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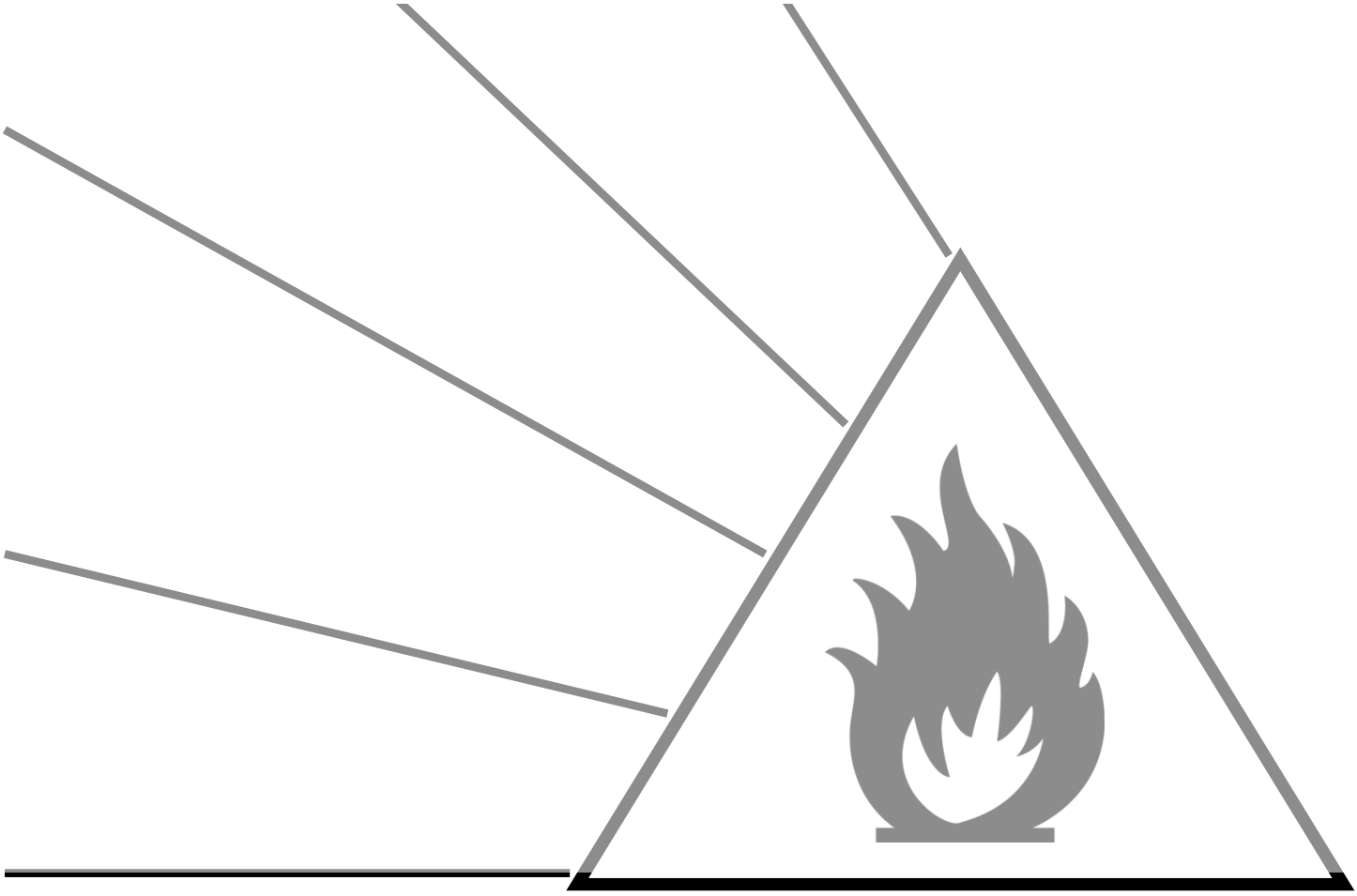
The Case for Investing in Prevention: *Fire Prevention*



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Executive Summary

Case for investment in the prevention of fires

In the latest year for which figures are available, 2004, it was seen that the total cost of fires in England and Wales was estimated at £7.03 billion or 0.78% of Gross Value Added (GVA) of the economy. In England alone this figure had risen to £8.3 billion by 2008 signifying that this problem is becoming more costly. The average cost of a domestic fire is estimated at £25,000, of which approximately £15,000 is accounted for by the economic cost of injuries and fatalities. It can be argued, therefore, that the NHS has a vested interest in reducing the number of fires by means of prevention in order to achieve cost savings by negating the need to treat patients that have been affected by fire. Around one third of all fires are caused following consumption of alcohol. Discarded cigarettes are a major cause of fires. It is apparent therefore that harm reduction policies associated with alcohol and smoking should also consider fire prevention. In terms of investing in fire prevention the Welsh Government has passed a law in 2014 to ensure that all new builds in Wales are fitted with a sprinkler system showing that there is appetite at a governmental level to tackle the problem.

Do fire prevention interventions improve health?

Results of intervention studies such as education or provision of equipment are varied. Whilst some good quality randomised control trials have found no evidence of an effect on health, other types of studies have reported reductions in morbidity or mortality from fire related injuries, largely through increased ownership and maintenance of safety equipment.

There is strong evidence that ownership and function of smoke alarms can be increased if smoke detectors are provided alongside advice on maintenance during a child health review in primary care. A more detailed review of the evidence should be carried out to find out if this would be a cost effective and acceptable opportunity to provide such advice as a brief intervention, however this is beyond the scope of this report.

Is investing in fire prevention interventions a good use of money?

The requirement for an intervention to be cost-effective uses National Institute for Health and Care Excellence (NICE) criteria, and refers to an intervention falling below the cost per quality adjusted life year (QALY) threshold of £20,000- £30,000. Other means of calculating cost-effectiveness are the Return on Investment (ROI) method which gives a ratio of the amount saved in relation to the amount invested and Net Present Value which compares the present value of benefits with the intervention's cost. This report shows examples of studies on the cost-effectiveness of fire prevention specifically, and highlights the need for further research into the topic. It identifies studies that show that interventions such as smoke detectors and sprinkler systems can be cost effective under certain circumstances and reports the potential cost savings that these interventions may have.

Introduction to the health and social problems associated with fires

In Wales, fires are a major cause of fatality, injury and health service use each year. Between 2009 and 2015, among fires responded to by Fire and Rescue Services (FRS) there were on average 20 fatal and 240 non-fatal injuries requiring hospital treatment each year in Wales [1] (Figure 1). This is based on actual figures rather than estimations. Additionally, a substantial number of people received first aid for minor injuries or were referred to primary care or to hospital for a precautionary check up in the absence of visible injury [1]

(Figure 1). Over that period nearly two thirds of fatal (Figure 2) and non-fatal casualties (Figure 3) were due to accidental domestic fires [2].

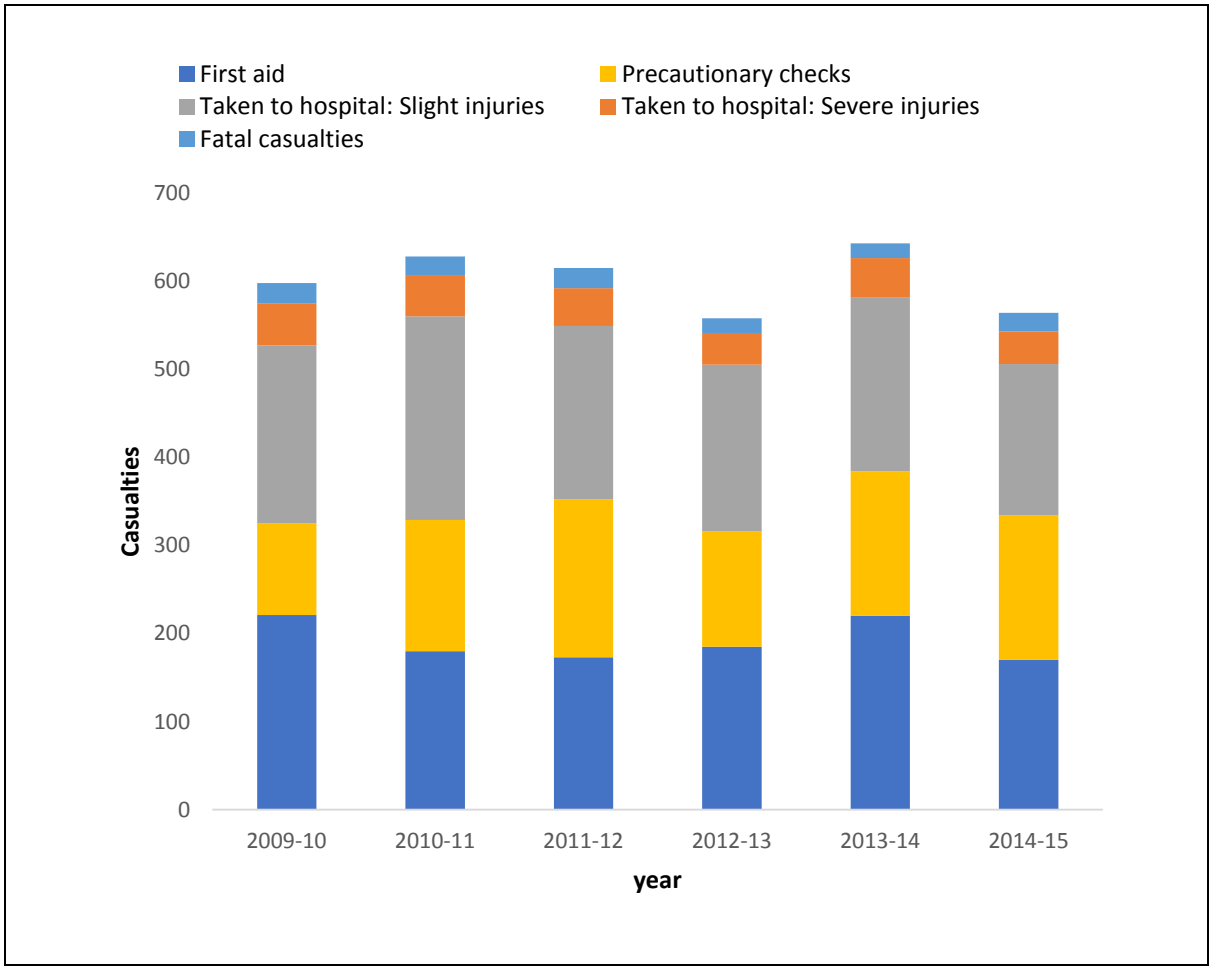

Figure 1: Number of fatalities, injuries and precautionary checks resulting from fires in Wales 2009-2015 [1]

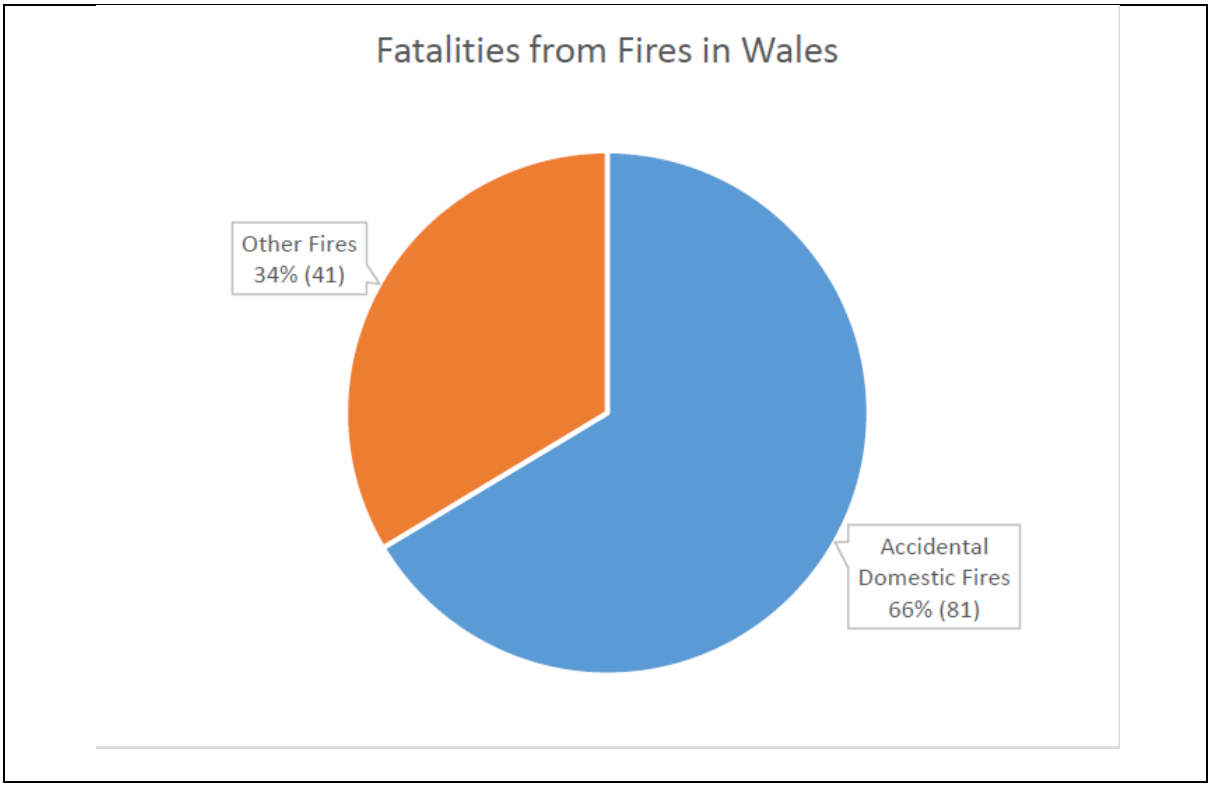

Figure 2: Proportion and number of fatalities resulting from accidental domestic fires in Wales between 2009 and 2015 (total = 122) [2]

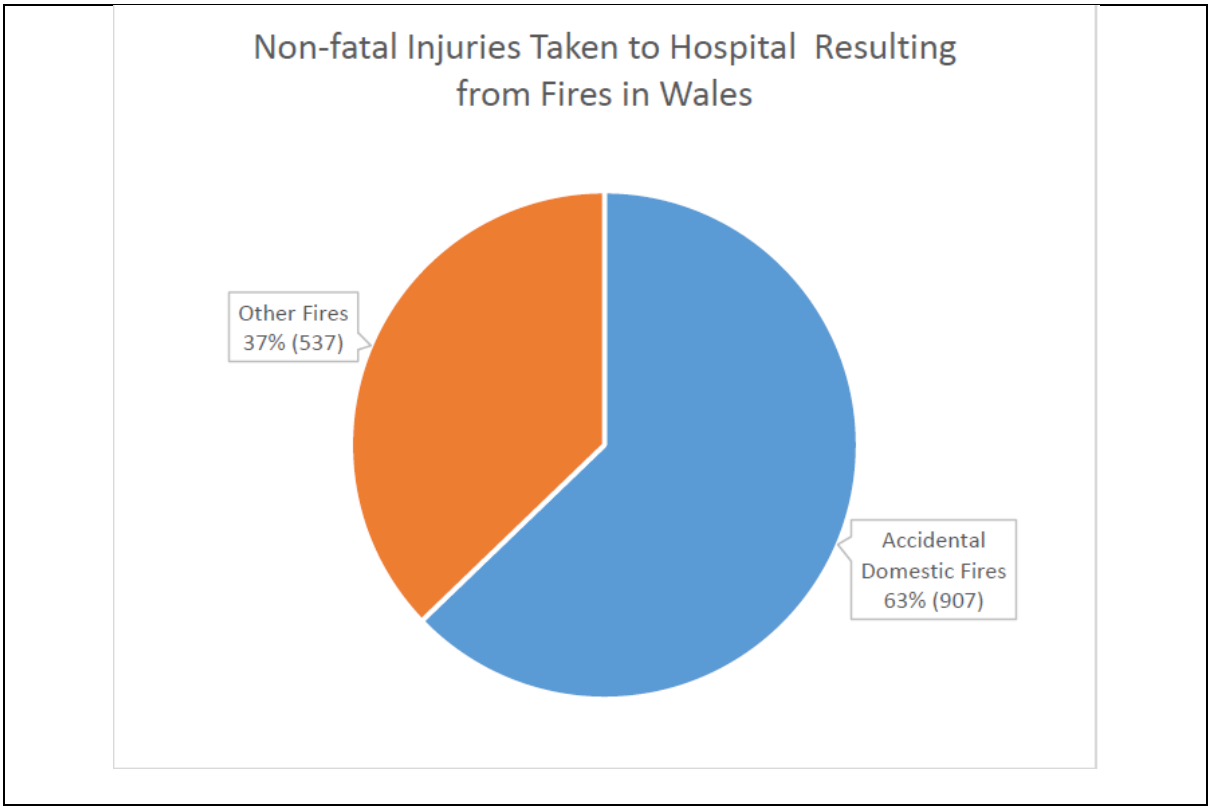

Figure 3: Proportion and number of non-fatal injuries resulting from accidental domestic fires in Wales between 2009 and 2015 (total = 1,444) [2]

It is estimated that one in three fires are caused by individuals under the influence of alcohol [4] and that two thirds of casualties admitted to hospital, or who die from burns, have consumed alcohol [4]. Between 2010 and 2011, around a third of fatal house fires in the UK were caused by smokers' materials, predominantly cigarettes. [5]. Additionally, the number of house fires in the UK linked to e-cigarettes has increased from only eight in 2012 to at least 62 in 2014 [6]. Therefore, harm reduction policies associated with alcohol and cigarette use should also potentially consider fire prevention.

Overview of the costs to health and to the wider society: the individual, the health system and the broader economy

According to Fire Safe Europe [7] the economic cost of fire is estimated to be close to 1% of Europe's GDP (2014 figures). This includes costs incurred in the anticipation of fire (e.g. insurance administration costs), costs of the fire and rescue services, and costs attributable to the consequences of fire in terms of property damage, lost business, the impact on the NHS of related injuries and fatalities and the wider health and care implications, and criminal justice costs associated with the prosecution of arsonists.

In the latest year for which figures are available, 2004, it was seen that the total cost of fires in England and Wales was estimated at £7.03 billion or 0.78% of Gross Value Added (GVA) of the economy [8]. The average cost of a domestic fire in 2004 is estimated at £24,900, of which £14,600 is accounted for by the economic cost of injuries and fatalities. A more recent report for England estimated the costs to the economy at £8.3 billion in 2008 equating to £161 per person [9]. Using this per person cost it can be estimated that the cost in Wales based on the mid-year population estimate [10] would have been £487.2 million in 2008. Of this, 40% (approximately £195 million) would have been associated with the consequences of fire[1] [9]. This cost would have been split evenly between the cost of fatal and non-fatal injuries (42%) and damage to property (45%), with the remainder being the cost of policing, criminal justice and loss of business [9]. Based on this split, it can be estimated that the cost of fatal and non-fatal injuries in Wales would have been £81 million in 2008.

[1] The rest was the cost of anticipation and response which includes fire protection, costs of

It is important to note that these figures are now eight years old and consideration needs to be given to deriving new figures to provide up to date estimates of the costs. Consequently, the methods for calculation of cost estimates are explored further in the next section.

Methods for calculating the economic cost of domestic fires

The following section outlines the different methods of evaluating the costs of house fires in Wales.

It should also be noted that a number of official published reports have looked into the costs to the NHS of domestic fires and fire prevention in detail [8,9,12], including a recent evaluation of domestic fire prevention work [12].

There are two steps required for any analysis: calculating the number of people affected and estimating the costs associated with each injury or fatality.

Calculating numbers of casualties

There are several ways of estimating or measuring the number of casualties.

Direct from published Fire Service Data

According to the most recent Welsh Government Statistics in Wales there are currently around 2240 fires in dwellings every year [11]. Over the last 10 years this has resulted in between 600-650 non-fatal casualties per year (see Figure 1), of which approximately 50% were taken for a precautionary check-up only [1], and between 16 and 28 fatalities per year [1]. These figures only take into account fires to which the fire service are called, and do not allow estimation of the number of minor injuries caused in small fires which are managed by the householder before they get out of control (e.g. with a fire blanket). It can be reasonably argued that the proportion of fires in this category will go up with increased fire prevention activity (e.g. smoke detector fitting) as residents will be alerted to potential issues earlier. There is also considerable variation in the small numbers reported year on year, and as a result confidence intervals will be very wide.

Direct from Health Service Data

Comparison of Fire Service data with that held by the NHS in Wales is difficult. For those admitted to hospital it relies on the admission being coded appropriately within the Patient Episode Database for Wales (PEDW) (ICD-10 codes X00-X08 Exposure to Uncontrolled Fire in a building or structure). Furthermore, with only a few casualties each year likely to require hospital admission this data source will hold relatively few records. Most patients, especially given the proportion taken for precautionary check-up, will be dealt with within emergency departments. Coding within this system is known to be difficult and can cause problems in differentiating burns from different causes. Using this source will also not capture health service activity associated with emergency response to incidents (e.g. ambulance costs). Furthermore, the small numbers will mean that coding errors on relatively small numbers of patients will have a large impact on costs.

Based on residential property type

In a recent cost benefit analysis published by the Welsh Government [12], the burden of house fires was estimated based on property type. Data from all fires in the UK was used to estimate the number of fires, fatalities and non-fatal injuries associated with a range of building types, to produce a risk per 1,000,000 buildings of each type. Applying these risks to the number of each property type in Wales, available from the Valuation Agency, will provide an estimate of the numbers of fatal and non-fatal injuries in Wales. This method will produce an estimate based on UK risks applied to local housing types.

Assigning a cost

There are a number of mechanisms used to assess costs associated with residential fires. These are outlined below.

Treasury Green Book Costs

The Treasury Green Book [13] puts figures on the value of fatality and injury prevention based on costs to health services, the wider economy and the individual in terms of physical and mental suffering. These are estimated at least in part using willingness to pay methods to judge the value placed by society in preventing suffering. These estimates have been devised by the Department of Transport for use in valuation of road traffic accident prevention measures. This values a prevention of a fatality at £1,632,111, with major and minor injuries valued at £183,380 and £14,140 respectively, based on 2012 prices [13]. Using this method allows estimation of the human cost, but does not reflect the actual cost incurred by health services in handling these patients. It is recognised in the Economic Cost of Fire report [8] produced by the UK Government, that the economic costs of lost productivity and the value placed on pain and suffering will form the bulk of these values. Furthermore, a judgement is required about the proportion of injuries that will be major, and those that are minor. These methods are widely used for estimating fire costs and have been used by the Building Research Establishment (BRE) in the Welsh Government cost benefit analysis of the sprinkler prevention requirements [12]. Although it is not possible to disentangle the healthcare costs from this, it is a useful mechanism for estimating costs which include those incurred by the NHS.

Healthcare cost estimates

The alternative costing mechanism is to examine costs incurred by health boards in providing care (per inpatient day, Elective Day visit, & ambulance dispatch) and apply these to estimates of the severity of injuries resulting from house fires and the number of casualties. This will provide a health care cost but is likely to result in substantial uncertainties in the estimation. Costs could be derived either directly from each health board or from the literature around healthcare costs, as appropriate.

Overview of the effectiveness of prevention programmes for fire prevention.

Three systematic reviews have been identified looking at interventions for fire prevention, or fire injury prevention. These include one published Cochrane review [14] and two further peer reviewed systematic reviews [15,16].

The most recent review [14] examines the evidence for interventions promoting smoke detector ownership and function. This review identified 26 trials, including 17 randomised trials. The combined results showed that only modest non-significant increases in smoke alarm ownership and function were identified, possibly due to the variety of the interventions. However, the review did highlight that interventions carried out as part of primary care child health check-ups significantly increased ownership and function of smoke alarms. However, the authors recognise that non-randomised evaluations have shown significant differences from the randomised studies [14]. These results were supported by a similar, slightly earlier, systematic review by the same authors [15].

The oldest systematic review [16] looked at both broad educational interventions on fire prevention, and equipment supply interventions. With many of the education studies there were significant methodological shortcomings and, although well received by target audiences, they were difficult to robustly evaluate. Subsequent studies have identified effective educational interventions, however many educational trials only measure knowledge as the outcome rather than reductions in morbidity or mortality. Consequently, it is difficult to evaluate how successful these are at reducing injury or death. We only identified four trials from the systematic review where mortality or morbidity from fires was the outcome measure. One of them, a randomised control trial of an education intervention, found no difference in morbidity or mortality from fires, whereas in another non-randomised trial fire injury rates decreased by 80% in four years after a smoke alarm giveaway intervention [16].

It also has to be noted that there is evidence from studies of smoke detector installation and maintenance that, although prevalence can be increased by interventions which deliver and help fit smoke alarms, in some cases the alarms will not be maintained or may have batteries removed reducing the effectiveness of the intervention [16]. This was also noted by Wood, Bellis and Atherton who reported on burns prevention programmes and noted mixed successes with one UK smoke detector intervention failing to increase smoke detector prevalence or reduce fires in its target area [17]. Programmes looking at

maintenance have shown some success with the England Fire Kills campaign saving an estimated 21 lives per year by promoting smoke detector checking and maintenance [17].

Consequently, it can be summarised that despite a wide range of studies evaluating fire injury prevention interventions it is difficult to determine if they are effective. When tested under randomised conditions there is little evidence of effectiveness. Other types of evaluations are subject to a number of different methodological flaws, but in some cases have shown impressive reductions in injury, and improvements in the possession and function of equipment designed to reduce injury.

It is important to note that the strongest evidence in randomised trials was found when the intervention was delivered at part of a primary care child health check-up [15], although effects on injures have not been examined. It is possible that in these cases the parent is more receptive to messages about protection of the child's health. More research would be valuable on the effectiveness of home safety interventions delivered in a primary care setting to determine whether this is an appropriate area where health services can invest in fire prevention.

The Economics of Fire Protection

Fire *protection* has its roots in two distinct concepts [2]: that of fire prevention, where interventions are implemented to prevent fire from occurring, and fire suppression – the act of extinguishing a fire once it has broken out. In economic texts discussing the issue, the term 'fire protection' is almost always synonymous with actual 'fire suppression'. Insofar as this is true, it is widely held that the provision of fire suppression is seen as a public good. It displays aspects of non-rivalry (the good can be consumed by one individual while not reducing the amount available for another) and non-excludability (one cannot exclude any individual from the benefits of the good). However, it is contended here that fire *prevention* can also be seen as a public good because it also displays aspects of non-rivalry in consumption and non-excludability. One cannot exclude any individual from the benefits of a smoke alarm, for example, and its use does not diminish the amount of benefit the good provides for others. Fire prevention goods, such as smoke alarms, also display positive externalities. The most obvious of these is that preventing a potential fire in one building

negates the possibility of a fire spreading to the adjacent building(s). For these reasons it can be seen that fire protection would be undersupplied by the free market, that is private enterprise, and so there has been scope for public provision of these services/products and a role for government to intervene in order to provide the socially optimal level. However, as with all government spending, decisions have to be made on how to spend limited resources and, to this end, the cost-effectiveness of various fire prevention interventions needs to be considered.

The question that often arises is – are we spending too much or too little on prevention? It is not possible to answer this question using total costs. Rather, economists often refer to marginal costs and benefits when assessing the optimal amount of a good or service to produce. The concept of marginality can be explained as the extra cost or benefit of producing one more unit of a good or service. The optimal amount of fire prevention that should be produced is when the marginal cost of producing it is equal to the marginal benefit gained from the consumption of the preventive good. The following figure explains this further:

The optimal provision of preventive fire goods and services is at Q1 in Figure 4. Any more and marginal costs exceed marginal benefits. That is, we are adding more to our costs than benefits. And, with any less than Q1, it is possible to add more to benefits than costs by producing more.

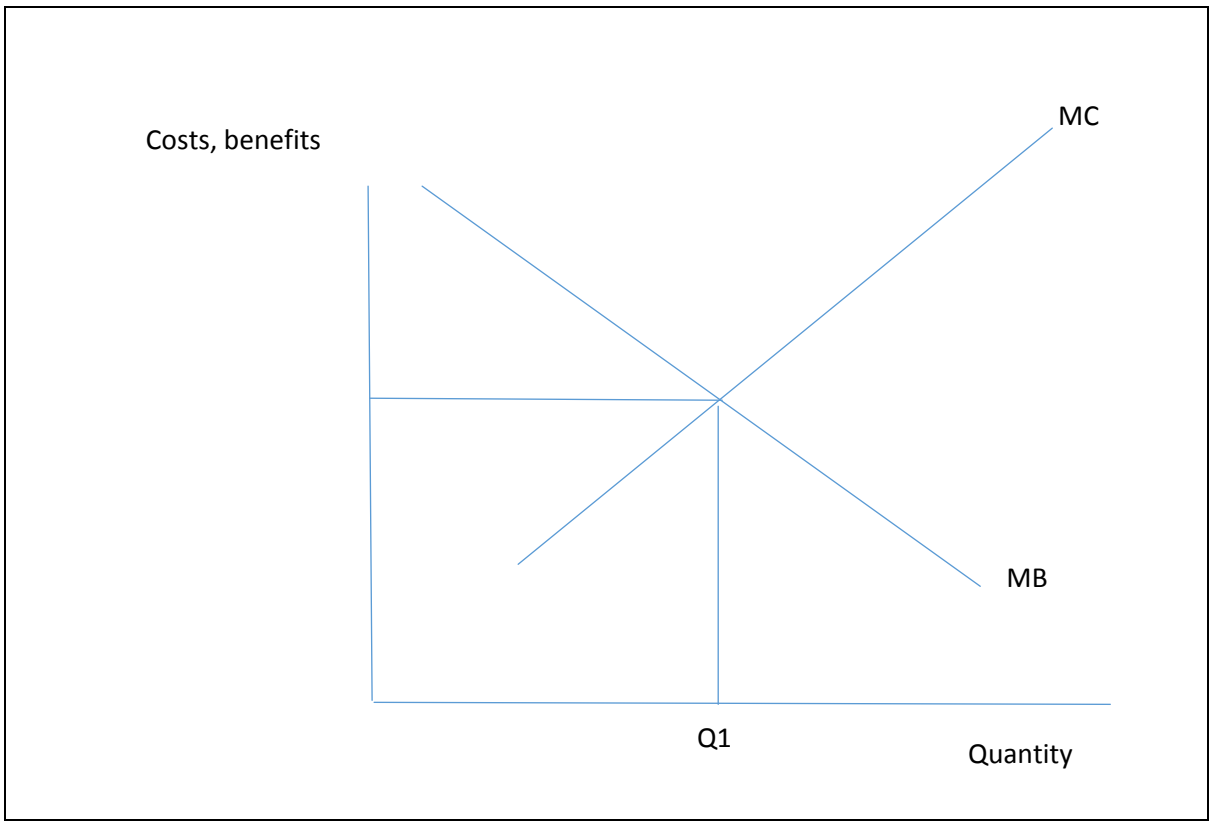

Figure 4: illustration of Marginal Cost (MC) and marginal benefit (MB) of fire prevention activities

Review of health economic analyses of interventions

There is a real paucity in the evidence on the economics of fire prevention (Table 1). The first study, by BRE 2012 [12], looks at the cost-effectiveness of sprinkler systems in the UK by conducting a cost benefit analysis. It concludes that there is no evidence that sprinkler systems are cost effective in preventing fires and that a NPV[2] (Net Present Value) of -£190.5 million shows the intervention is not cost effective in single occupancy housing. However for halls of residence and care homes, the NPV showed positive results. Another study on sprinkler systems, in the US, [19] showed that multipurpose network sprinkler systems are

[2] NPV - The difference between the present value of cash inflows (benefits) with the present value of cash outflows (costs)

cost effective with a positive NPV ranging from $2919 for colonial style house to $4166 for ranch style houses. Inflated to 2015 and converted into GBP[3] this would equate to £2550 and £3550. In a paper by Juas and Mattsson [20] it was found that in Sweden sprinkler systems are not cost effective, while smoke alarms and portable fire extinguishers are cost effective. Smoke alarms were said to provide an excess of benefit over cost of $19.10 per annum in 1993 prices. Fire extinguishers were calculated to provide benefits per household of $15.25 per annum while the annual cost of a fire extinguisher was only $6.25. They then assessed sprinkler cost-effectiveness in different settings. They were found to be cost effective in chemical plants and psychiatric wards, but not cost effective in the average manufacturing plant and hotels as they were too expensive.

The company Greenstreet Berman [21] conducted a study in 2013 to investigate the effectiveness and value for money of Home Fire Safety Checks (HFSC) in Wales. They conducted a cost analysis and found limited statistical evidence of an impact of the HFSCs on the rate of dwelling fires, deaths and casualties and an inverse relationship between funding and rate of fire casualties.

A paper by Buck and Yung [22] develops a risk-cost assessment model which is employed to assess the cost-effectiveness of fire safety systems in Australia and Canada. They argue that fire safety engineering design techniques can produce substantial cost savings while at the same time save lives. Two performance parameters were used to calculate the effect of a fire and these were a) expected risk to life and b) fire-cost expectation. These parameters were then assessed against six dwelling types and it was found that the dwelling type with a timber frame had the highest expected risk to life. The fire-cost expectation is not reported in this paper but is consistent with other research that shows that the most cost effective type of dwelling is the timber framed ones.

[3] Based on an exchange rate of £1:$1.43 as observed on 12/04/2016

Table 1 Evidence table highlighting current research in the field of the economics of fire prevention.

Author Date	Study type and description	Type of economic evaluation	Economic data results
BRE 2012 [12]	Report of cost benefits analysis of sprinkler systems for the Environment and Sustainability Directorate of Welsh Government	Cost Benefit Analysis	Overall net present value is -£190.5 million which shows that sprinklers are not cost effective
Juas & Mattsson 1994 [20]	Paper on the cost-effectiveness of different types of fire prevention	Cost Benefit Analysis	Smoke alarms provide a benefit of $19.10 per annum over costs. However this study was conducted in 1993.
Butry et al 2007 [19]	Report on residential fire sprinkler systems in the US	Cost Benefit Analysis	Net present value between $2919 and $4166 showing sprinklers can be cost effective
Greenstreet Berman 2013 [21]	An evaluation of Home Fire Safety Check (HFSC) work in Wales	Cost Analysis	Limited statistical evidence of an impact of the HFSCs on the rate of dwelling fires, deaths and casualties. There is an inverse relationship between funding and rate of fire casualties.
Parmer et al 2006 [25]	Analysis of smoke alarm installation in the US	Cost Analysis	For every 1% increase in alarm installation cost per alarm decrease by $1.32
Haddix et al 2001 [26]	Cost-effectiveness analysis of a smoke alarm giveaway programme in Oklahoma US.	Cost Effectiveness Analysis	From the health care system perspective, the total discounted net savings were almost $1 million and would have a net saving even if program effectiveness was reduced by 64%

A US study on the cost-effectiveness of smoke alarms [25] found that for every 1% increase in alarm installation the costs per alarm decreased by $1.32 showing that, as more smoke alarms are installed effective economies of scale take place. In relation to Figure 4 this would represent a tailing off and eventual fall in the marginal cost curve. The final study [26] that was found in this brief literature review was a study from the US on an

intervention to introduce free smoke alarms. The authors here found that from the health care system perspective, the total discounted net savings were almost $1 million and would have a net saving even if program effectiveness was reduced by 64%.

According to Hadjisophocleous and Kyle [23] the National Research Council of Canada (NRC) is developing a computer fire risk-cost assessment model that can be used to assess both the expected risk to life to the occupants and the expected costs of fire protection and fire losses in a building. The computer model is referred to as FiRECAMTM (Fire Risk Evaluation and Cost Assessment Model). The authors note that "To permit flexibility and cost-effectiveness in fire safety designs, many countries in the world, notably New Zealand, the U.K. and Australia, are moving towards performance-based building regulations, and away from the present restrictive, prescription-based regulations." They argue that, unlike prescription based regulations, performance based regulations allow the same level of life saving potential but at a lower cost.

Economic decisions concerning fire safety may have to deal with several attributes involving different methods of fire protection and consideration of different populations at risk. Also the need to choose among solutions may have to be met by different parties such as fire safety regulators, insurers, architects, manufacturers of fire protection measures, property owners and buyers. In a paper by Vaidogas et al [24] the authors suggest a Multi Criteria Decision Analysis (MCDA) to formalise this choice. They argue that selecting the most cost-effective solution would be difficult for a property owner faced with different and sometimes conflicting criteria. They suggest that MCDA can be successfully used to make these difficult choices.

We see therefore that, although this topic has an evidence base, there are gaps in our understanding of the cost-effectiveness of specific fire prevention interventions. Such information would help inform the use of limited resources for fire prevention activities.

Fire Prevention Policy in Wales

The Welsh Assembly Government has a fire safety policy for the Department of Health and Social Services. Its aims are twofold: to minimise the occurrence of fire in NHS estates in Wales; and to minimise the impact from fire on life safety, delivery of service and the

environment and property. It specifies that NHS organisations in Wales NHS organisations in Wales will:

- have a clearly defined fire safety policy covering all buildings they occupy
- nominate a board level director accountable to the Chief Executive for fire safety
- nominate a Fire Safety Manager to take the lead on all fire safety activities
- have an effective fire safety management strategy which enables:
  - the preparation and upkeep of the organisation's fire safety policy
  - adequate means for quickly detecting and raising the alarm in case of fire
  - means for ensuring emergency evacuation procedures for all areas, at all times the premises are occupied, without reliance on external services
  - all staff to receive fire safety training appropriate to the level of risk and duties they may be required to perform.

In terms of policy related to household dwellings in Wales, there is no specific policy document. However, a law was passed in 2014 stipulating that every new build in Wales should have a sprinkler system – the first policy of its kind anywhere in the world. The Domestic Fire Safety (Wales) Measure 2011 (REFERENCE) applies to newly built houses and blocks of flats, as well as care homes and university halls of residence. As the BRE report [12] showed mixed evidence of cost-effectiveness, the law has had its critics. Supporters of the measure, such as the Chief Fire Officers' Association, criticise the BRE report stating that they put a much lower value on a statistical life than is the case elsewhere in places such as Norway and the US. Further organisations such as the European Fire Sprinkler Network estimate the cost of sprinkler systems to reduce over time making them cost effective in the long run.

Conclusion

We see that the cost of fires in Wales is increasing if we assume that costs in Wales have increased in line with costs in England. Investment in fire prevention across Wales has the *potential* to reduce the prevalence of accidental fires and thus reducing the burden of costs needed to treat victims of fire related accidents, and other costs such as the cost of fire and rescue services, property damage and insurance administration, although the evidence supporting the actual effectiveness of these interventions is not conclusive. This report shows examples of studies specifically on the cost-effectiveness of fire prevention, such as sprinkler systems and smoke alarms. The evidence here points towards some circumstances under which such interventions can be cost effective. There are however areas which need further research such as the need for decision making tools for resource allocation and developing methods to assess and predict property, heritage and human loss from fire (27). Another area for future research would be on home safety interventions delivered in a primary care setting to measure the effectiveness of these programmes on injuries and see whether this is an appropriate area where health services can invest in fire prevention.

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