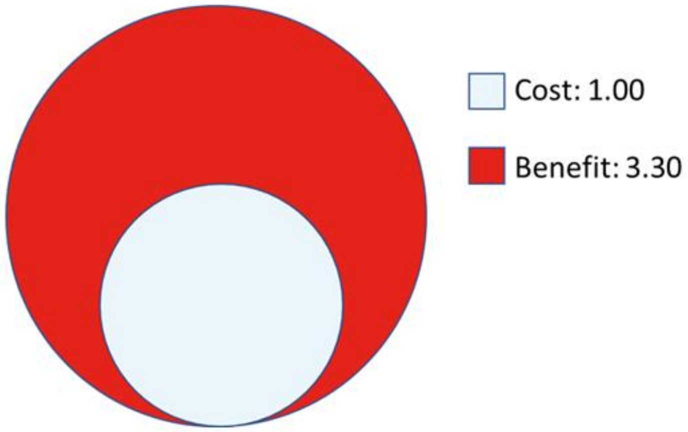


Figure 2.4: A Cost benefit visualisation of Fire setter and anti-social behaviour schemes.

Costs can be calculated for each FRS on an individual basis in a similar way by multiplying the number of hours x £27.55. Benefits can be calculated for each FRS on an individual basis by multiplying the input costs by £3.30.

ii) Fire, road and water safety education provision

For educational input and campaigns such as fire, road and water safety hours delivered in schools and in local communities, the appropriate TOMs is: NT8 Improved skills.

Costs (as described by the national TOMs):

Number of staff hours spent on local school and college visits e.g., delivering career talks, curriculum support, literacy, support, safety talks (including preparation time). This is the number of hours multiplied by the average cost of fire personnel time per hour at £19.00 (Greater Manchester Combined Authority, 2021 Unit Cost Database), plus on-costs to give £27.55.

Benefits:

In the absence of specific evidence that relates the input to an outcome, the social value approach supports the use of a proxy value. For this indicator, within the National TOMs database this proxy covers the value of the time provided by the person providing support and is based on a generic replacement cost for the wage of the individual. In this case, the average cost of fire personnel time per hour at £19.00 (Greater Manchester Combined Authority, 2021 Unit Cost Database) plus on-costs to give £27.55 is used. Hence, the social return on investment for this activity is £1 for every £1 of input.

Comment: This figure appears low on first observation, and we would not want to diminish the importance of these safety campaigns. The reason behind the low figure is likely to be a lack of systematic evaluation and recording of activities, rather than an actual lack of impact.

iii) Fire Cadets

For schemes that lead to a recognised vocational qualification the relevant TOMs is: NT9 Training opportunities.

Costs*:*

Number of weeks of training opportunities leading to a recognised qualification (e.g., BTEC, City & Guilds, NVQ, HNC) that have been completed during the year. This is number of hours of training delivered, multiplied by the average cost of fire personnel time per hour at £19.00 (Greater Manchester Combined Authority, 2021 Unit Cost Database), plus on-costs to give £27.55.

Benefits:

The proxy value has been based on the current economic benefit to the individual and the annualised future lifetime value to society of achieving the qualification. The National TOMs database gives this value as £258.45 per week per student. This value is expressed in units of per week training per student. It is more likely that a cohort of students would receive the training at one time. The benefit per student would still be £258.45 per week but the input costs would need to reflect the simultaneous input to a group of students. The following example is given to demonstrate how this metric could be applied in practice.

Example: If over a year there is the equivalent of four (37 hour) weeks of training (i.e., 148 hours) delivered simultaneously to a number of Fire Cadets, then the cost is 4 x 37 x £27.55 (the hourly rate of input) =4,077.40. The benefit per Cadet is 4 (weeks) x £258.45 = £1,033.80. If we assume that a cohort of 5 Fire Cadets are trained, then the total benefit for the five Cadets would be 5 x £1,033.80 = £5,169.00. This would give a social return on investment of 5,169.00 / 4,077.40 = 1.27. Figure 2.5 presents a simple infographic of the return-on-investment analysis. The benefit would be greater if more than 5 students are simultaneously trained. The above vignette is solely to demonstrate a potential use of this indicator; no publicly available data on the training of Fire Cadets across FRSs was available to apply the method in practice.

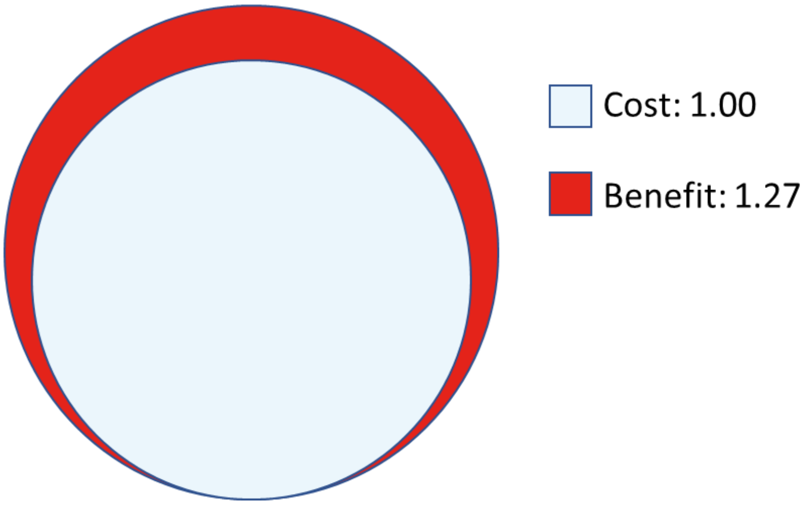


Figure 2.5: A Cost benefit visualisation of the Fire Cadet schemes.

Commentary on the use of the social value approach

This initial evaluation framework is proposed as a starting point for these activities. The nature of the inputs and social value outcomes could be refined in further work. In general, social value / SROI approaches are becoming more widely utilised in public services evaluations. This is entirely consistent with HM Treasury's guidance to include the wider social and economic benefits when evaluating public sector interventions, projects, and policies (HM Treasury's Green and Magenta Books). The approaches can be subjective, and success depends on the experience and judgment of experts to identify indicators and financial proxies, and to align those with views of stakeholders.

In addition, many interventions do not have detailed research evidence to underpin them or to help derive relevant proxy values. This is certainly the case with educational interventions such as safety talks and campaigns, where scholars have difficulties in isolating the educational input as being drivers of change and impact (reviewed in Reinhardt and Chatsiou, 2019). A recent systematic review of published work in this area (Senthilkumara et al., 2019) found that there were some short-term gains in knowledge following fire safety interventions delivered in educational settings to children. However, they noted that the studies were generally of low quality potentially leading to imprecision in the measured outcomes. Future studies should be designed to remedy these flaws. In addition, there is much to gain from conducting more studies in this area, with more detailed evaluations in practice to develop the evidence base. Houlston et al. (2018) for example, proposed several recommendations centred around a Safe and Well Standard Evaluation Framework. Overall, it is important to note that an absence of evidence should not result in an activity being stopped or curtailed. The implementation of a research framework to better understand the activity, through the collection of evidence is a more appropriate next step. Routine collection of data and its evaluation can also inform future research.

In terms of the social value approach to evaluation, many potential benefits from educational inputs are recognised for recipients. These include improving confidence, health, and interpersonal trust between the educators and the recipients in the community (Social Value UK, 2021b). Further research is warranted in this area before more robust values can be placed on these activities. This report, in line with the National TOMs guidance, has opted for a conservative approach and valued the impact to be equal to the input cost for fire, road, and water safety education activities.

2.3.4 Findings

From the analysis in the previous sections of prevention and protection activities and with reference to the literature and the relevant Fire Standards Board Standards, the following summary observations are made:

1. There is reasonably robust body of evidence regarding the economic and social value of home fire safety check visits. The key focus for future work is to develop the most effective strategies for targeted home visits. Work on the Definition of Risk project could inform these approaches.
2. Safe and Well Visits are implemented in a range of different approaches, but by inclusion of the essentials of a home fire safety check, then as a minimum they deliver the identified benefits and value as reported here. Given that Safe and Well Visits may include wider health and well-being advice they have the potential to yield further benefits and value. Development of these services together with recommended evaluation approaches e.g., the Safe and Well Standard Evaluation Framework

(Houlston et al. 2018), can be explored.

3. Audits/Inspections of commercial premises have demonstrated value by assessing the effect of unsatisfactory audit outcomes and follow-up actions.
4. Prevention education and campaigns including fire safety, road safety, and water safety can deliver value and further research and evaluations are needed in this area to better quantify the benefits.
5. There is an emerging literature and focus on the safety of children and young people in such prevention work. As with other prevention and protection activities, the use of risk information to target these activities is supported.

It should be noted that this study did not find data, or an appropriate method, to estimate the value of activities that provide Site-Specific Risk Information. Further work is required in this area.

2.4 Implementation of the methods to evaluate prevention and protection activities

It is envisaged that a reporting tool could be established at any level of the FRS to reflect prevention and protection activities. In summary, Table 2.16 shows the costs and benefits calculated for prevention and protection activities (specifically, targeted HFSCs, Unsuccessful audits, Fire setter/anti-social behavioural schemes and other campaigns and initiatives) reported over the years 2016/17 to 2018/19 across the FRSs in England.

Year	2016/17	2017/18	2018/19	Total	Average per year over 3 years
Costs (£)	40,650,337	49,125,764	25,191,266	114,967,367	38,322,456
Benefits (£)	116,041,805	117,397,177	94,676,836	328,115,818	109,371,939
Benefit: Cost ratio	2.85	2.39	3.39	n/a	2.85

Table 2.16: Prevention and protection costs and benefit values

(2018/19 figures are based on a reduced data set compared to previous years. Data not available in 2018/19 for the activities of Fire Setter and anti-social behaviour schemes and other campaigns and initiatives e.g., school education activity, road safety campaigns etc.).

Figure 2.6 shows how the methods could be implemented to value the prevention and protection activities of a single FRS. The Microsoft Excel sheet takes input values from routinely collected data and utilises the benefits ‘multipliers’ as estimated in the sections above.

Figure 2.6 Example Excel spreadsheet to calculate value from prevention and protection activities.

Fictitious 'Shire' FRS — Economic and social value of prevention and protection activities 2018/19

Activity	Number of events	Average cost per event (£)	Total cost (£)	Average benefit per event (£)	Total benefits (£)	Benefit:Cost ratio	
Number of targeted Home fire safety checks / Safe and Well visits (assuming average time of 4 hours per visit)	1,505	71.84	108,119.20	191.90	288,803.48	2.67	
Firesetter and anti-social behaviour schemes (assuming a minimum number of 70 hours per intervention)	3	1,928.50	5,785.50	6,364.05	19,092.15	3.30	
Number of Fire Cadet cohorts (assuming 5 cadets trained simultaneously over 148 hours)	1	4,077.40	4,077.40	5,169.00	5,169.00	1.27	
Other campaigns and initiatives e.g. school education activity, road safety campaigns etc. (assuming a minimum of 1 hour per event)	330	27.55	9,091.50	27.55	9,091.50	1.00	
Fire Safety Audits/inspections: number of unsatisfactory audits (assuming average time 5.58 hours per event)	206	153.73	31,668.38	638.24	131,477.23	4.15	
			158,741.98		**453,633.36**	**2.86**	**:1**
Fictitious (dummy) data	Data entry	Fixed values in this report - an FRS could update them with their own estimates	Autocalculated	Fixed values	Autocalculated	Autocalculated	

2.5 Conclusion

There is a detailed conclusion in Part One, covering the overall project to date, and this short conclusion will discuss Part Two. The headline conclusion is that most fire and rescue activities give a positive return on investment, and total benefits of £12.35bn.

However, for some activities, it is reasonable to state that the evidence base is not yet complete enough. One key set of activities falling into this category are safety campaigns. It is reasonable to assume that safety campaigns around water and road safety contribute significantly to our communities, but currently the evidence base for that is ssparce. Work by UK Fire and Rescue Services and the NFCC is under way to address this evidence gap, but the underlying requirement would be that consideration be given at the planning stages of safety campaigning for the measurement and recording of attributes relating to success, and appropriate methods of capturing such measurements be made.

Other considerations are the nature of targeting in Home Fire safety Visits, and whether more value can be delivered by a more systematic approach to that targeting. Again, work by the NFCC and UK Fire and Rescue Services is underway to investigate more precise geographic units for identifying vulnerable people, and to reduce the geographies to a household level if possible.

The improvement of data collection and empirical data on fire and rescue outcomes should directly feed into future evolutions of the assembled formula. For example, the 0.43 constant for damage to domestic dwelling fires, as used, is based on a midpoint between measurements from within two government documents, and ideally, this could be researched in more detail and a more defensible constant determined. The use of modelling or large-scale practical experiments may be able to provide empirical data to enhance input parameters in future formula.

It should be stated that a number of assumptions have been used throughout the varied calculations, yet the conservative approach of this project in only using data beyond the 3rd Standard Deviation, balances out assumptions and brings robustness to the projections.

Part Three:

Cost and Benefit of FRS Activities

3.1 Cost Benefit Calculations

In this section a cost-benefit calculation is made comprising all the benefit values derived in Part Two of the report. This includes the economic and social value of FRS responses to fire incidents, non-fire incidents and prevention and protection work. The net current expenditure for the FRSs in England in 2018/19 was £2,004.8bn Ministry of Housing, Communities and Local Government (2021). Applying this to the 2018/19 benefit estimate calculated in this report of £12.35bn, then an overall return of investment of 6.17:1 is estimated (details in Table 2.17). These returns on investments are calculated by dividing total benefits by total costs. They represent the average benefit generated through each pound of existing funding, not the additional impact of increasing or reducing the funding by one pound.

	Economic and Social Value (£)
	2018/19
Responses to fire incidents	
Saved property	4,344,253,503
Saved lives	5,283,714,066
Responses to non-fire incidents	
Flooding and rescue from water incidents	1,095,783,317
Making environments safe incidents	599,164,925
Spills and leaks incidents	335,999,513
Extrications incidents	544,710,024
Medical assistance incidents	63,685,570
Prevention and Protection activities	94,676,836
Total	12,352,522,014
Net current expenditure	2,004,800,000
Gross Return on Investment (Total ESV / Net current expenditure)	**6.17**

Table 2.17. Overall return on investment estimate

There is no study in the literature that is directly comparable to the one presented here. However, for context it is useful to place the calculated return on investment with ones from similar domains. For example, Schober et al. (2012) calculated a social return on investment

(SROI) based on the firefighting system of Upper Austria. They estimated the benefits from the perspectives of a wide range of stakeholders including industry, the public, insurance companies and others. They calculated a SROI value of 10.20:1.
Weinholt and Andersson Granberg (2015) evaluated first responder initiatives within the Swedish FRS. They reported a benefit:cost ratio of 8.00:1.

From a different domain, Elvic (2002) produced a cost–benefit analysis of ambulance and rescue helicopters in Norway. They reported a benefit:cost ratio of 5.80:1

Part Four:

Summary of Methods and Data Sources

The following Table presents further detail on the methods and specific data sources used in the analyses and serves to supplement Part Two of the report.

Section	Calculation	Field/variable/value	Data source	Evidence	Data years
FRS interventions in fire incidents	Value of saved property (0.43 * average building size in a region – square meters affected by the fire) x price of a square metre in that region	0.43	Mid-point of two published estimates of likely damage (16% and 70%).	Audit Commission (1995) and Home Office (2019).	N/A
		average building size in a region	Office for National Statistics (2021)		2021
		square meters affected by the fire	Download of IRS data		2011/12 to 2019/20
		average price of a square metre in that region	GOV.UK (2021)		2021
FRS interventions in fire incidents	Value of saved lives (Saved lives= $\alpha+\beta 1$firefighters+ $\beta 2$firealarm +$\beta 3$firesize)	Data on Saved lives, *firefighters*, *firealarm* and *firesize* taken from the incidents reported in the IRS.	Download of IRS data		2011/12 to 2019/20

Section	Calculation	Field/variable/value	Data source	Evidence	Data years
	See main text for details Value of a statistical life	All parameter values (*β_1* etc.) are derived from a multiple linear regression equation based on the data. Department for Transport's value of a road traffic fatality. This can be seen as a proxy for the cost to life in fire. The published DfT value for a fatality (over a lifetime) is £2,146,852. These costs include lost output, human costs and medical/ ambulance cost.	Department of Transport 2019 Tag Data Book, May, v1.12, Table A4.1.1 (adjusted for inflation)		2019
FRS interventions in non-fire incidents	Value of saved lives Saved lives= $\alpha + \beta_1$ *per* See main text for details.	Data on *Saved lives* and *per* are from the questionnaire. All parameter values (*β_1* etc.) are derived from a linear regression equation based on the data. The method is applied only to certain categories of cases where it is likely that people are at risk; and (b) we only look at the most severe cases in terms of	Bespoke questionnaire data on resources required to resolve a number of different incident scenarios Download of IRS data		Data collected in 2021 2011/12 to 2019/20

Section	Calculation	Field/variable/value	Data source	Evidence	Data years
		deployed personnel and time at the scene – see main text for details.			
	Value of a statistical life	DfT's value of a road traffic fatality. This can be seen as a proxy for the cost to life in fire. The published DfT value for a fatality (over a lifetime) is £2,146,852. These costs include lost output, human costs and medical/ ambulance cost.	Department of Transport, 2019 Tag Data Book, May, v1.12, Table A4.1.1 (adjusted for inflation)		2019
Prevention: targeted home visits (home fire safety checks or safe and well visits)	Change in the number of accidental dwelling fires (*ADFs*) associated with targeted home visits (*targHVs*) ADFst+1= α+β1ADFst+β2(targHVs t−targHVst−1)	Data on ADFs. Data on targeted home visits. The key parameter β2 is derived from the conditional change regression model. Cost of a dwelling fire	Home Office, 2021b, Fire Statistics Table 0202. Home Office, 2021a, Fire Statistics Table 1201. Greater Manchester Combined Authority, 2021 Unit Cost Database	Department for Communities and Local Government (2011).	2017-2020 2017-2020 2021

Section	Calculation	Field/variable/value	Data source	Evidence	Data years
		£53,498.			
Protection: audits/inspections of public sector and commercial properties	Change in the number of public sector and commercial properties (*NumFires*) associated with the number of premises deemed unsatisfactory and with follow-up actions (*Unsatis*) NumFirest+1= α+β1NumFirest+β2(Unsatist−Unsatist−1)	Data on fire in commercial and public sector buildings. Data on the number of premiseswith unsatisfactory audit outcome and follow-up action. The key parameter β2 is derived from the conditional change regression model. Cost of a dwelling fire £53,498.	Home Office download from IRS. Home Office, 2021c, Fire Statistics Table 1204. Greater Manchester Combined Authority, 2021 Unit Cost Database	Department for Communities and Local Government (2011).	2017-2020 2017-2021 2021
Prevention: Fire setter and anti-social behaviour schemes	Economic and social return on investment	Benefits: Financial proxies for reduced antisocial and dangerous behaviours and improved behaviours at home and at school. Costs Number of staff hours of staff time spent on the activity. Average cost of fire personnel time per hour at £19.00 plus on-costs.	National TOMs database: indicator NT24: Initiatives aimed at reducing crime. Home Office, 2019, Fire Statistics Table 1203. Greater Manchester Combined Authority, 2021 Unit Cost Database.	Ward and Thurston (2009). Department for Communities and Local Government (2011).	2019

Section	Calculation	Field/variable/value	Data source	Evidence	Data years
Prevention: education campaigns including fire safety, road safety and water safety	Economic and social return on investment	Benefits A benefits proxy equal to the cost of input. Costs Number of staff hours spent on local school and college visits e.g., delivering career talks, curriculum support, literacy, support, safety talks (including preparation time). Average cost of fire personnel time per hour at £19.00 plus on-costs.	National TOMs database: indicator NT8 Improved skills. Home Office, 2019, Fire Statistics Table 1203. Greater Manchester Combined Authority, 2021 Unit Cost Database.	Department for Communities and Local Government (2011).	2021 2019 2021
Fire cadets	Economic and social return on investment	Benefits The proxy value has been based on the current economic benefit to the individual and the annualised future lifetime value to society of achieving the qualification. The National TOMs database gives this value as £258.45 per week per student. Costs Example: if over a year there is the equivalent of four (37 hour) weeks of training (i.e., 148 hours) delivered simultaneously to a number of Fire Cadets then the cost is 4 x 37 x 19.00 = £2,812.00.	National TOMs database: NT9 Training opportunities.		2021

References

Arch, B.N. & Thurston, M.N. 2013. An assessment of the impact of home safety assessments on fires and fire-related injuries: a case study of Cheshire Fire and Rescue Service. Journal of Public Health, 35:2 2, 200–205. doi:10.1093/pubmed/fds068

Audit Commission. (1995), In the Line of Fire., H.M.S.O., London. ISBN 0118864041

Berrington, A. and Smith P. (2006). An Overview of Methods for the Analysis of Panel Data. ESRC National Centre for Research Methods Briefing Paper. Southampton: Economic and Social Research Council.

Carlson, J. A. (2005). The economics of fire protection: from the great fire of London to rural/metro 9th IEA discussion paper. London: Institute of Economic Affairs.

Chief Fire Officers Association (2015). A Service for the Future: 670,000 Opportunities to Add Value.

Clare, J., Garis, L., Plecas, D., & Jennings, C. (2012). Reduced frequency and severity of residential fires following delivery of fire prevention education by on-duty fire fighters: Cluster randomized controlled study. Journal of Safety Research, 43, 123–128.

Cutello, C.A., Hellier, E., Stander, J. & Hanoch, Y. (2020). Evaluating the effectiveness of a young driver-education intervention: Learn2Live. Plymouth: University of Plymouth. http://hdl.handle.net/10026.1/15396

Da, Z. and Huang, X. (2020). Harnessing the Wisdom of Crowds. Management Science, 66, pp. 1847- 1867.

Department for Communities and Local Government (2011). The economic cost of fire: estimates for 2008.

Department of Transport (2019). TAG Data Book, May 2019, v.1.2.

Elvik, R. (2002). Cost–benefit analysis of ambulance and rescue helicopters in Norway: reflections on assigning a monetary value to saving a human life Applied Health Economics & Health Policy, 1, 55-63.

Epp, D.A. (2017). Public policy and the wisdom of crowds. Cognitive Systems Research, 43, pp. 53-61.

Fire and Rescue Service Employers (National Employers England), the National Fire Chiefs Council (NFCC) and the Local Government Association (LGA) (2020). Fit for the Future: How fire and rescue services can improve to meet the challenges of the 21st century [Online]. Available at: https://www.ukfrs.com/fit-for-the-future?bundle=section&id=31960. [Accessed 5 January 2022].

FSO (2005). The Regulatory Reform (Fire Safety) Order 2005 [online]. Available at https://www.legislation.gov.uk/uksi/2005/1541/contents/made. [Accessed 10 September 2021].

GOV.UK (2021). UK House Price Index summary: September 2021 [Online]. Available at: https://www.gov.uk/government/statistics/uk-house-price-index-summary-september-2021/uk-house-price-index-summary-september-2021#access-the-data [Accessed 26 November 2021].

Greater Manchester Combined Authority. (2021). Unit Cost Database [Online]. Available at https://greatermanchester-ca.gov.uk/what-we-do/research/research-cost-benefit-analysis/ [Accessed 14 October 2021].

Greenstreet Berman (2010). Evaluation options for Fire and Rescue Service fire safety activities. London: Department for Communities and Local Government.

Greenstreet Berman (2013). Evaluation of Home Fire Safety Checks. London: Greenstreet Berman Ltd.

Guiso, L. & Sodini, P. (2013). Household finance: An emerging field. In Constantinides, G. M., Harris, M., Stulz, R. M. (Eds.), Handbook of the economics of finance (Vol. 2, Part B, pp. 799–1612). Elsevier.

Hewitt, M & Biermann, F. 2020. The social and economic value of the UK Fire and Rescue Services: a review and recommendations of methods and metrics to demonstrate value for money. UK National Fire Chiefs Council (NFCC).

HM Treasury (2014). Supporting public service transformation: cost benefit analysis guidance for local partnerships. London: HM Treasury.

Home Office (UK). (2019a). Detailed analysis of fires attended by fire and rescue services, England, April 2018 to March 2019, The Government Statistical Office, UK.

Home Office (2019b). FIRE1203: Fire and rescue authority campaigns and initiatives, by fire and rescue authority [online]. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file

/835120/fire-statistics-data-tables-fire1203-031019.xlsx [Accessed 6 September 2021].

Home Office (2021a). FIRE1201: Home fire risk checks carried out by fire and rescue authorities and partners, by fire and rescue authority [online]. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file

/1017817/fire-statistics-data-tables-fire1201-160921.xlsx [Accessed 7 September 2021].

Home Office (2021b). FIRE0202: Primary dwelling fires, fatalities and non-fatal casualties in dwellings by motive and fire and rescue authority [online]. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file

/1009812/fire-statistics-data-tables-fire0202-120821.xlsx [Accessed 7 September 2021].

Home Office (2021c). FIRE1204: Fire safety returns, by fire and rescue authority [online]. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1017819/fire-statistics-data-tables-fire1204-160921.xlsx [Accessed 18 July 2022].

Home Office (2022). Emergency Evacuation Information Sharing (EEIS) consultation [online]. Available at: Impact Assessment (publishing.service.gov.uk) [Accessed 26 July 2022].

Houlston, E., Devereux, G. & Bell, L. (2018). Safe and Well Standard Evaluation Framework Pilot Report. London: National Fire Chiefs Council.

IBM Corp. (2019). Released 2019. IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp.

Kniesner, T.J., and Viscusi, W.K. (2019). The Value of a Statistical Life. Oxford Research Encyclopedia of Economics and Finance. Oxford University Press.

Mannes, A. E., Larrick, R. P., & Soll, J. B. (2012). The Social Psychology of the Wisdom of Crowds. In J. Rosenthal, JS. (2006) A First Look at Rigorous Probability Theory 2nd Edition, World Scientific

Ministry of Housing, Communities and Local Government (2021). Local Government Financial Statistics England No.31 2021 [online]. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/999747/Local_Government_Financial_Statistics_England_No.31_2021.pdf [Accessed 12 August 2022].

National Audit Office (2019). NHS Ambulance Services [Online]. Available at https://www.nao.org.uk/report/nhs-ambulance-services/# [Accessed 5 January 2022].

Office for National Statistics (2019). Activities, spending and productivity in the Fire and Rescue Services since 2009. London: Office for National Statistics.

Office for National Statistics (2021). Admin-based statistics for property floor space, feasibility research: England and Wales [Online]. Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/housing/methodologies/adminbasedstatisticsforpropertyfloorspacefeasibilityresearchenglandandwales#geographical-analysis-of-median-floor-space [Accessed 26 November 2021].

Plimmer G. (2019). 'Sole outsource bidders win more public sector contracts', Financial Times, 13 January 2019,

Qualtrics (2021). Qualtrics, Provo, UT, USA. https://www.qualtrics.com

Reinhardt, G.Y. & Chatsiou, K. (2019) Using community education interventions to build resilience and avert crises: how accidental dwelling fires decreased in Essex County, UK, Local Government Studies, 45:3, 394-412, DOI: 10.1080/03003930.2019.1573729

Rosenthal, J.S. (2006). A First Look at Rigorous Probability Theory 2nd Edition, World Scientific.

Schober, Christian/More-Hollerweger, Eva/Rauscher, Olivia (2012): SROI-Analyse für die Feuerwehren in Oberösterreich. Wien: NPO-Kompetenzzentrum, WU. In: Simsa, R., Herndler, M. and Trotter, M. (2015). Meta-Analysis of SROI Studies – Indicators and Proxies, TSI Working Paper Series No. 6. Seventh Framework Programme (grant agreement 613034), European Union. Brussels: Third Sector Impact.

Senthilkumaran M, Nazari G, MacDermid JC, Roche K & Sopko K. (2019) Effectiveness of home fire safety interventions. A systematic review and meta-analysis. PLoS ONE 14(5): e0215724. https://doi.org/10.1371/journal.pone.0215724

Social Value UK (2021a). What is Social Value [online]. Available at https://socialvalueuk.org/what-is-social-value/ [Accessed 15 October 2021].

Social Value UK. (2021b). Quantifying the Impact of Investment in Education [online]. Available at https://socialvalueuk.org/resource/quantifying-impact-investment-education/ [Accessed 15 October 2021].

Social Value Portal (2021). The TOMs Measures Handbook [online]. Available at https://socialvalueportal.com/wp-content/uploads/2021/04/TOMs_measures_handbook_issued_v1.0_210222.pdf [Accessed 15

October 2021].

Steed, S. and Nicholles, N. (2011). Small slices of a bigger Pie: Attribution in SROI [online]. Available at https://socialvalueuk.org/wp-content/uploads/2016/09/Small_Slices_of_a_Bigger_Pie1-SROI-REPORT.pdf [Accessed 15 October 2021].

Sund, B., Bonander, C., Jakobsson, N. and Jaldell, H. (2019). Do home fire and safety checks by on-duty firefighters decrease the number of fires? Quasi-experimental evidence from Southern Sweden. Journal of Safety Research 70, 39-47.

Tannous, K.W., Whybro, M., Lewis, C., Ollerenshaw, M.,Watson, G., Broomhall, S., & Agho, K. E. (2016). Using a cluster randomized controlled trial to determine the effects of intervention of battery and hardwired smoke alarms in New South Wales, Australia: Home fire safety checks pilot program. Journal of Safety Research, 56, 23–27.

Taylor, M., Appleton, D., Keen G., & Fielding, J. (2019) Assessing the effectiveness of fire prevention strategies, Public Money & Management, 39:6, 418-427, DOI: 10.1080/09540962.2019.1579439

Ward, F. & Thurston, M. (2009). RESPECT: a personal development programme for young people at risk of social inclusion. Chester: University of Chester.

Weinholt, A., & Andersson Granberg, T. (2015). New collaborations in daily emergency response: Applying cost-benefit analysis to new first response initiatives in the Swedish fire and rescue service. International Journal of Emergency Services, 4(2), 177–193.

Williams, N., Evans, R., Rogers, A. and Wright. M. (2009). Final Evaluation of the Home Fire Risk Check Grant and Fire Prevention Grant Programmes. Fire Research 2/2009 Department for Communities and Local Government.