Assessing the effectiveness of fire prevention strategies

Abstract

In this paper, we examine the process of assessing the effectiveness of fire prevention within a Fire and Rescue Service in North West England, and demonstrate how this was applied in practice. The approach to fire prevention strategy assessment included overall fire and rescue service performance, performance in relation to different population segments, cost per head performance, and multi-agency collaboration to support an effectiveness based rather than outcomes based performance assessment.

Keywords: Fire, Prevention, Strategy, Effectiveness

Introduction

McKevitt (2015) commented that defining and measuring effectiveness at the organizational level is complex. Typically, public sector organisations are assessed by output measures rather than by effectiveness measures (Ammons and Roenigk, 2015). In terms of public management theory there is a need for public sector organisations to move towards performance measures that assess effectiveness rather than just outputs, since ultimately it is important that public sector organisations are actually effective in what they do. Currently English fire and rescue services are mainly assessed through outcome measures (FRNF, 2018). UK Fire and Rescue Services are currently expanding their scope of operations through the Safe and Well initiative (Safe and Well, 2017) (an evolution of the Home Fire Safety Check initiative (HFSC, 2017)), which involves not only fire prevention, but also health and social care prevention initiatives such as smoking cessation, and alcohol management. This has the potential to improve fire prevention effectiveness by not only advising potentially vulnerable individuals of how to avoid house fires, but also overall to reduce the impact of factors such as alcohol consumption and smoking that are linked with house fire incidence (Higgins et al, 2013). An important aspect of fire prevention is the fitting (if not present) and checking of smoke alarms. Operational smoke alarms prevent or reduce many fires and the associated injuries or fatalities (Tannous et al, 2017). Costs associated with Home Fire Safety Checks can include internal costs such as staff salaries, and on-costs, marketing costs, and travel costs, and external costs such as home fire safety material (batteries, smoke alarms, information booklets, calling cards, and fire blankets) (Tannous et al, 2107).

Puolokainen (2017) stated that the desired fire and rescue service outcomes that include the emergencies prevented or suppressed, and ultimately, the human life and property preserved are not easily measured. Evaluations of the UK Home Fire Safety Check initiative in Wales had identified the relationship between the installation of smoke alarms and reductions in dwelling fires and non-fatal casualties. The benefits of the Home Fire Safety Check initiative were found to far outweigh the revenue and capital costs of the initiative (Welsh Government Social Research, 2013). Tannous et al (2017) in a study in New South Wales, Australia, commented that analysis of the cost of fire within the region, combined with measurements of the success of similar home fire safety check programs internationally, demonstrated the home fire safety check program's cost effectiveness within New South Wales. Weinholt and Andersson Granberg (2015) commented that a common tool for evaluating policy initiatives in the public sector is cost-benefit analysis (CBA), where all the benefits and costs are monetized and compared to each other, and that this approach was beginning to be applied to collaborations between emergency services.

The academic challenge of the research reported in this paper is to examine how a fire and rescue service can move from output based performance measures to effectiveness based measures, and in practical terms, how fire prevention strategies can be assessed in terms of their effectiveness. The potential impact of this research is the ability to inform future fire prevention approaches, based upon assessment of the effectiveness of current approaches. The originality of the research presented in this paper is the detailed examination of the process of assessing the effectiveness of fire prevention within a UK Fire and Rescue Service. Although the UK National Audit Office (NAO, 2015) argued that despite the budget reductions experienced by UK Fire and Rescue Services the sector had coped well, there is still a need to develop a deeper understanding of the effectiveness of current fire prevention activities, in order for future fire prevention activities to be as effective and efficient as possible given the decreasing level of funding available.

Literature review

Fire prevention approaches

UK fire and rescue services generally adopt an Integrated Risk Management Planning approach that involves the development of operational strategies to reducing risk within the community. This is typically achieved by combining prevention, protection and emergency response, on a risk-assessed basis in order to improve the safety of the community (MFRSIRM, 2018). Jennings (2013) commented that research into fire in the community residential context has remained fragmented and isolated by discipline. Various fire prevention initiatives have been introduced in different communities around the world in an attempt to reduce fire incidence, morbidity and mortality. These initiatives have included education and training of children, parents, and certain high risk populations such as the elderly (Jonsson et al, 2013; Wuschke et al, 2013) in community based programs (Lehna et al, 2015; Warda et al 1999). Andrews et al (2014) commented that on the community service side, firefighters seek to build commitment to fire prevention. This is an area with fewer rules and much more discretion on how to approach the task, it is also an area in which the relationship between the service provider and client may hold the key to success. However, the research conducted by Andrews et al (2014) focussed more on equality and diversity in fire and rescue services rather than actual performance management.

Typically, the fitting or checking of smoke alarms is a major fire prevention initiative (Tannous et al, 2017) undertaken by fire and rescue services. Fires detected by smoke alarms tend to be discovered more rapidly and are associated with a reduced risk of death and property damage (Saramago et al, 2014). However, Jennings (2013) warned that when developing fire prevention strategies based upon risk levels, the dynamic of fire risk may vary depending on the level of analysis. Care needs to be taken to avoid ecological fallacy when moving from higher-level statistical data to making conclusions about household or individual behaviour or risk.

UK Fire and Rescue Services are currently expanding their scope of operations through the Safe and Well initiative (Safe and Well, 2017) (an evolution of the Home Fire Safety Check initiative (HFSC, 2017)), which involves not only fire prevention, but also health and social care prevention initiatives involving referrals to other agencies such as smoking cessation, and alcohol management. In terms of assessing the usefulness of referrals to other agencies (such as the UK NHS or local council) via a Home Fire Safety Check or Safe and Well visit, the

Quality-adjusted life year measure can be beneficial (Prieto and Sacristan, 2003). The Quality-adjusted life year measure is a measure of the state of health of a person or group in which the benefits, in terms of length of life, are adjusted to reflect the quality of life. One QALY is equal to 1 year of life in perfect health. QALYs are calculated by estimating the years of life remaining for a patient following a particular treatment or intervention and weighting each year with a quality-of-life score (on a 0 to 1 scale). It is often measured in terms of the person's ability to carry out the activities of daily life, and freedom from pain and mental disturbance. This can be used to assess generic (and banded) levels of the person's ability to carry out the activities of daily life (for example with regard to dementia patients). An important aspect of fire prevention approaches such as the Home Fire Safety Check or Safe and Well visit is targeting of resources towards those most at risk of fire. This includes vulnerable groups such as the elderly, those with disabilities, and those with lifestyles and behaviours such as binge drinking and smoking that can increase the risk of fire (Chainey, 2013; Corcoran et al, 2013; Higgins et al, 2013; Taylor et al, 2016; Turner et al, 2017).

Fire prevention effectiveness

Delvin and Parkin (2004) stated that evidence on cost effectiveness is used in many countries to inform decisions about the allocation of public funds to public services and products. Saramago et al (2014) commented that assessing cost-effectiveness, as well as effectiveness, is important in a public sector system operating under a fixed budget restraint. Abdel-Maksoud et al (2015) stated that there can be issues regarding whether the development of performance measures is properly aligned with the objectives of public organizations. Kloot (2009) commented that fire and rescue service performance assessments need to examine both operational and financial performance outcomes.

Hastie and Searle (2016) commented that there continues to be striking inequalities in the way in which dwelling fire incidence is distributed through society. Jennings (2013) commented that fires can be comparable in cost to crimes and therefore warrant the significant attention of the public and governments at all levels. Warda et al (1999) had commented that the effectiveness of fire prevention approaches in reducing fire incidence, injuries and deaths requires further study. Educational programs in particular are widespread, but their relative effectiveness has not really been established. Clark and Smith (2015) commented that further research is required into how fire risk is perceived and mitigated against by individuals, in particular with regard to the importance of clear communication in fire prevention strategies, including communicating the causes of fire. Studies of fire prevention interventions have reported variable success in reducing fire injury. Typically, this is measured in terms of the rates of fire incidence, injury and fatality before and after the fire prevention intervention. Typically, such measurements do not take into account socio-economic groupings, and do not include the use of control groups. Jaaskelainen et al (2012) commented that in general, measurement of service operations has proven to be a significant challenge.

McNamara (2017) commented upon the difficulties associated with determining fire prevention strategy priorities. Previous studies of fire prevention effectiveness have not really analysed whether targeting high-risk age groups achieves a greater reduction in injuries or produces a larger increase in the implementation of fire safety practices than alternative age prioritisations. Typically, studies of individual fire prevention programmes may be unreliable due to inconsistent design or performance measures, lack of randomness or controls, and inadequate sample size or follow-up time. Murphy and Greenhalgh (2013) commented upon the changing nature of performance management regimes adopted by the UK government for

Fire and Rescue Services. Murphy and Greenhalgh (2013) stated that a particular focus of performance review for English fire and rescue services was the Integrated Risk Management Plan, however, they also advocated that further assessment of performance management regarding efficiency and effectiveness was required. This is an important area of research, given that UK fire and rescue services need to meet the challenges of continuously improving their services. Carvalho et al (2006) and Adcroft and Willis (2005) stated that the delivery of public services can be undermined by the time, effort and management expertise deployed to cope with ever more elaborate forms of performance measures.

A study by the Welsh Government concluded that targeting was essential for successful Home Fire Safety Check initiatives. To reduce the number of dwelling fires, Home Fire Safety Checks need to be targeted at those most at risk, such as vulnerable populations (Welsh Government Social Research, 2013). Clare et al (2012) commented that public education, and targeted home visits by fire and rescue services have produced promising results via a range of outcome measures, from reduction in rates of fires and fire-related casualty, through to increased presence of working smoke alarms when residences were audited. A study by Clare et al (2012) in British Columbia, Canada, used Pre and Post home visit comparisons via percentages and ANOVA to analyse for significant difference in fire incidence rates following home visits by fire and rescue service staff.

Overall, previous research (Jaaskelainen et al, 2012; Murphy and Greenhalgh, 2013) had indicated that it can be difficult to conclusively deem any given fire prevention strategy to be effective, given the general absence of appropriate randomized controls across studies, without which positive results have to be interpreted with caution. The contribution of the research reported in this paper is the development of an approach to assess the effectiveness of fire prevention strategies, in order to inform future fire prevention approaches.

Research method

Merseyside Fire and Rescue Service staff and staff from a University in the North West region of the UK were involved in the assessment of fire prevention strategy effectiveness over a six month period. Merseyside Fire and Rescue Service staff involved in the assessment of fire prevention strategy effectiveness included the Community Risk Manager, the Director of Strategy and Performance, the Corporate Information and Systems Manager, and the Business Intelligence Manager.

The Business Intelligence Manager within Merseyside Fire and Rescue Service performed the primary data collection. Merseyside Fire and Rescue Service generated the data for internal purposes. The university staff and the Business Intelligence Analyst undertook the analysis of the data following discussions regarding the analysis approach to be adopted involving the Community Risk Manager, the Director of Strategy and Performance, the Corporate Information and Systems Manager, and the Business Intelligence Manager within the fire and rescue service studied. The research was internally driven within Merseyside Fire and Rescue Service by the Director of Strategy and Performance, and the Community Risk Manager. The collection of data was mainly an internal exercise for the organisation managed by the Corporate Information and Systems Manager, and undertaken by the Business Intelligence Manager, apart from the population data that was gathered by the university staff from the UK Office for National Statistics. In order to address issues of ethics, subjective bias and objectivity to preserve the validity and sanctity of the data gathered, all the work undertaken conformed

to the codes of ethics and professional conduct in operation at Merseyside Fire and Rescue Service and the university involved in the research.

Fire prevention within the area covered by Merseyside Fire and Rescue Service in the North West region of the UK was mostly conducted through the Home Fire Safety Check initiative (HFSC, 2017)), which involves not only fire prevention (mainly the fitting (if not present) and checking of smoke alarms), but also health and social care prevention initiatives such as smoking cessation, and alcohol reduction, which can assist in addressing the underlying factors which may contribute to fire risk. The referrals to other agencies carried out during home fire safety checks (and later expanded) during safe and well (Safe and Well Visit Principles, 2017) visits included: Smoking cessation referrals, Alcohol reduction referrals, Bowel cancer referrals, and Falls risk assessment referrals. Barton and Valero-Silva (2013) had commented upon the positive impact on service users of successful multi-agency working.

The research questions posed by the research reported in this paper were:

- How can the effectiveness of overall fire and rescue service provision be assessed?
- How can the effectiveness of a given fire prevention strategy be assessed?
- How can the effectiveness and of the targeting of fire prevention be assessed?

The research questions arose from the need of the fire and rescue service studied to assess effectiveness of operations. Previously English fire and rescue services were mainly assessed through outcome measures (FRNF, 2018), however, the new inspection approach by HM Inspectorate of Constabularies, Fire and Rescue Services (HMICFRS, 2018) for the 45 fire and rescue services in England places greater emphasis on measures of efficiency and effectiveness. During the period of the study, Merseyside Fire and Rescue Service had not been inspected under the new inspectorate regime. In addition, given the reductions in the rates of fire in England during the last ten years (during a period of reducing budgets), fire prevention, and in particular the targeting of fire prevention are increasingly important aspects of fire and rescue service operations.

These are important research questions since the continuing budget reductions experienced by Merseyside Fire and Rescue Service (and other UK Fire and Rescue Services) necessitates a deeper understanding of the effectiveness of current fire prevention activities, in order for future fire prevention activities to be as effective and efficient as possible given the decreasing level of funding available. Funding for Merseyside Fire and Rescue Service had decreased to £59.490 million for 2017 / 2018, from £73.576 million for 2004 / 2005. Merseyside Fire and Rescue Service has had the largest budget reductions of any English fire and rescue service (MFRS, 2018). The research questions arose from a need to understand how effective fire prevention approaches were given the continuing budgetary reductions being experienced. The main objectives for the resolution of the research questions were to develop an approach that could assess effectiveness of fire and rescue service operations at different levels, firstly at an overall operational level, and secondly at the level of operational fire prevention.

Study of the outcomes from an intervention might typically use random samples from intervention and control groups. However, in the case of fire prevention, due to duty of care requirements, it would not be appropriate, having identified vulnerable groups to apply such fire prevention in some areas within the region and not others, in order to assess the relative

impact on the number of fire incidents, injuries and fatalities. In addition, in the case of fire prevention, typically home fire safety checks and safe and well visits would be conducted across the areas in a region over a relatively long period of time (due to the number of visits involved, and the limited numbers of fire safety officers). For these reasons, analysis of effectiveness was more appropriate over a longer time period, than shorter term analyses. The research approach adopted was appropriate given the time periods over which fire prevention activities are conducted, and the time taken for the impact of fire prevention approaches to be measurable in terms of the frequency of production of fire statistics. Data for the analyses undertaken in order to answer the research questions posed was obtained from Merseyside Fire and Rescue Service and the UK Office for National Statistics.

The conceptual contribution of the research is the development of an approach to assessing the effectiveness of fire prevention strategies, based upon analysis of the approach to targeting fire prevention, and multi-agency collaboration. A limitation of the research presented in this paper is that the results are only relevant to one fire and rescue service (there are 44 other fire and rescue services in England) that serves a relatively small population, and therefore the applicability and generalisability to a wider population may be limited. However, due to the variable nature of the populations served by different fire and rescue services and the different area geographies, and the different funding levels, meaningful comparisons of effectiveness between different fire and rescue services would be difficult to interpret.

Research results

Assessing the effectiveness of overall fire and rescue service provision

The first stage in the examination of fire prevention strategy effectiveness was to determine what quantifiable measures could potentially be used to assess the effectiveness of fire and rescue service provision. Discussions with the relevant staff within Merseyside Fire and Rescue Service identified the following potential measures:

- Overall number of fire incidences, injuries and fatalities per year within the area covered by the fire and rescue service.

- Number of fire incidences, injuries and fatalities per year within the different population segments within the area covered by the fire and rescue service.

- Proportion of individuals within each different population segment per 100,000 of population within the area covered by the fire and rescue service involved in a fire incidence, injury and fatality.

These measures could be used to assess overall fire and rescue service performance, performance in relation to different population segments, and performance in relation to vulnerable population segments. These measures address the research question: How can the effectiveness of overall fire and rescue service provision be assessed?

Table 1. shows the overall number of fire incidences, injuries and fatalities in the period 2006 to 2016 within the area covered by Merseyside Fire and Rescue Service.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Fire	1384	1318	1315	1337	1248	1183	1090	1221	1023	1084	1049

incidences											
Fire injuries	129	100	106	115	126	145	110	146	118	110	104
Fire fatalities	6	11	10	6	7	5	3	10	9	15	10

Table 1. Overall number of fire incidences, injuries and fatalities in Merseyside 2006 to 2016

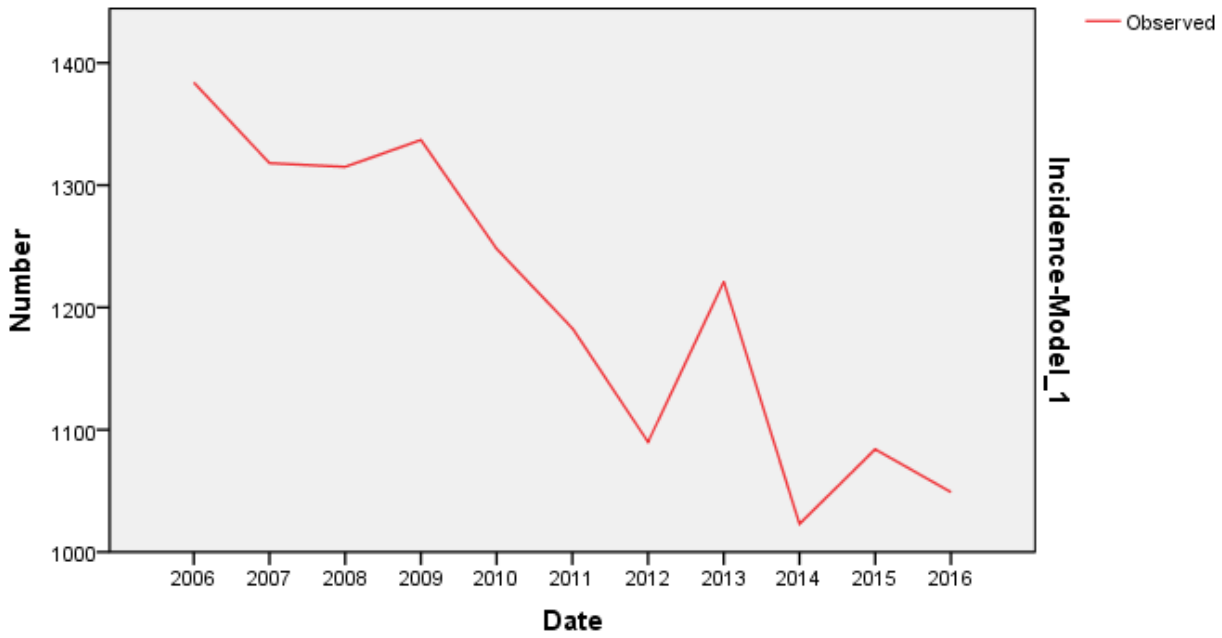

Figure 1. Fire instances in the UK Merseyside area 2006 to 2016.

In terms of overall fire and rescue service effectiveness indicated by how many fire incidences, injuries and fatalities occurred over the ten-year period 2006 to 2016, there was a clear downward trend in the number of fire incidences. In the other 44 fire and rescue services in England, the number of fire incidents had also been on a general downward trend since 2004 (HO, 2017). This data answers the research question: How can the effectiveness of overall fire and rescue service provision be assessed, since by comparing fire incidence rates over time, a significant reduction in fire incidences was identified. In terms of the pattern of fire injuries and fatalities, due to the relatively small number of such, a small number of fires could significantly affect the figures, which makes interpreting such more difficult.

Table 2. shows the overall number of fire incidences, injuries and fatalities by population segments within the Merseyside area in the period 2006 to 2016. Merseyside Fire and Rescue Service had identified the elderly (those aged 65+) as being the most vulnerable population segment in terms of fire risk (as had other previous research (Mulvaney et al, 2009; Corcoran et al, 2011)). In the period 2006 to 2016 for the Merseyside area, 56% of fire fatality victims were over the age of 65.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Fire Incidences (All ages)	1384	1318	1315	1337	1248	1183	1090	1221	1023	1084	1049

Fire injuries (Age 65+)	35	31	35	24	25	43	36	52	40	35	25
Fire Injuries (Age < 65)	94	68	70	91	101	102	71	93	77	73	75
Fire Fatalities (Age 65+)	4	5	5	3	3	4	1	4	6	10	6
Fire Fatalities (Age < 65)	2	6	5	3	4	1	2	6	3	5	4

Table 2. Overall number of fire incidences, injuries and fatalities by population segments in the Merseyside area 2006 to 2016 (Data regarding dwelling occupants involved in a fire incidence is typically only recorded for fire injuries and fatalities). This data also answers the research question: How can the effectiveness of overall fire and rescue service provision be assessed, since by examining fire fatality and injury rates in greater detail via different identified population segments it was possible to examine the differences in frequency between different population segments over time.

Table 3. shows the proportion of individuals within each different population segment involved in fire incidences, injuries and fatalities by population segment per 100,000 of population in the Merseyside area in the period 2006 to 2016.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Fire Incidences Proportion (All ages)	101.1	96.4	96.1	97.5	90.7	85.7	78.7	88.1	73.5	77.5	74.6
Fire Injuries Proportion (Age 65+)	15.2	13.4	15.1	10.3	10.6	18.0	14.6	20.7	15.6	13.5	9.5
Fire Injuries Proportion (Age < 65)	8.3	6.0	6.2	8.0	8.9	8.9	6.2	8.2	6.8	6.4	6.6
Fire Fatalities Proportion (Age 65+)	1.7	2.2	2.2	1.3	1.3	1.7	0.4	1.6	2.3	3.9	2.3
Fire Fatalities Proportion (Age < 65)	0.2	0.5	0.4	0.3	0.4	0.1	0.2	0.5	0.3	0.4	0.3

Table 3. Proportion of individuals within each different population segment per 100,000 of population involved in fire incidences, injuries and fatalities by population segment in the Merseyside area 2006 to 2016. Data regarding dwelling occupants involved in a fire incidence

is typically only recorded for fire injuries and fatalities. This data also answers the research question: How can the effectiveness of overall fire and rescue service provision be assessed, by examining the proportions of different identified population groups involved in fire incidences since this allows an examination of the relative rates of fire injury and fatality between difference population segments over time. In particular, the proportion of elderly individuals involved in fire injuries and fatalities was significantly higher than the proportion of the non-elderly population.

For the purposes of calculating population proportions, the population estimate figures for Merseyside were (in 000's) (Nomis, 2017):

2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
1,368	1,367	1,369	1,372	1,376	1,381	1,386	1,387	1,391	1,398	1,406

Table 4. Population figures for Merseyside 2006 to 2016 (000's).

The population estimate figures for Merseyside residents aged 65+ were (in 000's) (Nomis, 2017):

2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
230	231	232	234	236	239	247	251	256	259	263

Table 5. Population figures for Merseyside residents aged 65+ 2006 to 2016 (000's).

There appeared to be a clear downward trend in the overall proportion of the Merseyside population involved in a fire incidence over the ten-year period studied. The small proportions of those involved in a fire injury and fatality meant that these figures were less clear to interpret. However, there appeared to be a clear indication that those aged 65+ were proportionately more likely to be injured or die in a dwelling fire than those aged less than 65.

Assessing fire incidences, injuries and fatalities compared to spend per head

The next effectiveness measures assessed the number of fire incidences, injuries and fatalities compared to the relevant spend per head:

- Fire incidences, injuries and fatalities versus overall spend per head of overall population in the area.

- Fire incidences, injuries and fatalities versus overall fire prevention spend per head of overall population in the area.

- Fire injuries and fatalities versus overall fire prevention spend per head of different population segments in the area.

Table 6. shows the overall fire and rescue service spend per head (in £s) and the overall number of fire incidences, injuries and fatalities in the Merseyside area in the period 2006 to 2016

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016

Spend per head of population	48.72	50.23	51.80	51.07	52.24	51.14	52.63	53.64	52.07	43.37	46.73
Fire incidences	1384	1318	1315	1337	1248	1183	1090	1221	1023	1084	1049
Fire injuries	129	100	106	115	126	145	110	146	118	110	104
Fire fatalities	6	11	10	6	7	5	3	10	9	15	10

Table 6. Overall fire and rescue service spend per head (in £s) and overall number of fire incidences, injuries and fatalities in the Merseyside area 2006 to 2016 and Table 7. shows the ratio of overall fire and rescue service spend (or cost) (in £000's) to fire incidents / injuries / fatalities

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Cost / fire incidence ratio	48	52	54	52	58	60	67	61	71	56	63
Cost / fire injuries ratio	517	687	669	609	570	487	663	510	614	551	632
Cost / fire fatalities ratio	11108	6242	7091	11678	10269	14125	24315	7440	8048	4042	6570

Table 7. Ratio of overall fire and rescue service spend (or cost) (in £000's) to fire incidents / injuries / fatalities in the Merseyside area in the period 2006 to 2016.

This data also answers the research question: How can the effectiveness of overall fire and rescue service provision be assessed, by examining the spending associated with fire incidents, injuries and fatalities over time, in terms of the cost per fire incident, injury and fatality.

Assessing the effectiveness of fire prevention strategies

Table 8. shows the overall fire prevention spend per head (in £s) and the number of fire incidences, fire incidents involving injuries, and fire incidents involving fatalities in the Merseyside area in the period 2006 to 2016.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Fire prevention spend per head of population	16.07	15.11	13.72	14.26	13.50	14.73	14.00	15.62	16.99	13.86	16.11
Fire incidences	1384	1318	1315	1337	1248	1183	1090	1221	1023	1084	1049

Fire incidents involving injuries	109	84	85	90	84	112	86	114	91	86	77
Fire incidents involving fatalities	6	11	10	6	7	5	3	9	9	14	7

Table 8. Overall fire prevention spend per head (in £s) and overall number of fire incidences, fire incidents involving injuries, and fire incidents involving fatalities in the Merseyside area 2006 to 2016

This appeared to indicate that overall the spend per head on fire prevention has been effective in reducing the number of fire instances over the ten-year period studied. However, the impact upon fire injuries and fatalities was more difficult to interpret. Table 9. shows the ratio of overall fire prevention spend (or cost) (in £000's) to fire incidents / fire incidents involving injuries / fire incidents involving fatalities

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Fire prev. cost / incidence ratio	16	16	14	15	15	17	18	18	23	18	22
Fire prev. cost / incidences involving injuries ratio	202	246	221	217	221	182	226	190	260	225	294
Fire prev. cost / incidences involving fatalities ratio	3664	1878	1878	3261	2654	4068	6468	2407	2626	1384	3236

Table 9. Ratio of overall fire prevention spend per head of population (or cost) (in £000's) to fire incidents / fire incidents involving injuries / fire incidents involving fatalities in the Merseyside area in the period 2006 to 2016

This data answers the research question: How can the effectiveness of a given fire prevention strategy be assessed? by examining the spending associated with fire prevention compared with the number of fire incidents, injuries and fatalities. However, due to the fluctuations in the spend per head of population, and in the overall spend on fire prevention per year over the period studied, it was difficult to discern an overall trend or pattern. For example, whether spending more on fire prevention was associated with fewer fire injuries and fatalities, or spending less on fire prevention was associated with fewer fire injuries and fatalities year on year.

Assessing the effectiveness of the targeting of fire prevention

Table 10. shows the fire prevention spend per head (in £s) and the number of fire injuries and fatalities by population segment in the Merseyside area in the period 2006 to 2016. (Data regarding dwelling occupants involved in a fire incidence is typically only recorded for fire injuries and fatalities)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Fire prevention spend per head of population (Age 65+)	2.70	2.55	2.32	2.43	2.32	2.55	2.49	2.83	3.12	2.57	3.01
Fire prevention spend per head of population (Age < 65)	13.37	12.56	11.39	11.83	11.18	12.18	11.51	12.49	13.86	11.30	13.11
Fire Injuries (Age 65+)	35	31	35	24	25	43	36	52	40	35	25
Fire Injuries (Age < 65)	94	68	70	91	101	102	71	93	77	73	75
Fire Fatalities (Age 65+)	4	5	5	3	3	4	1	4	6	10	6
Fire Fatalities (Age < 65)	2	6	5	3	4	1	2	6	3	5	4

Table 10. Fire prevention spend per head (in £s) and the number of fire injuries and fatalities by population segment in the Merseyside area 2006 to 2016 (Data regarding dwelling occupants involved in a fire incidence is typically only recorded for fire injuries and fatalities)

This data answers the research question: How can the effectiveness of the targeting of fire prevention be assessed? by examining the spending associated with fire prevention for different population groups compared with the number of fire incidents, injuries and fatalities for the different population groups. Overall fire prevention activities appear to have had a clear impact on the number of fires, which have steadily reduced during the period 2006 to 2016, even though the spend per head of the population on fire prevention has fluctuated between £13.50 and £16.99 during this period.

The impact of fire prevention on fire injuries and fire fatalities over the period studied was less clear. The number of fire incidents involving injuries fluctuated between 77 and 114 with a mean value of 92.6, and the number of fire incidents involving fatalities fluctuated between 3 and 14 with a mean value of 7.9. There did not appear to be an overall trend with either the

numbers of fire incidents involving injuries, or the numbers of fire incidents involving fatalities. There did not appear to be a link between the spend per head of the population on fire prevention in a given year and the numbers of fire incidents involving injuries, or fire incidents involving fatalities in that year (or the following year).

However, analysis of the factors associated with fire fatalities over the period 2006 to 2016 in the Merseyside area revealed that:

50.5% of fire fatalities involved smoker's materials, which indicated that referrals to NHS smoking cessation services that are an integral part of the home fire safety checks carried out by Merseyside Fire and Rescue Service were an appropriate and necessary aspect of current and future fire prevention.

39.8% of fire fatalities involved alcohol consumption, which indicated that referrals to NHS alcohol reduction services that are an integral part of the home fire safety checks carried out by Merseyside Fire and Rescue Service were an appropriate and necessary aspect of current and future fire prevention.

55.9 % of fire fatalities and 21.5% of fire injuries involved those aged over 65, indicating that this age group was the most in need of fire prevention support, which is the current main focus of fire prevention activities carried out by Merseyside Fire and Rescue Services.

64.5 % of the fire fatalities involved those living alone, indicating that this social group was also the most in need of fire prevention support.

This data also answers the research question: How can the effectiveness and of the targeting of fire prevention be assessed? by examining the different population groups and lifestyles and behaviours associated with fire fatalities. Overall the effectiveness measures described in this research combined what was done by the fire and rescue service studied, the value to the users of the service (the population of Merseyside), and the manner in which the services were delivered (Fryer et al, 2009).

Effectiveness of communication strategy

A particular issue with regard to assessing the effectiveness of fire prevention approaches was attempting to understand the communication aspect of fire prevention (Andrews et al, 2014). Behavioural insights can potentially aid in determining how best to contact / influence people with regard to fire prevention according to the behaviours they display (Clark and Smith, 2015). Typically, communication methods can include face-to-face via home fire safety checks or safe and well visits, leaflets or flyers distributed to local residents as part of a publication scheme under the UK Freedom of Information Act 2000. In addition, referral to other agencies such as NHS smoking cessation or alcohol reduction can provide an effective communication approach.

Conclusions

Evidence on cost effectiveness is used in many countries to inform decisions about the allocation of public funds to public services and products. In this paper we have examined a fire prevention strategy assessment approach that supports moving from output based performance measures to effectiveness based performance measures. The fire prevention

strategy assessment approach included overall fire and rescue service performance, performance in relation to different population segments (especially the most vulnerable groups such as the elderly), and fire incidences, injuries and fatalities compared to spend per head of the population covered by the fire and rescue service concerned.

The key contribution from the research study reported in this paper is the development of an approach to assessing the effectiveness of fire prevention strategies, based upon analysis of the approach to targeting fire prevention, and multi-agency collaboration. The approach measures overall fire and rescue service performance, performance in relation to different population segments, and performance in relation to vulnerable population segments using fire and rescue service data and UK national statistics and NHS data.

In terms of overall fire and rescue service effectiveness indicated by how many fire incidences, injuries and fatalities occurred over the ten-year period studied, there was a clear downward trend in the number of fire incidences within the region studied. There also appeared to be a clear downward trend in the overall proportion of the Merseyside population involved in a fire incidence over the ten-year period. The small proportions of those involved in a fire injury or fatality meant that these figures were less clear to interpret. Over the ten-year period studied, overall the fire and rescue service spend per head on fire prevention appeared to have been effective in reducing the number of fire instances.

Given that a significant proportion of the fire fatalities over the time period studied involved smoker's materials and alcohol consumption, this indicated that referrals to NHS smoking cessation and alcohol reduction services were an appropriate and necessary aspect of current and future fire prevention.

The implications for theory and practice of the research reported in this paper are the need to move from output based performance measures to effectiveness based performance measures. In this paper we have examined how this can be achieved via detailed analysis of fire incidences, injuries and fatalities in terms of the different population segments within the area covered by a given fire and rescue service. In addition, it is necessary to analyse the costs associated with fire prevention for the different population segments, and finally it is important to recognise the need for fire and rescue services to work closely with other public sector agencies.

A limitation of the research presented is that due to the variable nature of the populations served by different fire and rescue services and the different area geographies, and the different funding levels, meaningful comparisons of effectiveness between different fire and rescue services would be difficult to interpret. Future research could however, examine the use of the fire prevention effectiveness assessment measures in other fire and rescue service contexts. It is hoped that the examination of fire prevention strategy assessment reported in this paper will be of benefit to other fire and rescue services, both in the UK and elsewhere.

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