Economic Evaluation of Fire and Rescue Service Activities: A Scoping Review

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BACKGROUND

Over the past two decades, the number of fires attended, and fire related fatalities have significantly reduced due to prevention and protection work (Bryant & Preston, 2017). In 2013, an independent review of efficiency and operations in fire and rescue authorities in England concluded that with fire related incidents at an all-time low whilst expenditure remained relatively stable, there was room for reconfiguration within the service to increase efficiency and effectiveness (Knight, 2013). In the decade since this 'Facing the Future' report was published, there have been substantial funding cuts across the public sector, requiring agencies to do more with less. For example, for standalone fire services, government funding reduced by £137 million between 2010-2020 (Local Government Association, 2019). In contrast, the UK is starting to experience the effects of climate change, with the frequency, intensity, and impact of extreme weather events expected to worsen, resulting in increased flooding, wildfires, heatwaves, and droughts (Met Press Office, 2022; Wentworth, 2021). Preparation, response, and recovery for these events will place added demands on finite emergency service resources.

The need for robust economic analysis is becoming increasingly important for both demonstrating efficiency and effectiveness of service delivery, and for providing evidence to inform decisions regarding use of finite resources. In recognition of this, the National Fire Chiefs Council (NFCC) are undertaking a project to examine the 'Economic and Social Value of the UK Fire Service', which aims to "*provide the UK Fire and Rescue Service with the ability to consider the economic and social value of their activities when planning*"[1]. This project is taking a bottom-up approach, with existing fire service data being used to produce a report that will provide an important overview of the value of the fire service to the UK public and economy. However, as other recent evaluations of fire service response highlight, there are likely to be gaps and inconsistencies in existing data across regions that will affect the completeness and comprehensiveness of this economic modelling (Waring et al., 2022).

To complement the NFCC Economic and Social Value project, this report details the findings of a top-down approach. We have used a systematic and rigorous scoping review method to address the following question: *'what economic modelling work has been published in relation to fire service activities, both in the UK and internationally?'*. The review aims to provide a balanced assessment of what is currently known about the economic value of fire sector activities to serve as an evidence based empirical map. This report details the findings, highlighting the current state of knowledge and assessing the evidence quality and implications for knowledge claims. Findings are beneficial for the fire service in a) providing an evidence base to inform discussions regarding the future of the sector and preparing for future events of national significance, b) identifying knowledge gaps for commissioning research to inform future practice, and c) informing discussions regarding improving data collection and evaluation across the sector to demonstrate effectiveness and impact.

METHOD

We conducted an extensive search of academic and grey literature published between January 2010 and May 2022 to identify any work that focused on economically modelling fire service activities in the UK or internationally. Due to the lack of systematic focus directed to synthesising knowledge of the economic value of fire service activity, we adopted a scoping review method, a type of research synthesis that maps literature relating to a particular topic

[1] https://www.nationalfirechiefs.org.uk/EVoFRS

to identify key concepts, gaps, and sources of evidence to inform policy and practice. The scope of the research question was determined through discussion with members of the NFCC to complement work underway as part of the Economic and Social Value of the UK Fire Service Project. Table 1 highlights details of the inclusion and exclusion criteria used to address the following question: *'what economic modelling work has been published in relation to fire service activities, both in the UK and internationally?'*.

The literature search strategy was structured using the 'Population, Intervention, Comparator, and Outcome' framework (Falzon et al., 2010). The search strategy sequence was as follows: {Fire and Rescue Services} OR {Fire Service} OR {Fire station} OR {Firefighters} AND {Organisational Response} OR {Operational Response} OR {Strategic Response} OR {Protection Strategies} OR {Prevention Strategies} OR {Multi-agency} OR Partnership OR Collaborat* AND Cost OR Financial OR {Social Value} OR Economic OR {Cost-benefit} OR {Cost-utility} OR {Cost-effectiveness} OR {Return on Investment} OR {Social Return on Investment}.

Table 1. Inclusion and exclusion criteria for scoping review

Population	Fire and rescue service
Inclusion criteria	• Academic or grey literature focusing on emergency response relating to activities performed by fire and rescue services. • Includes empirical data (either qualitative or quantitative) that measures economic impact of organisational responses of fire and rescue services, or any information that may assist in establishing economic costs • Published in the UK or internationally • Written in English • Only sources where the full-text version is openly accessible online or through University of Liverpool subscriptions to databases
Exclusion criteria	• Does not focus on activities of fire and rescue • Does not include empirical data that examines any aspect of the activities of fire and rescue or economic costs • Not available in English • Full-text version is not readily available

As economic evaluation of fire service activity is a multidisciplinary topic, the following range of databases were searched: Scopus, Web of Science, PsycInfo, Science Direct, Econlit, and Google Scholar. The Fire Department Economic Impact Think Tank also provided access to their shared Google Docs platform where academics and professionals from across the fire sector upload papers and reports they have produced or accessed relating to economic modelling of fire sector activities. The reference lists of all relevant papers were also reviewed to check for other potentially relevant sources. References for papers included in the review were entered into the Social Science Citation Index to identify and screen other work that had referenced the article for inclusion. In addition, we e-mailed national fire bodies across Ireland, Scotland, Europe, USA, Australia, and New Zealand requesting reports that focus on economic evaluation of fire sector activities. A response was received from New Zealand to express interest in this scoping review, but no country provided documents of relevance.

In line with guidance from Peterson et al. (2017), we adopted a systematic approach for screening literature for inclusion in the scoping review. CB conducted the initial screening of titles and abstracts against the predetermined inclusion / exclusion criteria. If relevance was unclear, the full article or report was downloaded and read. The full version of all sources identified as potentially relevant during the initial screening were then downloaded and read to determine their relevance (see Figure 1). This resulted in 32 academic articles and reports being initially identified as potentially relevant for inclusion. Inter-rater reliability was then conducted, with SW and SG independently reading and reviewing these documents. This resulted in 93% agreement, and 100% agreement after discussion.

In total, 23 academic papers and reports were identified as relevant to include in the scoping review. Data was extracted from across these sources using a systematic approach to improve consistency, method transparency, and quality assessment of strengths and weaknesses of studies. We developed a data extraction form based on PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). Study quality was assessed using the Joanna Briggs Institute (2017) Checklist for Economic Evaluations. Quality assessment was undertaken by CB in consultation with SW and SG.

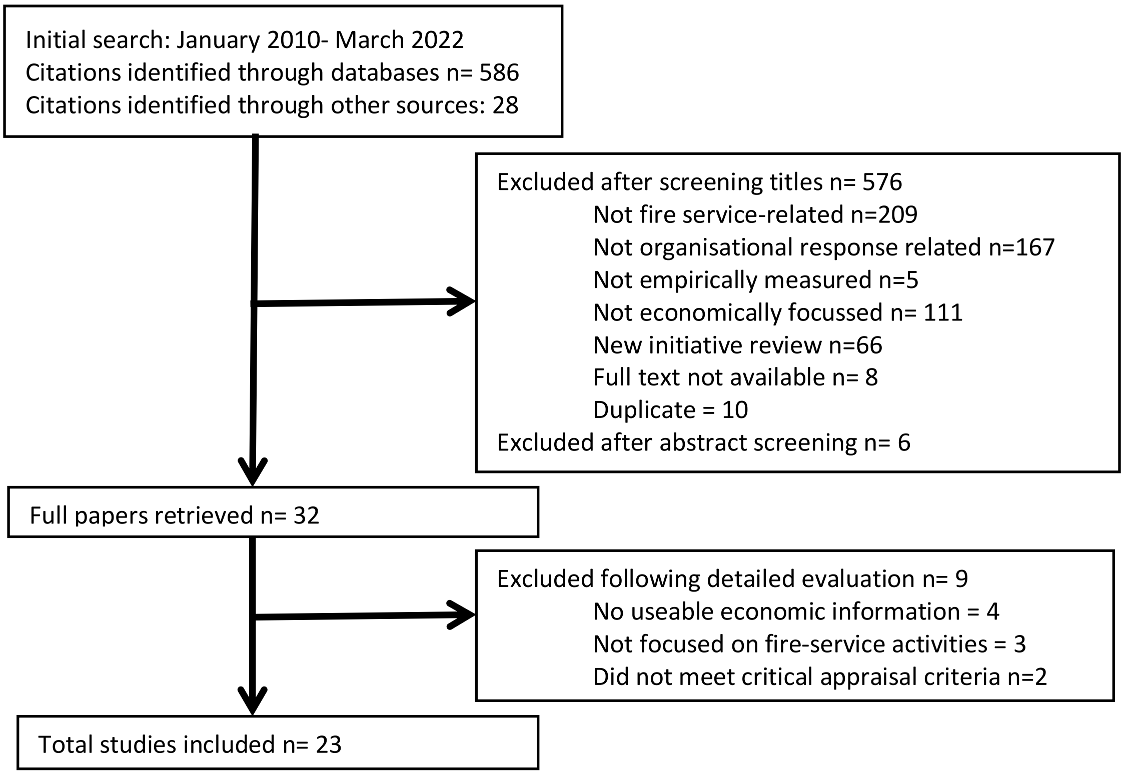

Figure 1. Flow diagram of study selection, adapted from "Moher et al. (2009). Preferred items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Medicine, 6*(7).

RESULTS

1. Overview of focus, methods, and measurement types used across sources included in the scoping review

Most of the 23 sources included in the scoping review utilised quantitative data only but a small number also (N = 3) utilised qualitative data. This included a structured expert judgement exercise (Ashe et al., 2011), surveys, and semi-structured interviews (Tannous et al., 2017). Most quantitative data were gathered from emergency service records, but two studies also used Willingness to Pay measures to quantify costs (Mavsar et al., 2012; Roman et al., 2013). In total, 20 sources focused on western countries (USA, N = 6; Sweden, N = 4; Canada, N = 3; UK, N = 3; Spain, N = 2; Europe, N = 1; Western Countries, N = 1) and three were focused on fire service activity in Australia.

Areas of activity that economic models were applied to varied but predominantly focused on prevention (N = 10) and suppression (N = 7). Most sources focused solely on the fire service (N= 16), but a smaller number examined activities involving collaboration with health services (N= 4), and other agencies (N = 3), including security officers (Weinholt & Granberg 2015), government bodies (Aldag et al. 2020), and multiple agencies such as health, police, data protection, and project managers (Higgins et al. 2015). Table 2 provides an overview of methods, area of activity, and whether unit costs were provided in sources.

Methods of analysis varied across sources and included cost effectiveness and cost-utility analysis (N = 11; comparing the costs and effects of alternative interventions), cost-benefit analysis (N = 6; comparing the costs and benefits of an intervention), and general cost analysis (N = 5; stating actual costs without making comparisons); one study focused on socio-economic status rather than costs (Higgins et al., 2015)[2]. The measures used to quantify costs varied substantially across studies and have been categorised into 16 distinct types to provide an overview of the measures previously deemed relevant to include in economic models (see Table 3). The most common categories of measures used were losses/damages (N=17), time sensitive costs (N=13), and direct fire service costs (N=13).

Due to the range of populations, focus, evaluation methods, and measures used, we were unable to make direct comparisons between economic figures calculated across different studies. Accordingly, we are unable to consider the reliability of economic models, nor to make comparisons between different fire service activities and interventions delivered in different regions to consider whether some modes of delivery are more cost effective than others within contexts. Instead, we have conducted a narrative synthesis, using an interpretive approach to synthesise meaning across studies (Gough et al, 2012; Harden, 2010), with findings discussed in section two below.

Table 2. Methods of analysis, areas of activity, and unit costs provided across publications

Reference	Country	Method	Area of activity			Unit cost
			Fire prevention	Fire suppression	Other	
Aldag et al. (2020)	USA	Cost-effectiveness			✓	Not available
Ashe et al. (2011)	Australia	Cost-utility	✓	✓		Not available
Bel & Belerdas-Castro (2021)	Spain	Cost-benefit			✓	Not available
Craig et al. (2015)	Scotland	Cost-benefit	✓			£231 net savings per client due to intervention - prevented 4.4 fires (£32,390 saved per fire prevented)
Delorme & Waterhouse (2021)	Canada	Cost-utility	✓			Not available
Delorme & Waterhouse (2018)	Canada	General cost		✓		Total cost of the operation for the fire service was calculated at 253,644.12 CAD

[2] For further information on types of economic analysis, see Turner, H. C. et al. (2021). An introduction to the main types of economic evaluations used for informing priority setting and resource allocation in healthcare: Key features, uses and limitations. *Frontiers in Public Health*. https://doi.org/10.3389/fpubh.2021.722927

Delorme & Waterhouse (2017)	Canada	Cost-utility		✓		Cost savings of 433.6M CAD in 2017 due to fire suppression efforts
Gerbert & Black (2012)	USA	Cost-effectiveness		✓		$1805 per acre for direct suppression, $998 for modified suppression, and $747 for limited suppression
Geneva Association (2014)	13 Western Countries	General cost	✓			Not available
Hall (2010)	USA	General cost	✓			Total cost of fire is estimated at $347 billion = ~2.5% of US GDP
Harvey et al. (2020)	Australia	General cost			✓	Not available
Hawkins et al. (2014)	USA	Cost-utility		✓		Cost savings of $720M in GDP and $196M in RDPI
Heines et al. (2018)	USA	Cost-benefit	✓	✓		Optimal prevention management costs $65mil in prevention and $42M in suppression
Higgins et al. (2015)	UK	No cost focus			✓	Not available
Holmgren & Weinholt (2016)	Sweden	Cost-utility			✓	Overall cost per year per capita spending for FRS in Sweden = 917 SEK (2012)
Mavsar et al. (2012)	Multiple European Countries	Cost-utility				Not available
Roman et al. (2013)	Spain	Cost-utility	✓			No costs outlined
Sund et al. (2012)	Sweden	Cost-benefit			✓	Total costs for prevention = €8.1M
Sund et al. (2019)	Sweden	Cost-utility	✓			Total benefit costs due to prevention in 2015 = SEK 9.8M for all fires and SEK 13.2M for developed fires
Tannous et al. (2017)	Australia	Cost-benefit	✓			Annual average cost of fire to the community = $535,622,000
Taylor et al. (2019)	England	Cost-effectiveness	✓			Fire prevention spend per head of population in 2016 was £16.11
Weinholt & Granberg (2015)	Sweden	Cost-benefit		✓		Average yearly benefit of $24,600 due to intervention by security officers
Zhuang et al. (2017)	USA	General cost			✓	Total cost of fire in 2014 = $328.5 billion ~1.9% of GDP (expenditure = 273.1 billion, loss = $55.4 billion)

Table 3. Types of measures included in economic models across studies

Category of measure	Explanation of categories with examples from sources	Frequency
Overall Cost	An overarching financial figure for all fire and related services is provided but does not include a cost breakdown. For example, Hall et al. (2010) refer to 'money spent on prevention' as a single figure without demonstrating how this was arrived at by detailing each resource and its cost.	10
Deaths/injuries/ general health	Measures that include number of deaths, injuries (number and type) and health outcomes (NHS costs, number of hospitalisations etc.).	11
Losses/ damages	Any monetary losses from fires and general damages. For example, Heines et al. (2018) record the number of trees burned and Hawkins et al. (2014) record the number of jobs lost.	17
Time sensitive costs	Measures that can change in value depending on time. For example, response times of fire services (Holmgren & Weinholt 2016), vegetation recovery time (Roman et al., 2013), and duration of operation (Delorme & Waterhouse, 2018).	13
Travel	Measures relating to travel, including duration, travel costs, and fuel costs.	2
Equipment/ resources used	Measures involving type and amount of equipment / resources used by fire and related services. For example, quantity of emulsifying agent (Delorme & Waterhouse,2018), amount and cost of fire alarms (Tannous et al. 2017), or medical kits (Weinholt & Granberg 2015).	12
Other-agency workload	Measures that include aspects that do not relate to fire service costs or activities. For example, NHS staff administration tasks (Craig et al. 2015) and turn-out costs for security officers (Weinholt & Granberg, 2015).	6
Intervention development costs	Measures relating to creation of an intervention/activity. For example, education and training (Weinholt & Granberg 2015), marketing of a pilot program (Tannous et al. 2017), and costs of intervention implementation (Delorme & Waterhouse 2017).	6
Avoided costs/damages	Any costs or damages that did not take place because of the actions of the fire service or related agencies. For example, number of fires avoided due to prevention measures (Craig et al. 2015).	4
Type of response	Measures that compare the financial costs of different responses. For example, comparing active or passive prevention (Delorme & Waterhouse 2021), or level of management strategies (Gebert & Black 2012).	2
Number of fires	Measures quantifying the number of fires taking place in a specified time frame.	4
Insurance	Measures that relate to costs of insurance or number of insurance claims made due to fire/fire services.	2
Repair costs	Measures that focus on the cost of repairing damages or restoration after fires/fire service activity, including reconstruction (Mavsar et al. 2012) and maintenance costs (Sund et al. 2012).	3
Local economy	Measures relating to local economy. For example, average personal income or employment number (Hawkins et al. 2014).	11
Flow of goods and services	Measures that relate to changes in flow of goods and services due to fire and fire service activities. For example, measuring the effect of wildland fire on usual human benefits from that area such as crops (Mavsar et al. 2012).	2
Direct fire costs	Other costs directly incurred by the fire service aside from equipment. For example, staff wages (Sund et al. 2019).	13

2. Overview of common themes from across sources

Across the 23 sources, consideration was given to various aspects of costs, including establishing financial savings made because of prevention and suppression activities introduced, losses that could be avoided, or noting interventions that could be introduced to save costs. The following six recurring themes were identified and are discussed in further detail below: i) Fire Prevention; ii) Fire Suppression; iii) Risk Assessment; iv) Collaboration; v) Forecasting; vi) Indirect Impacts/Costs.

i) Fire prevention

Ten sources focused on fire prevention activities. Whilst a wide range of activities can be implemented under a fire prevention strand, such as safety checks, education, and provision of specialist equipment, many sources did not provide specific details about what activities had been under focus within the economic model. Where such information was provided, the focus was predominantly on home fire safety checks (HFSCs).

For example, two studies provided cost-benefit analyses of HFSCs in Sweden (Sund et al., 2019) and Australia (Tannous et al., 2019). Despite taking place on different sides of the world, these interventions were similar and consisted of firefighters conducting home visits to identify possible fire hazards (including locating candles and flammable equipment), install smoke alarms and provide other materials (fire blankets and fire extinguishers), and offer general fire safety information. Both studies aimed to establish whether the benefits of implementing HFSCs in terms of preventing potential fires outweighed the costs of providing this service to households. In Sweden, Sund et al. (2019) studied the intervention across a 5-year period (2010-2015) and found a cost benefit ratio of 8.2-11.1, preventing 17 fires and 11 developed fires per year, equating to cost savings of SEK 23 million (around £1.9 million GBP). In Australia, the HFSC was introduced as a pilot scheme and the total deployment of the HFSC pilot cost $296,213 AUD (around £168,000 GBP), with a cost per house of $1371 (~£780 GBP). Tannous et al. (2019) concluded that providing the intervention to 1% of households saved between $4.20 to $12.51 (~£2 to £7) for every dollar spent on the intervention. However, when the intervention was provided to more that 5% of homes, the cost-of-service provision outweighed the savings from fire reduction.

Whilst both studies focused on applying costs to HFSCs and fire prevention, the measures used to establish total service costs differed. Tannous et al. (2019) considered a wide range of costs incurred including staff uniforms, travel, and accommodation/food, whereas Sund et al. (2019) only included the cost of firefighter salary and equipment provision. These inconsistencies in what was included in costs prevents direct comparison and affects ability to generalise figures to other contexts. This poses implications for developing a robust evidence base to inform decisions regarding investment in prevention. One UK study also included analysis of HFSCs but focused on collaboration with health services (Craig et al. 2015). More information on this is provided in the 'Collaboration' theme below.

The remaining seven sources did not specify the activities involved in prevention efforts. Instead, they provided overall costs of prevention as a single figure. For example, Delorme and Waterhouse (2021) stated an average spend of $227,719 CAD for fire prevention activity within Laval Fire services, and between $27,242 CAD and $47,962 CAD for MRC de La Matapedia Fire Services. However, they did not provide details of what fire prevention activities were included, nor any information on the measures used to arrive at these cost figures. This lack of transparency prevents judgements from being made about the reliability of figures and findings from being applied or compared to other contexts.

ii) Fire Suppression

Five sources focused on fire suppression activities, examining the costs of putting out fires and minimising their damage. Across sources, a wide range of styles of suppression management were examined, with most adopting a case study approach. Studies focused on economically evaluating the cost of responding to a fire, reduction in response times, forecasting the impact of lack of intervention, and response to wildfires.

For example, Delorme and Waterhouse (2018) conducted a cost analysis of the operational response of Service de Securitie Incendi de Montreal to a truck crash and subsequent fire, providing a detailed breakdown of the costs associated with responding to this single fire. They included amount of emulsifying agent (extinguisher), number of firefighters present, and type of vehicle required with running costs, calculating the total cost to be $253,644.12 CAD (~£160,000 GBP). They also considered the indirect impacts of the crash and fire, recording time of operation and the subsequent financial impact of people being stuck in traffic caused by the crash and therefore unable to attend their jobs. This topic will be considered in further depth in the 'Indirect Impacts/Costs' theme below.

In the US, one study focused on the economic impact of reducing the time taken to respond to fire call outs. Weinholt and Granberg (2015) examined the introduction of a collaborative initiative whereby security officers were trained to initiate suppression activities if they were able to reach a call out before the fire service. Across seven instances where security officers arrived at the fire before firefighters, there was a cost saving of ~$61,000 USD (~£50,000 GBP) due to reduced damages/losses, with an average yearly benefit of ~$25,000 USD (~£20,000 GBP). Another US study focused on callouts for Orange County Fire Rescue, including whether the fire was or was not active when firefighters arrived (Hawkins et al. 2014). Hawkins et al. examined potential impacts to the local economy had the fire service not intervened. This study is covered in more detail in the 'Forecasting' theme below.

Finally, two US studies focused on response to wildland fires. Gebert and Black (2012) compared different strategies of fire suppression and their subsequent economic impact. They compared the cost per acre of different levels of intervention, including direct suppression (aggressive firefighting), and modified suppression (seeking control of the fire but not necessarily minimising the burned area). The study did not provide a detailed breakdown of what activities and resources were used for each approach, instead giving an overall average cost, with direct suppression costing $1805 USD per acre (~£1500 GBP), and modified suppression $998 USD per acre. (~£800 GBP). In contrast, Heines et al. (2018) compared the economic impact of using prevention and suppression efforts simultaneously or alone. The prevention strategy they investigated was fuel treatment prevention, but no further information was provided for this or for suppression strategies. They found that if prevention management was not used, an average of $236 million USD (~£190 million GBP) would be spent on fire suppression over 50 years. When optimal prevention management was implemented, the average spend over 50 years was $42 million USD (~£33 million GBP) for suppression and $65 million USD (~£52 million GBP) for prevention, equating to a total of $107 million (~£85 million GBP).

iii) Risk assessment

Six sources considered the use of risk assessments for targeting prevention activities to ensure spending efficiency and effectiveness. Low socioeconomic status was associated with higher fire risk for both dwelling fires (Craig et al. 2015) and wildland fires (Roman et al. 2013), indicating the importance of targeting prevention activities in these higher risk areas. In Australia, both socioeconomic status and previous historical residential fire incident data (2007-2012) was used to identify one urban and one rural area to target during the HSFC pilot scheme (Tannous et al., 2019). As detailed in the 'Fire Prevention' theme above, findings highlighted that focusing on 1% of people in high-risk areas is cost effective but increasing the rollout to include areas at lower risk leads to overspending and fewer benefits. Findings from a study by Taylor et al. (2019) conducted in the UK further support the idea that targeting prevention activities toward groups at higher risk from fire, such as the elderly, is more cost and resource effective and has greater benefits.

iv) Collaboration

Six sources referenced collaborations between the fire service and other agencies, predominantly focusing on three areas: i) fire service aiding health service, ii) collaboration between health and fire to provide a new service, and iii) other agents aiding the fire service.

Fire service aiding the health service: Three sources discuss support fire services provide to ambulance services. In Sweden, Holmgren and Weinholt (2016) detailed the support the fire service was providing in responding to ambulance callouts where they were able to arrive quicker, thereby reducing response time and allowing basic first aid to be administered quicker. The study describes changes in policy so that rather than receiving all ambulance callouts, the fire service is only notified if it is a particularly severe case. This policy change has not resulted in cost savings, but the authors highlight that response times have been reduced, which is beneficial for aiding in life-threatening situations.

In contrast, Sund et al. (2012) and Hollenberg et al. (2009) examined instances of suspected out-of-hospital cardiac arrest (OHCA) in Sweden. The scheme involved the fire service receiving callouts at the same time as the ambulance service and providing defibrillation if they arrived on scene first. As part of the scheme, 43 defibrillators were distributed across fire stations in Stockholm. Firefighters assisted in providing cardiopulmonary resuscitation for 94% of OHCA cases in 2005 and were first on scene in 36% of cases (Hollenberg et al., 2009). The total project costs amounted to €8.1 million. Results of a cost-benefit analysis estimated an additional 16 lives were saved per year and that for every €1 spent, there was a €16 saving (prices are from 2007).

Collaboration between health and fire to provide a new service: Craig et al. (2015) provided an economic evaluation of a new fire safety risk assessment initiated by Scottish Fire and Rescue Service and NHS Tayside. As part of the scheme, after receiving an initial risk assessment by a healthcare practitioner, high-risk patients are forwarded to a Community Fire Safety Link Worker to receive relevant fire safety assistance. This can include providing information, advice on fire exits, and provision of necessary equipment including smoke alarms and fire-resistant bedding. Prior to introducing the programme, the average number of fires a year was 14.6, which reduced by 4.4 after the introduction of the programme to 10.2. Craig et al. calculated a cost saving of £143,061 in total (£286 per client). The cost of the service was estimated at £55 per client, which when deducted from the savings results in a total savings of £231 per client visited during the risk assessment. These results assume an average cost of fire; when the lowest cost of fire is applied (25% lower saving per dwelling fire avoided), this equals £24,290 and results in around £160 cost savings per client.

Other agents assisting the fire service: Two studies provide examples of other agencies supporting fire service activities. As noted in the 'Fire Suppression' theme above, Weinholt and Granberg (2015) economically evaluated a collaboration between the fire service and security officers in Sweden, which resulted in reduced response times and an average yearly benefit of ~$25,000 USD (~£20,000 GBP). The cost for providing this assistance mostly comprised of training materials, which equated to approximately $3870 USD (~£3100 GBP). The authors noted that the collaboration may have been particularly affective because security officers had good knowledge of the local area and keys to many buildings. With security officers being able to regularly communicate with residents, they also supported prevention work through engagement with young people and other social groups.

In contrast, Harvey et al. (2020) outlines a research plan for a future study into health impacts and economic costs of residential fires in New South Wales (NSW). The study plans to use data from seven sources to develop a more comprehensive picture of the impacts of residential fires and individual casualty pathways through a fire event. Data sources will include: i) The Australian Computer Aided Dispatch system, which records all emergencies requiring fire or ambulance attendance; ii) the NSW Ambulance dataset including data from patient healthcare records and electronic medical records; iii) the NSW Emergency Department Data Collection; iv) the NSW Admitted Patient Data Collection to identify residential fire-related hospital admissions; v) The Agency for Clinical Innovation NSW State-wide Burn Injury Service Registry; vi) NSW Registry of Birth, Deaths, and Marriages; and vii) Australian Bureau of Statistics Cause of Death Unit Record File.

v) Forecasting

Eight sources used a prediction or estimation of what could have happened without fire service intervention to examine the economic value of fire service activities. For example, Delorme and Waterhouse (2017) gathered data on all commercial building fires intercepted by the Sherbrooke Fire Department in Quebec, Canada in 2017 (12 different fire incidences in total). Economic impact was assessed through comparing outcomes from across 300 simulations using the Quebec input-output model (Institut de la Statistique du Quebec). The authors concluded that for every $1 CAD invested into the fire department, the local economy has seen a $2,168 CAD return, which equated to a total economic value of $433.6 million CAD in 2017. This total value includes $368.8 million saved through businesses being able to remain open, 1,917 jobs and eight lives being saved (with the average human life being valued at $8.1 million CAD). Similarly, as mentioned in the 'Fire Suppression' theme above, Hawkins et al., (2014) forecasted the economic impact of Orange County Fire Department intervention to have saved $720 million USD (~£573 million GBP) in GDP and 8,742 jobs. Other sources where forecasting was present include Craig et al. (2015) with their review of the Link Worker collaboration with Scottish Fire and Rescue and NHS Tayside, and Weinholt and Granberg (2015) with their examination of collaborations between the fire service and security officers.

vi) Indirect impacts/costs

Seven sources used indirect impacts and cost measures to consider the wider costs and benefits of fire service activities. For example, Delorme and Waterhouse (2018) include a multitude of indirect measures that contribute to the economic impact of a truck crash in Quebec, including calculating estimates of how long people spent in traffic caused by diversions and road stoppages and the subsequent economic impact of this loss of work productivity. This included the impact of people being late to work/unable to attend (which permits the businesses to receive compensation), productivity impacts for businesses due to distractions (resulting in revenue losses), delays in transportation of goods and services, and the average traffic flow. They calculated cost estimations for different lengths of wait time, including 30-minutes (~$2.1 million CAD/~£1.4 million GBP), 60-minutes (~$4.2 million CAD/~£2.7 million GBP), and 90-minutes (~$6.3 million CAD/~£4 million GBP). Anecdotal evidence was used to establish that wait times varied from 30 minutes to 4.5 hours depending on where vehicles were situated in relation to the crash, with a median wait time of 2.5 hours and an economic cost of $10,451,715 CAD (~£6.7 million GBP). The authors noted that the cost of this operation would have been considerably higher had the Sherbrooke Fire Department not been successful in their intervention.

Two sources considered indirect costs in relation to residential/dwelling fires. Harvey et al. (2020) plan to include a multitude of indirect impacts in their future research that will economically model a person's journey through a fire event. They will consider all health data for casualties involved in a fire related incident, including burn registry recovery processes and ambulance patient records (see Collaboration theme for further details). In their evaluation of the OHCA project, Sund et al., (2012) included indirect costs such as administration for the health service and maintenance of defibrillators and other materials provided (which was considered across a 10-year span) in addition to direct service costs for staff and resources. They were also one of the only sources in this review to consider quality-adjusted life years as opposed to just deaths/injuries, including the aftermath costs for people who suffered life-altering injuries.

Two sources also consider the indirect costs and impacts of wildland fires. For example, Mavsar et al. (2012) distributed a survey across 12 European countries to gain insight into factors that should be included when calculating the economic costs of wildfires. This survey provided information about common measures of fire valuation, including infrastructure damages, material costs, and flow of goods and services. However, it also showed measures not commonly considered such as carbon emissions/ sequestration, soil erosions, tourism, and health impacts through smoke inhalation. This was the only source included in this review to measure these indirect (and direct) costs of wildland fire, with other countries adopting a less robust approach to costings. Mavsar et al. (2012) also suggest the use of Willingness to Pay as a method for quantifying the economic valuation of some of these measures, however the study itself does not calculate costs. Nevertheless, it highlights a range of direct and indirect measures it would be beneficial to consider when valuing the economic cost of wildland fires.

In contrast, Roman et al. (2013) conducted vulnerability assessments of forest fires in Spain by estimating potential losses during re-establishment of pre-fire environmental conditions. They considered three categories of impacts including i) productive, ii) ecological, and iii) recreational functions of the affected ecosystems. They found that the greatest damage to the ecosystem came from loss of carbon sequestration, leading to large amounts of carbon emissions that contribute to global warming (equating to a cost of 4,054,930 TEUR [TEUR = 1000 Euros]). The next largest cost related to wildland fires, with loss of outdoor leisure opportunities such as hunting, and fishing included (estimated to cost 853,325 TEUR). Thirdly, the damage to productive functions of the forest, including wood and firewood, was estimated to cost 622,739 TEUR. This study does not outline the timespan that these costs relate to but provides an overview of indirect measures that would be useful to include to measure the economic impact of wildland fires.

DISCUSSION

This scoping review sought to identify and synthesise knowledge from across academic papers and reports that focus on economic analysis of fire service activities (both in the UK and internationally). Overall, 23 sources were identified that had focused on this topic since 2010 and were written in English. Most of the 23 studies included in the scoping review were conducted in western countries, with a small number in Australia. This is a limited body of research for demonstrating the costs and benefits associated with the wide variety of activities fire services undertake as part of their remit. It also presents a limited evidence base for informing decisions about where best to allocate limited resources. It is possible that further work has been conducted across fire services but has not been published or made publicly accessible, which also creates issues for transparency and ability to make comparisons to develop robust and reliable evidence. Further details about the quality of evidence available are discussed below with a view to informing discussions about commissioning future research.

Quality assessment

Focus was directed to a wide variety of fire related activities but most related to either fire prevention or suppression activities. In addition, a wide variety of methods of economic analysis were employed across sources, reflecting further differences in focus. For example, some sources sought to calculate the economic cost of fires. Others sought to compare the economic impact of implementing an intervention, different forms of intervention, or consider what the costs would have been had fire services not intervened. Even where a collection of sources focused on similar areas of activity and applied similar methods of analysis, cost measures included differed. Some focused on direct costs only such as salary and equipment, whilst others also considered wider indirect costs to the economy such as loss of productivity. These inconsistencies prevent direct comparisons from being made across studies to test the reliability of economic models and consider whether different types of fire service activities may represent a better investment of resources in different contexts. However, by drawing together studies, this scoping review provides a broader overview of the range of cost measures that could be included in economic models. This is important for informing sector-wide discussions about developing standardised models that include a more comprehensive range of costs to demonstrate the economic value of the fire service more accurately. Moving forward, standard economic frameworks for measuring different aspects of fire service activities are needed to improve the quality of evidence.

Overall, most studies were data driven, with authors using existing data and information provided by fire services and government bodies (e.g., Aldag et al., 2020; Bel & Belerdas-Castro, 2021), or data collected by other institutes (e.g., Gebert & Black, 2012; Harvey et al., 2020; Roman et al., 2013). This is understandable given that this bottom-up approach allows economic models to be developed straight away without needing to wait for new data to be collected using newly developed measurement tools. However, existing data has usually been collected for service delivery rather than economic evaluation purposes and so is often missing information that would be needed for developing robust economic figures or providing a transparent breakdown of these figures. Often, there are different data collection standards within and between services, which leaves practitioners and researchers working with inconsistent and unreliable data that affects the reliability of economic models. These inconsistencies in the way data are collected also further prevents direct comparisons from being made to understand whether some activities are more efficient and cost effective in different contexts. Addressing this issue requires longer term investment in developing and implementing standardised data collection and economic evaluation frameworks.

Another key issue was the lack of transparency across many studies, both in terms of what activity was being economically evaluated, and how costs were being calculated (i.e., what measures were being included in costs). For example, many studies referred to ‘prevention costs’ with no further information as to what specific prevention activities were being evaluated, nor what resources and outcomes were being included in the economic costings (e.g., Gebert & Black 2012; Heines et al., 2018). This creates further barriers for making comparisons to examine the reliability of economic models. In addition, even where prevention costs were broken down, little information was provided as to *how* costs were derived. For example, Delorme and Waterhouse (2018) provided costs of fuel and emulsifying agent required to suppress a truck crash fire but did not specify how this cost was calculated (i.e., through measuring the amount of fuel used and multiplying this by the cost of fuel at the time of the incident). Moving forward, this type of information should be included to allow better comparison across studies and incidents, along with supporting the development of standardised methods for calculating costs for different resources.

Finally, most studies did not use sensitivity analysis (a process of recalculating outcomes under alternative assumptions to identify the impact of a variable). Sensitivity analysis is important for demonstrating the robustness of conclusions drawn from data, both in terms of reliability (consistency) and validity (measures what it claims to measure) of economic models. Without this, it is difficult to generalise findings beyond the study to other contexts or to understand under what conditions the findings are relevant (for example, can findings be generalised to another service? Can findings be generalised to another type of incident or context?). Given that there is so little published economic analysis of fire service activities, it is not surprising that sensitivity analysis was not included. Two exceptions to this were studies conducted by Sund et al (2012;2019), which provided both a detailed overview of measures used and conducted sensitivity analyses, serving as an example of how this can be done. As the field of economic analysis in relation to fire service activities grows, this should be a future goal.

Summary

In summary, the 23 sources included in this scoping review provide beneficial insights into various direct and indirect measures that are appropriate to use in economic models of fire service activity. There are also some areas in which clusters of research are starting to emerge, predominantly in relation to prevention and suppression. However, there is a need for greater practitioner and researcher focus to be directed toward economically modelling fire service activity to strengthen the evidence base for informing decisions regarding use of finite resources. The quality of this evidence base could also be improved by:

i) Ensuring detailed and transparent information is provided of how measures were operationalised (i.e., *how* was the cost of fuel calculated?).
ii) Providing a detailed breakdown of the individual costs included in the model.
iii) Clarifying what specific fire service activities the model focuses on.
iv) Developing standardised economic frameworks for measuring different fire service activities.
v) Performing sensitivity analyses to assess confidence levels.

REFERENCES

Aldag, A. M., Warner, M. E., & Bel, G. (2020). It depends on what you share: The elusive cost savings from service sharing. *Journal of Public Administration Research and Theory*, *30*(2), 275–289. https://doi.org/10.1093/JOPART/MUZ023

Ashe, B., McAneney, J., & Pitman, A. (2011). Is the allocation of resources towards mitigation and response to fire in Australia optimal? *Journal of Risk Research*, *14*(3), 381–393. https://doi.org/10.1080/13669877.2010.541561

Bel, G., & Belerdas-Castro, A. (2021). Provision and production reform of urban fire services: privatization, cooperation, and costs. *Https://Doi-Org.Liverpool.Idm.Oclc.Org/10.1080/14719037.2021.1886317*. https://doi.org/10.1080/14719037.2021.1886317

Bryant, S. & Preston, I. (2017). *Focus on trends in fires and fire related fatalities.* Home Office. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/650869/focus-trends-fires-fatalities-oct17.pdf

Craig, J. A., Creegan, S., Tait, M., & Dolan, D. (2015). Partnership working between the Fire Service and NHS: Delivering a cost-saving service to improve the safety of high-risk people Health Services Research. *BMC Research Notes*, *8*(1), 1–5. https://doi.org/10.1186/S13104-015-1120-1/TABLES/2

Delorme, F., & Waterhouse, D. (2021). *Comprehensive Study on the Economic and Social Benefits of Fire Prevention REPORT*. https://strategicfire.org/wp-content/uploads/2022/02/Handout-4.2-Report_Fire_Prevention_Econ_Social_Benefits.pdf

Delorme, F., & Waterhouse, D. (2018). *Methodology Used to Calculate the Economic Impact of a Fire Department's Operational Activities on Highways*. https://numerique.banq.qc.ca/patrimoine/details/52327/3551869

Delorme, F., & Waterhouse, D. (2017). *Study of the Economic Impact of the Sherbrooke Fire Department's interventions for year 2017*. https://strategicfire.org/wp-content/uploads/2022/02/Handout-4.2-Ecom_impact_Study_Sherbrooke_FD.pdf

Falzon, L., Davidson, K.W., & Bruns, D. (2010). Evidence searching for evidence-based psychology practice. *Profess Psychol Res Practice. 41*, 550–7. https://doi.org/10.1037/a0021352

Gebert, K. M., & Black, A. E. (2012). Effect of suppression strategies on federal wildland fire expenditures. *Journal of Forestry*, *110*(2), 65–73. https://doi.org/10.5849/JOF.10-068

Geneva Association. (2014). *World Fire Statistics Bulletin No. 29 | Geneva Association*. https://www.genevaassociation.org/research-topics/world-fire-statistics-bulletin-no-29

Hall, J. R. (2010). *The Total Cost of Fires in the United States*. www.nfpa.org/osds

Hand, M., Katuwal, H., Calkin, D. E., & Thompson, M. P. (2017). The influence of incident management teams on the deployment of wildfire suppression resources. *International Journal of Wildland Fire*, *26*(7), 615–629. https://doi.org/10.1071/WF16126

Hand, M. S., Thompson, M. P., & Calkin, D. E. (2016). Examining heterogeneity and wildfire management expenditures using spatially and temporally descriptive data. *Journal of Forest Economics*, *22*, 80–102. https://doi.org/10.1016/J.JFE.2016.01.001

Harvey, L. A., Ghassempour, N., Whybro, M., & Kathy Tannous, W. (2020). Health impacts and economic costs of residential fires (RESFIRES study): Protocol for a population-based cohort study using linked administrative data. *BMJ Open*, *10*(9). https://doi.org/10.1136/BMJOPEN-2020-037709

Hawkins, C. v, Thalmueller, N., & Nieves-Ruiz, L. (2014). *The Economic Impacts of Successful Orange County Commercial Fire Interventions Economic Development Program Manager East Central Florida Regional Planning Council*. https://ccie.ucf.edu/wp-content/uploads/sites/12/2018/11/report-EconomicImpactsofSuccessfulOrangeCountyCommercial-FireInterventions.pdf

Heines, B., Lenhart, S., & Sims, C. (2018). Assessing the economic trade-offs between prevention and suppression of forest fires. *Natural Resource Modeling*, *31*(1). https://doi.org/10.1111/NRM.12159

Higgins, E., Taylor, M., Francis, H., Jones, M., & Appleton, D. (2015). Transforming fire prevention: A case study. *Transforming Government: People, Process & Policy*, *9*(2), 223–236. https://doi.org/10.1108/TG-05-2014-0017

Holmgren, J., & Weinholt, Å. (2016). The influence of organisational changes on cost efficiency in fire and rescue services. *International Journal of Emergency Management*, *12*(4), 343–365. https://doi.org/10.1504/IJEM.2016.10000713

Hollenberg, J., Riva, G., Bohm, K., Nordberg, P., Larsen, R., Herlitz, J., Pettersson, H., Rosenqvist, M., & Svensson, L. (2009). Dual dispatch early defibrillation in out-of-hospital cardiac arrest: the SALSA-pilot. *European Heart Journal*, *30*(14), 1781–1789. https://doi.org/10.1093/EURHEARTJ/EHP177

Joanna Briggs Institute. (2017). *Checklist for Economic Evaluation.* https://jbi.global/critical-appraisal-tools

Knight, K. (2013). *Facing the future: Findings from the Review of Efficiencies and Operations in Fire and Rescue Authorities in England*. Department for Communities and Local Government. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/200092/FINAL_Facing_the_Future__3_md.pdf

Local Government Association. (2019). *The Impact of Funding Reductions on Fire Services, House of Commons, 20 February 2019*. https://www.local.gov.uk/parliament/briefings-and-responses/impact-funding-reductions-fire-services-house-commons-20

Mavsar, R., Varela, E., Corona, P., Barbati, A., & Marsh, G. (2012). *Economic, Legal and Social Aspects of Post-Fire Management*. 45–78. https://doi.org/10.1007/978-94-007-2208-8_3

Met Press Office. (2022). Up to 50% Increase in Wildfires by 2100. Met Office. https://www.metoffice.gov.uk/about-us/press-office/news/weather-and-climate/2022/up-to-50-increase-in-wildfires-by-2100

Peterson, J., Pearce, P. F., Ferguson, L. A. & Langford, C. A. (2017). Understanding scoping reviews: Definition, purpose, and process. *Journal of American Association of Nurse Practitioners, 29*(1), 12-16. https://doi/10.1002/2327-6924.12380

Román, M. V., Azqueta, D., & Rodrígues, M. (2013). Methodological approach to assess the socio-economic vulnerability to wildfires in Spain. *Forest Ecology and Management*, *294*, 158–165. https://doi.org/10.1016/J.FORECO.2012.07.001

Sund, B., Svensson, L., Rosenqvist, M., & Hollenberg, J. (2012). Favourable cost-benefit in an early defibrillation programme using dual dispatch of ambulance and fire services in out-of-hospital cardiac arrest. *The European Journal of Health Economics: HEPAC :*

Health Economics in Prevention and Care, *13*(6), 811–818. https://doi.org/10.1007/S10198-011-0338-7

Sund, B., Bonander, C., Jakobsson, N., & 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. https://doi.org/10.1016/J.JSR.2019.04.006

Tannous, W. K., Whybro, M., Lewis, C., Broomhall, S., Ollerenshaw, M., Watson, G., Fish, C., & Franks, E. (2017). Home Fire Safety Checks in New South Wales: an economic evaluation of the pilot program. *Https://Doi.Org/10.1080/13669877.2017.1281336*, *21*(8), 1052–1067. https://doi.org/10.1080/13669877.2017.1281336

Taylor, M., Appleton, D., Keen, G., & Fielding, J. (2019). *Public Money & Management Assessing the effectiveness of fire prevention strategies Assessing the effectiveness of fire prevention strategies*. https://doi.org/10.1080/09540962.2019.1579439

Waring, S., Laveback, L., & Giles, S. (2022). *An Independent Quantitative Process Evaluation of the National Fire and Rescue Service Response to the COVID-19 Pandemic*. Report produced for the National Fire Chiefs Council.

Weinholt, Å., & 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. https://doi.org/10.1108/IJES-01-2015-0002/FULL/PDF

Wentworth, J. (2021). *Horizon Scanning: Preparing for More Extreme Climate Impacts and Disasters.* Post: UK Parliament. https://post.parliament.uk/preparing-for-more-extreme-climate-impacts-and-disasters/

Zhuang, J., Payyappalli, V. M., Behrendt, A., & Lukasiewicz, K. (2017). *Total Cost of Fire in the United States*. National Fire Protection Association. https://www.nfpa.org//-/media/Files/News-and-Research/Fire-statistics-and-reports/US-Fire-Problem/RFTotalCost.pdf