International Fire Death Rate Trends

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Fire Research

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Abstract

The number of fire fatalities in Sweden has not changed significantly during the last two decades, in spite of information campaigns and an increased use of smoke detectors and fire extinguishers in homes. In recognition of this The Swedish Civil Contingencies Agency initiated and funded a research program to investigate what could be done in order to reduce the fatalities in residential fires. This work is a first step in that process where fire fatalities statistics are studied to determine what measures have proven efficient in other countries. Both USA and Great Britain have reduced the number of fire fatalities steadily over the last three decades, and now have a lower fire death rate per capita compared to Sweden. One explanation to this could be that both countries have introduced fire regulations for furniture and furnishing, which is something that Sweden has not yet done.

Key words: Fire, fire fatalities, fire statistics, residential fires.

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Summary

Approximately 90 persons die every year in a domestic fire in Sweden. The number has not changed significantly during the last two decades, in spite of information campaigns and an increased use of smoke detectors and fire extinguishers in homes. In recognition of this The Swedish Civil Contingencies Agency initiated and funded a research program to investigate why the number has not decreased and what could be done in Sweden in order to reduce the fatalities in Sweden in residential fires. This work is a first step in that process where fire fatalities statistics are studied from other countries together with measures taken in these countries to determine what measures have proven efficient in other countries. The report is focused on technical parameters which could have an impact on the number of fatal residential fires. Information campaigns and similar activities that might contribute to the total impact are not studied.

Initially, a first screening of countries is made using data from the World Fire Statistics reports from CTIF – International Association of Fire and Rescue Services. Countries that show a significant decline in fire death rates are then chosen to be studied further, either by literature review or by analyzing available statistics from national fire incident reporting systems.

Overall, the death rates seem to decrease in most countries, but a few countries show major improvements during the last decade, with a fairly steady downwards trend:

- Estonia
- Germany
- Great Britain
- Latvia
- Russia
- USA

In this report, Great Britain and USA are chosen for a deeper study. Both countries now have a lower death rate per capita compared to Sweden. Except for an increased use of smoke alarms and sprinkler systems, which has been seen in Sweden as well during the same time period, both USA and Great Britain have introduced fire regulations for furniture and furnishings, and for children´s sleepwear. Evaluations of the regulations for furniture and furnishings show that a large part of the decline in fire fatalities can be attributed to these changes.

1 Introduction

Approximately 90 persons die every year in a domestic fire in Sweden [1]. The number has not changed significantly during the last two decades, in spite of information campaigns and an increased use of smoke detectors and fire extinguishers in homes. In recognition of this The Swedish Civil Contingencies Agency initiated and funded a research program to investigate why the number has not decreased and what could be done in Sweden in order to reduce the fatalities in Sweden in residential fires. This work is a first step in that process where fire fatalities statistics are studied from other countries together with measures taken in these countries to lower the number of fatalities in residential fires.

Since every country has different methods of data collection and analyses of fires, fire fatalities and fire injuries, direct comparisons will not be made between countries, instead trends are studied within the countries separately. Countries which have been successful in reducing fire fatalities are studied in more depth concerning regulations and other actions and parameters that can have had an influence on the number of fire fatalities.

1.1 Method

Initially, a first screening of countries is made using data from the World Fire Statistics reports [2, 3, 5, 6] from CTIF – International Association of Fire and Rescue Services. Countries that show a significant decline in fire death rates are then chosen to be studied further, either by literature review or by analyzing available statistics from national fire incident reporting systems.

1.2 Limitations

The statistics used in this report are primarily statistics from CTIF and the World Fire Statistics Centre together with country specific data. Data from CTIF and the World Fire Statistics Centre differs for some countries while the data is more similar for other countries. No further analysis of the reasons for these discrepancies is made.

Reporting practices varies from country to country and there may be large differences in definitions, how data is collected as well as other uncertainties when comparing statistics between different countries. The focus in the study is on trends in number of fatalities and therefore a direct comparison of numbers in different countries is not of interest, which makes the different statistics collection habits in different countries less crucial. In addition, as trends are of interest there is no need to analyse the data against different living conditions in the countries.

2 Screening of countries

In the first screening of countries, data from the World Fire Statistics reports [2, 3, 5, 6] from CTIF – International Association of Fire and Rescue Services is studied. The reports provide statistics on numbers and rates of fires, fatalities and injuries due to fires, and on-duty firefighter fatalities and injuries, from 42 countries between the years 2002-2012.

Since every country has different methods of data collection and analyses of fires, fire fatalities and fire injuries, direct comparisons should not be made between countries. The purpose is to look at the trend in each country, in order to find any significant changes and if any specific reasons for these changes can be found.

Figure 1 – Figure 22 show number of fire fatalities per year for the studied time period, and number of fatalities per year per 100 000 inhabitants. The countries are shown primarily in alphabetical order. To account for demographic trends in each country, population data from the United Nations [7] for each year have been used. This data is presented in order to be able to select countries for further study. All diagrams showing the actual number of fire fatalities are based on the CTIF reports number 11, 13, 16, 17 and 18 [2, 3, 4, 5, 6]. The diagrams showing the number per 100 000 inhabitants is based on the CTIF reports together with the population data from the United Nations [7] for each year. In some cases data is not available for all years, in those cases no point for that particular year is provided in the diagrams.

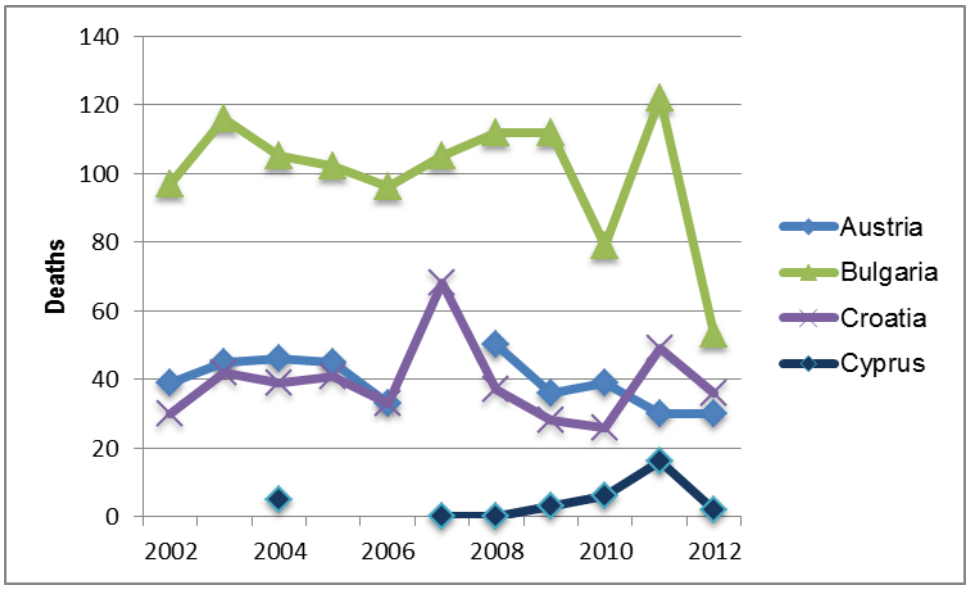

Figure 1 **Fire fatalities in Austria, Bulgaria, Croatia and Cyprus.**

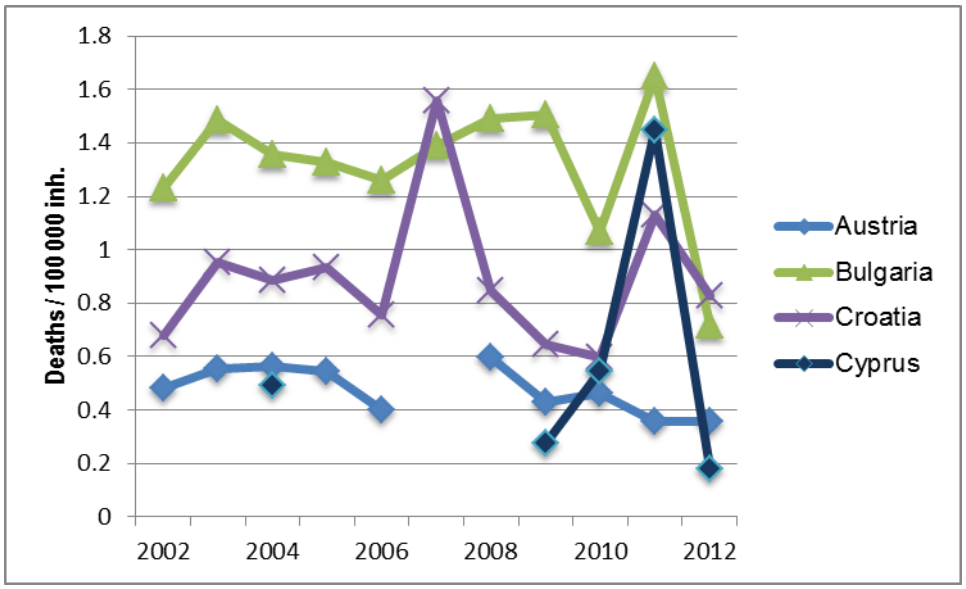

Figure 2 **Fire fatalities per 100 000 inhabitants in Austria, Bulgaria, Croatia and Cyprus.**

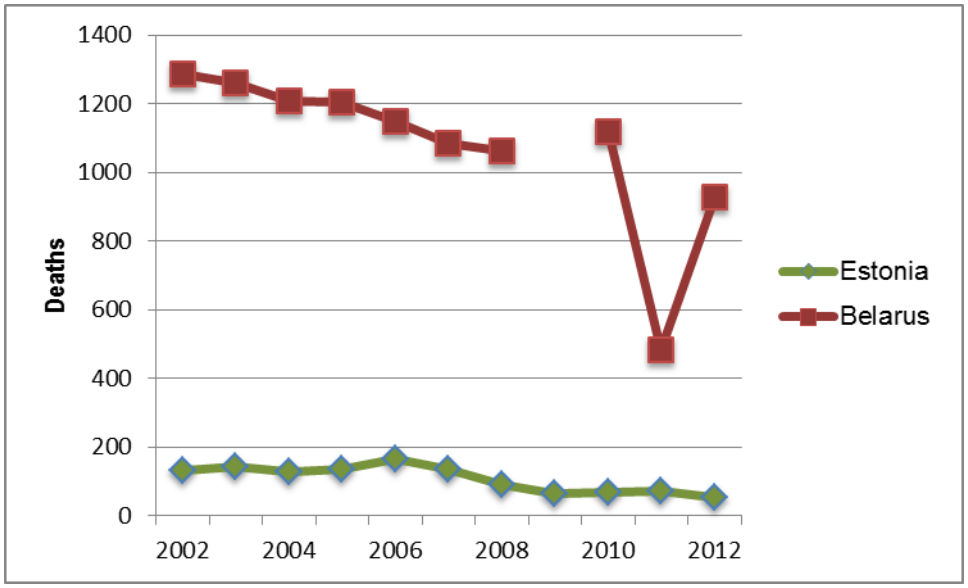

Figure 3 **Fire fatalities in Estonia and Belarus .**

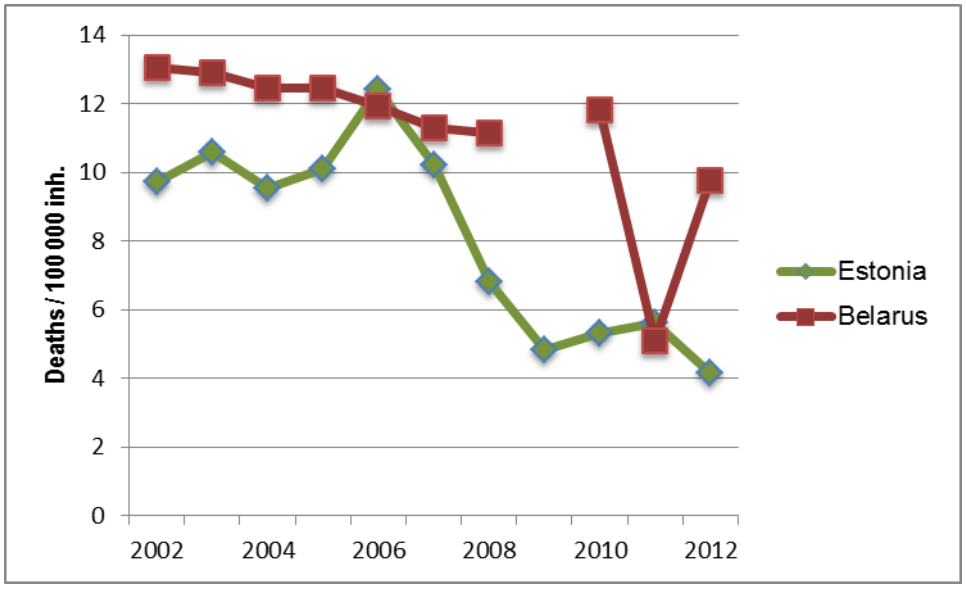

Figure 4 **Fire death rates per capita in Estonia and Belarus.**

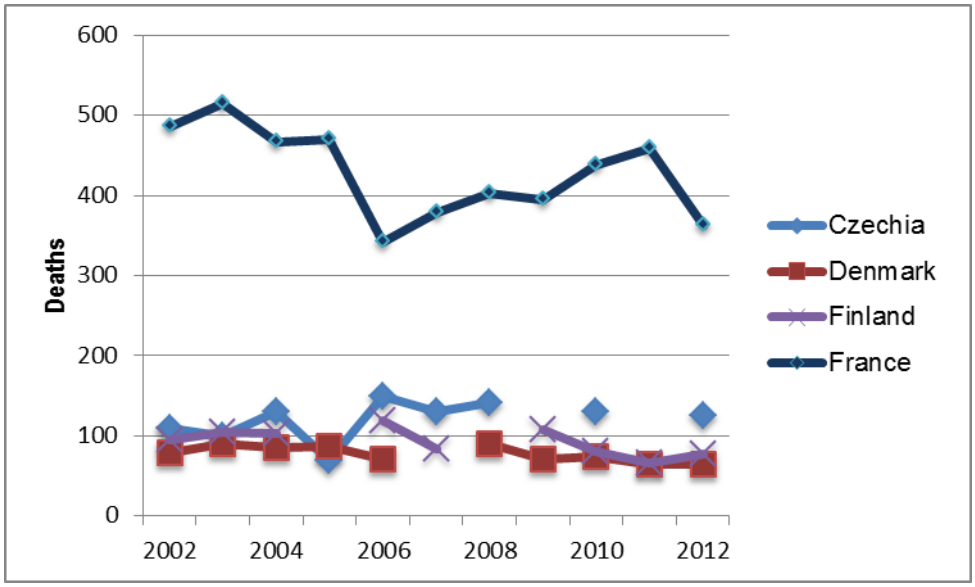

Figure 5 **Fire fatalities in Czechia, Denmark, Finland and France.**

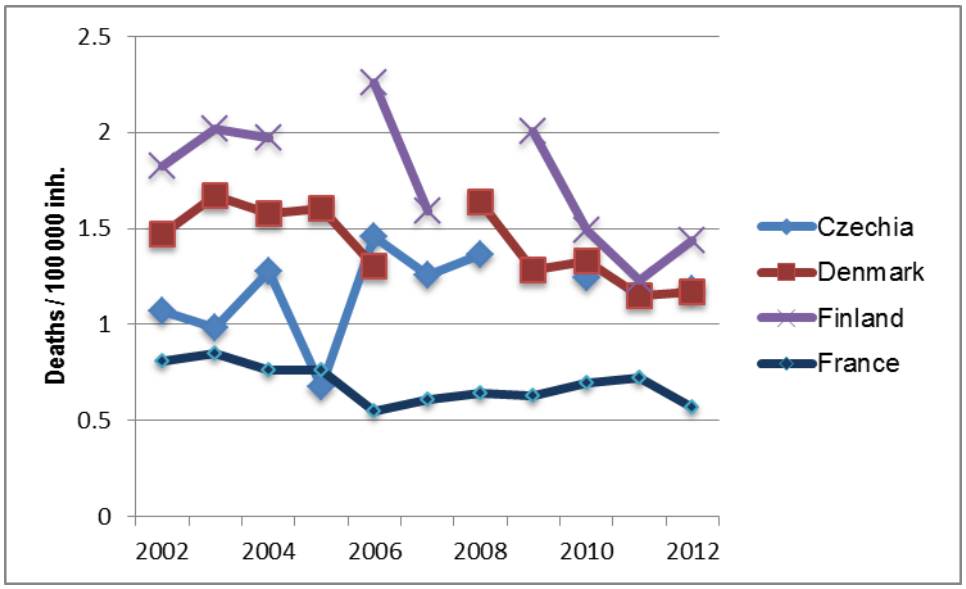

Figure 6 **Fire death rates per capita in Czechia, Denmark, Finland and France.**

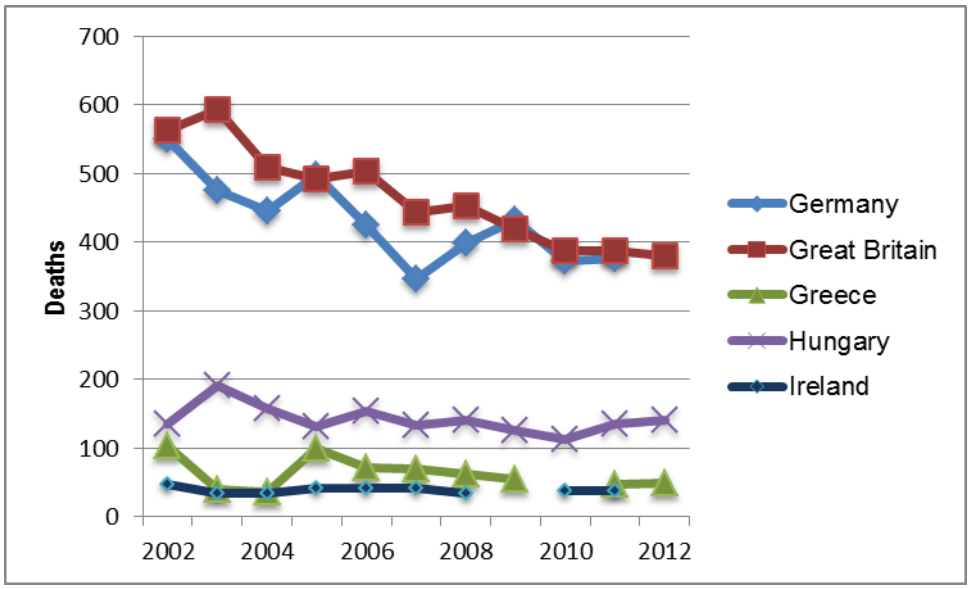

Figure 7 **Fire fatalities in Germany, Great Britain, Greece, Hungary and Ireland.**

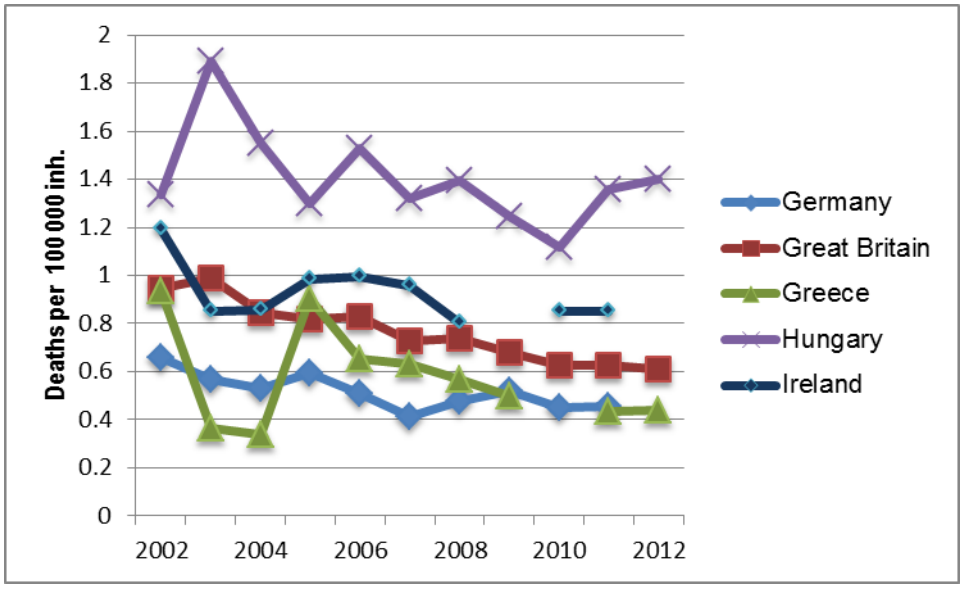

Figure 8 **Fire death rates per capita in Germany, Great Britain, Greece, Hungary and Ireland.**

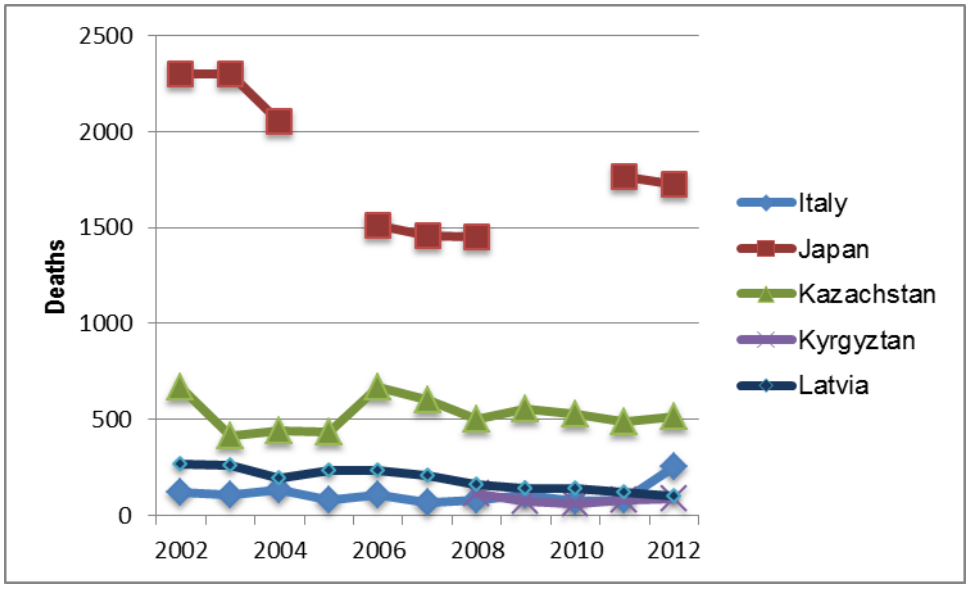

Figure 9 **Fire fatalities in Italy, Japan, Kazachstan, Kyrgyztan, and Latvia.**

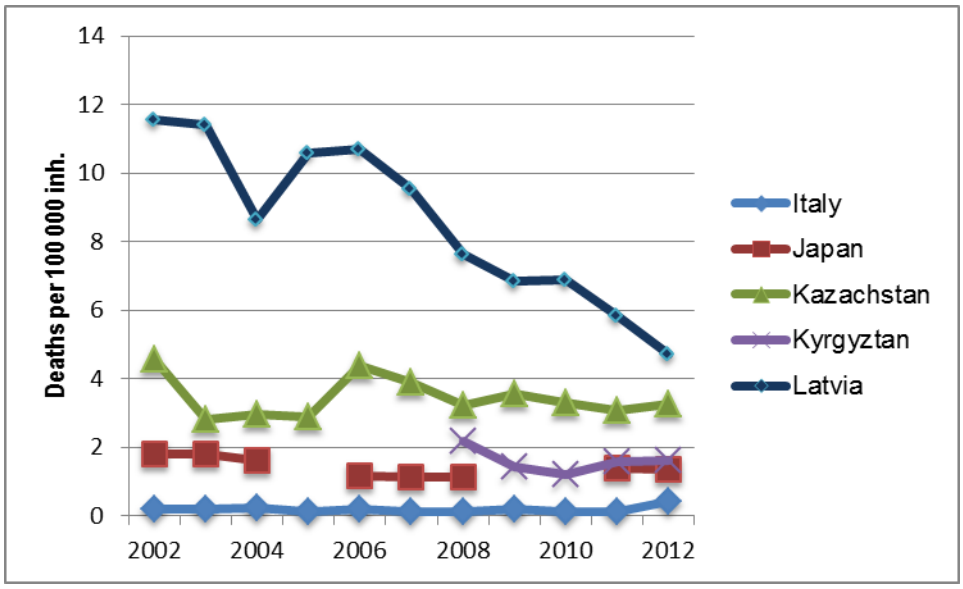

Figure 10 **Fire death rates per capita in Italy, Japan, Kazachstan, Kyrgyztan, and Latvia.**

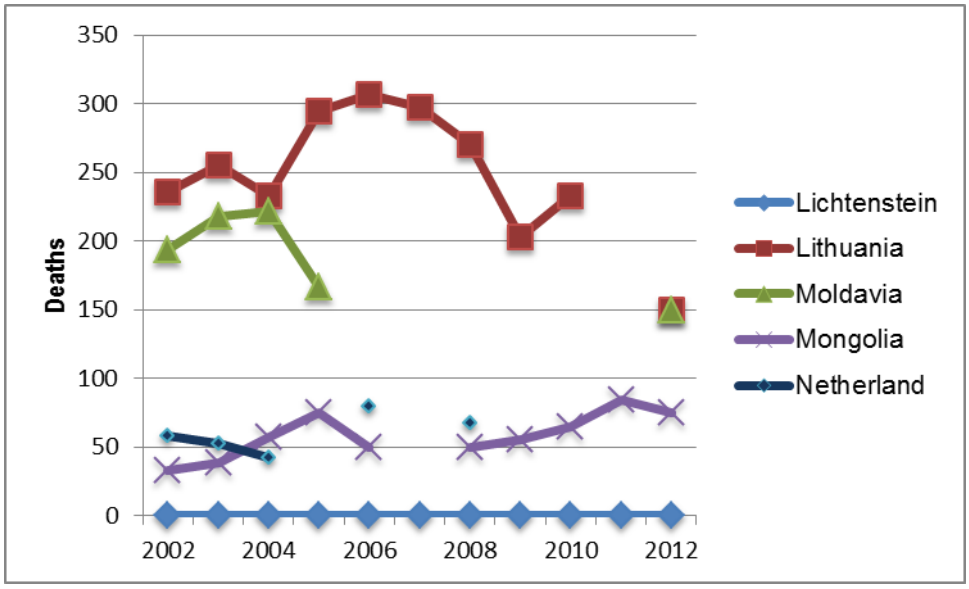

Figure 11 **Fire fatalities in Lichtenstein, Lithuania, Moldavia, Mongolia and Netherland.**

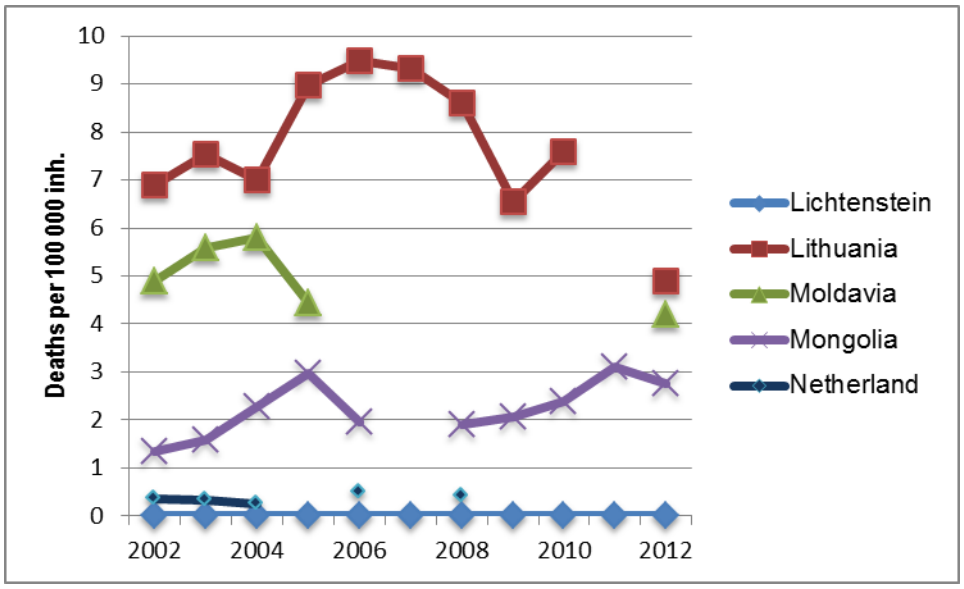

Figure 12 **Fire death rates per capita in Lichtenstein, Lithuania, Moldavia, Mongolia and Netherland.**

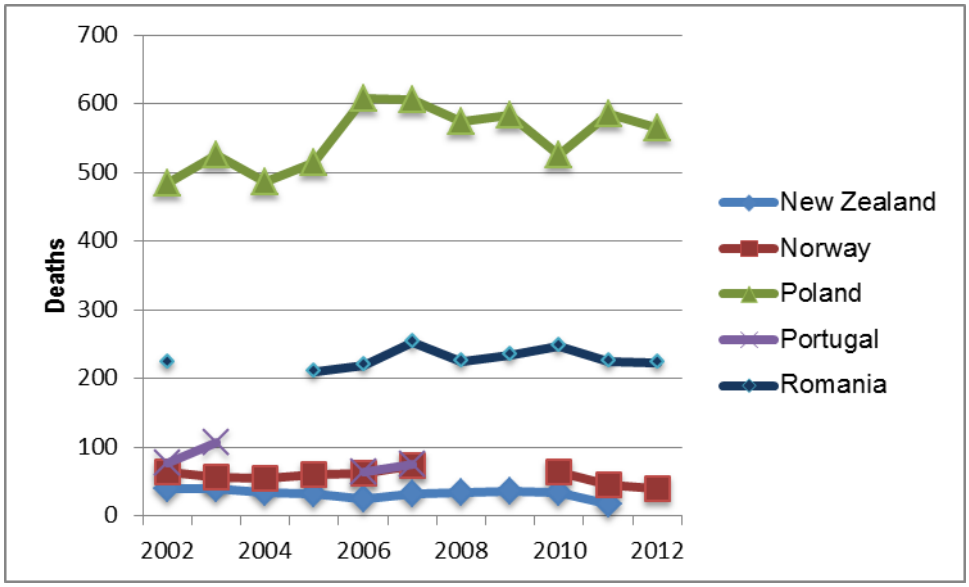

Figure 13 **Fire fatalities in New Zealand, Norway, Poland, Portugal and Romania.**

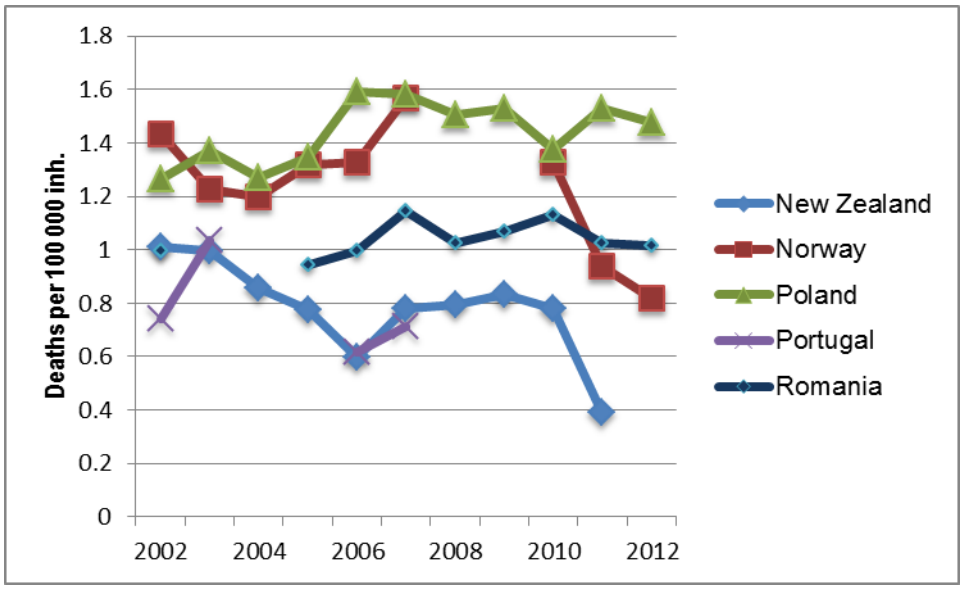

Figure 14 **Fire death rates per capita in New Zealand, Norway, Poland, Portugal and Romania.**

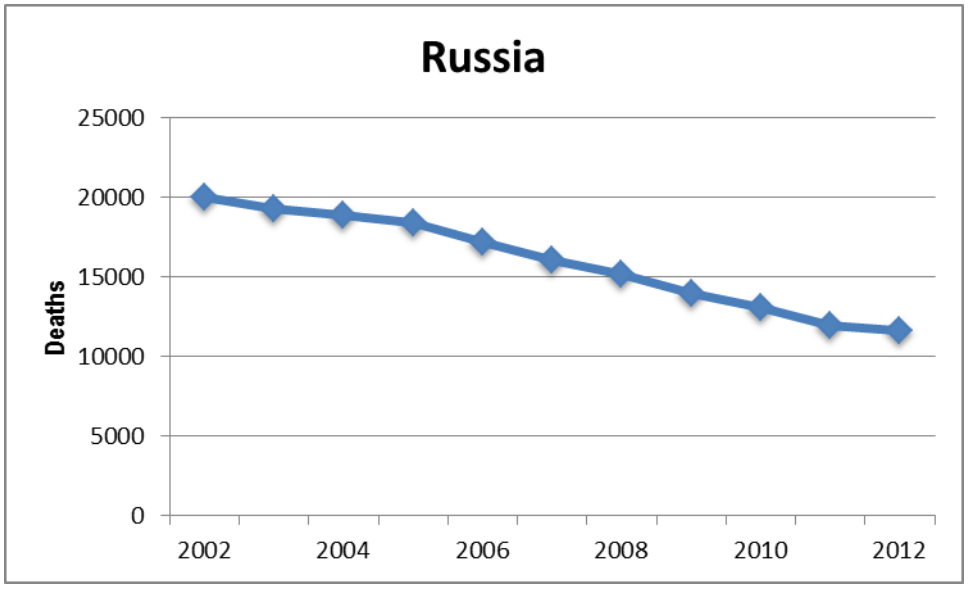

Figure 15 Fire fatalities in Russia.

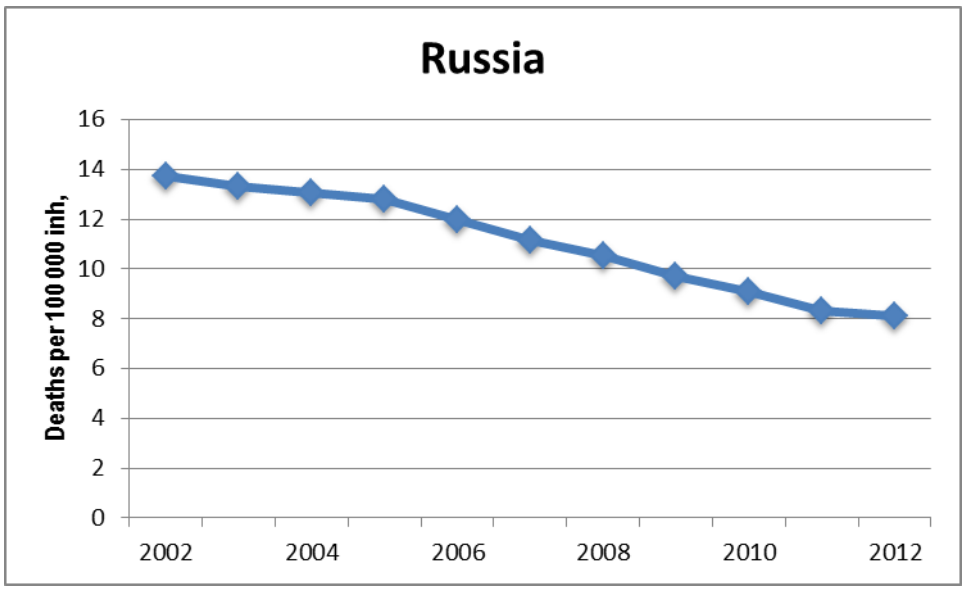

Figure 16 Fire death rates per capita in Russia.

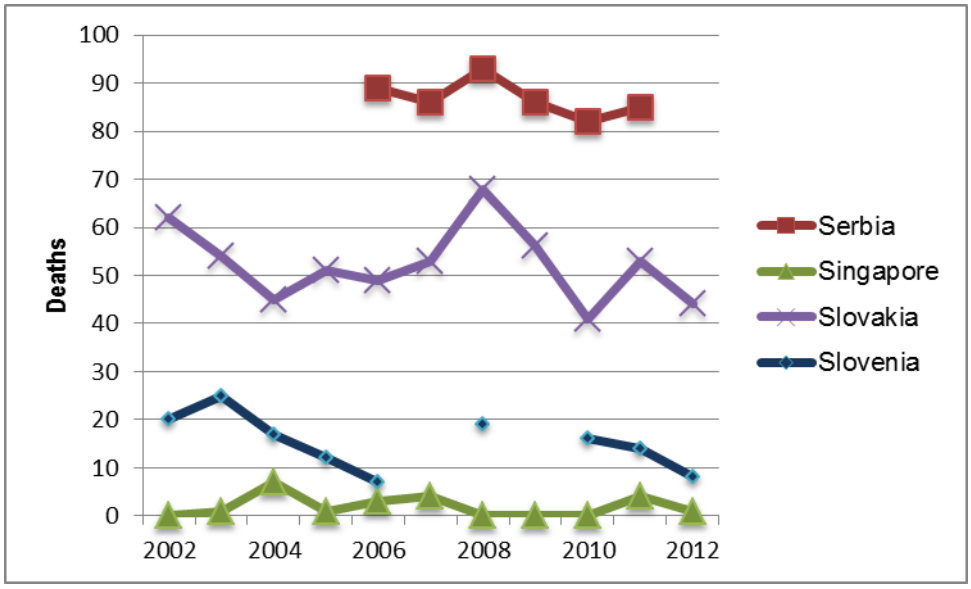

Figure 17 **Fire fatalities in Serbia, Singapore, Slovakia and Slovenia.**

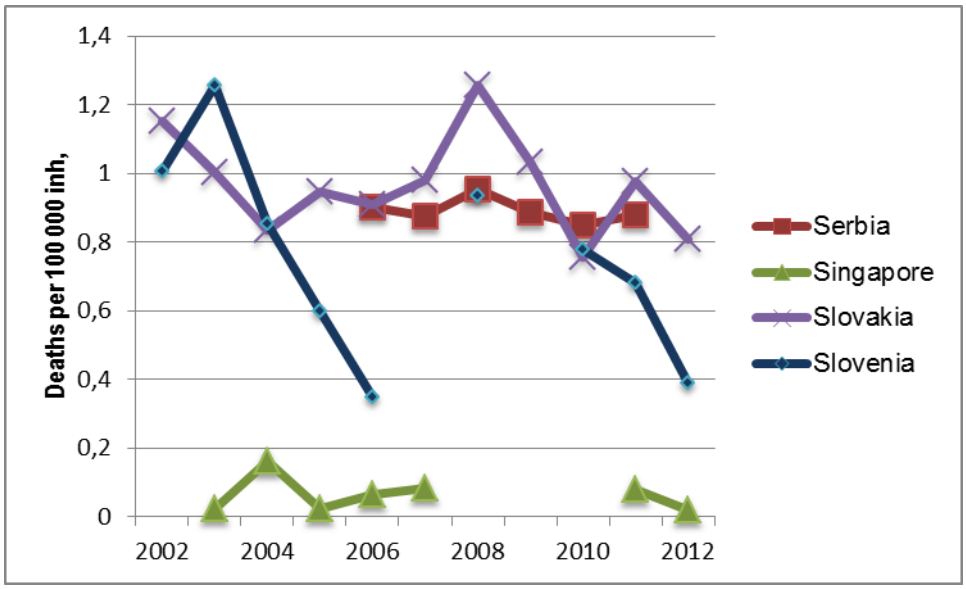

Figure 18 **Fire death rates per capita Serbia, Singapore, Slovakia and Slovenia.**

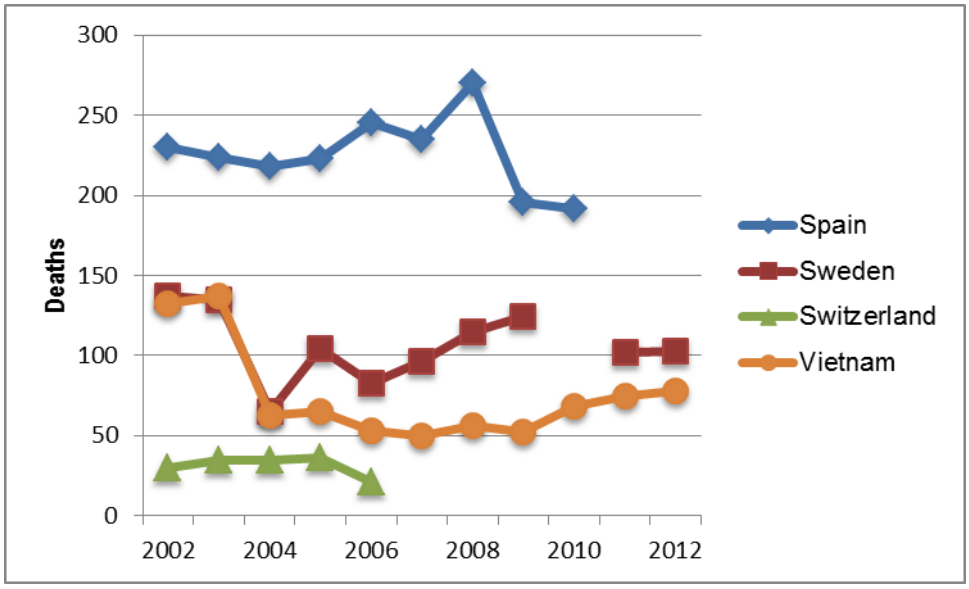

Figure 19 **Fire fatalities in Spain, Sweden, Switzerland and Vietnam.**

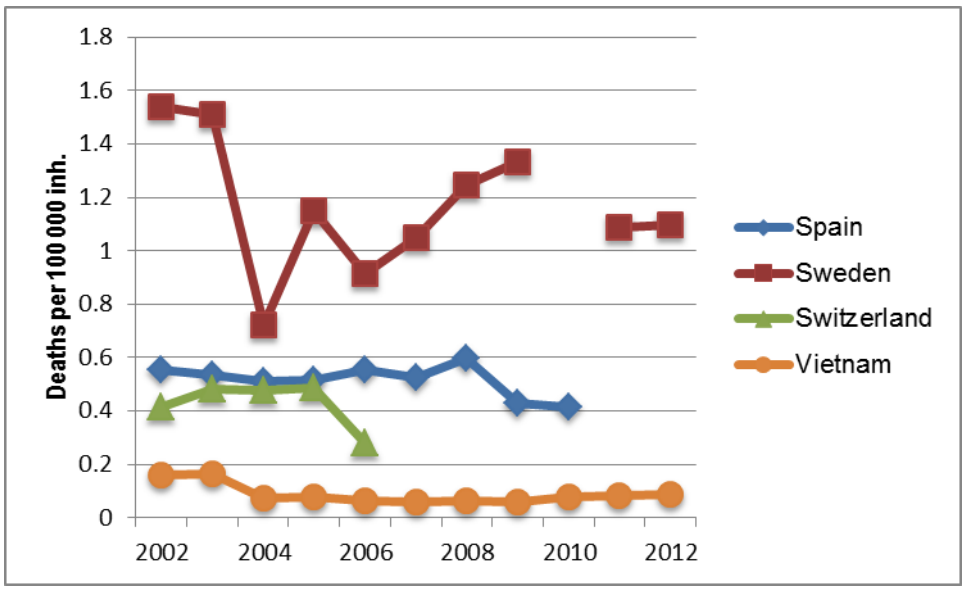

Figure 20 **Fire death rates per capita in Spain, Sweden, Switzerland and Vietnam.**

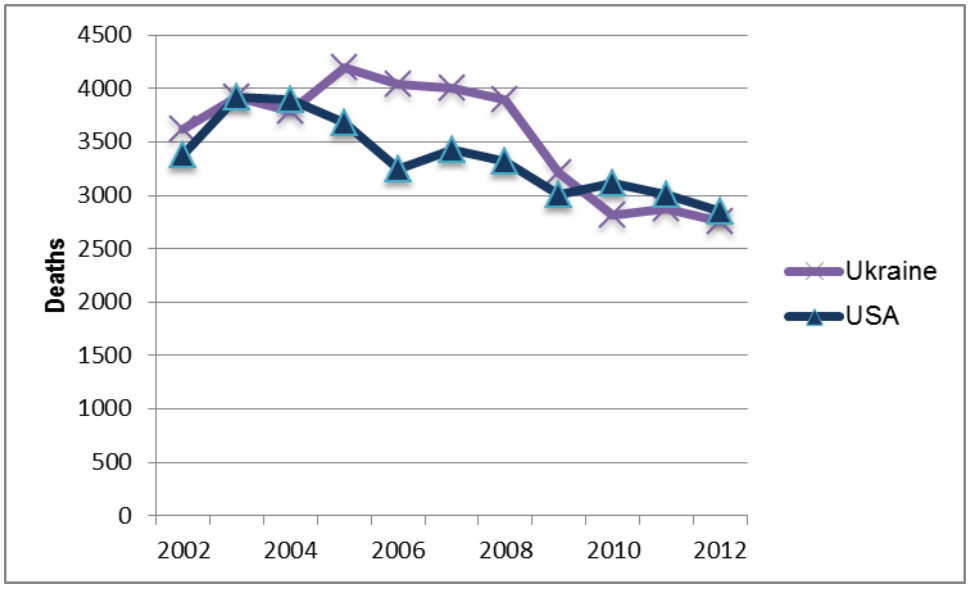

Figure 21 **Fire fatalities in Ukraine and USA.**

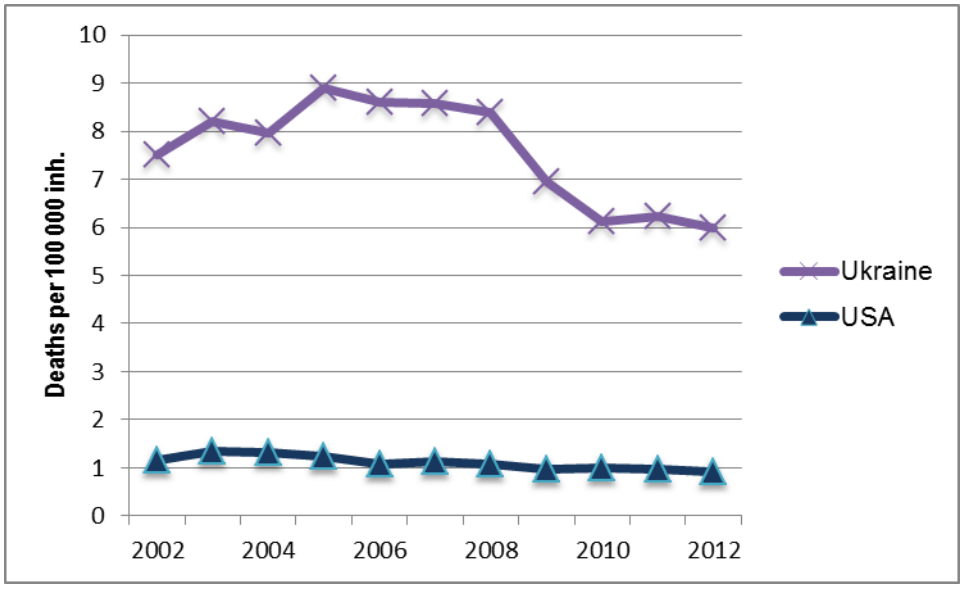

Figure 22 **Fire death rates per capita in Ukraine and USA.**

3 Countries chosen for further study

Overall, the death rates seem to decrease in most countries. A few countries show major improvements during the last decade. As can be seen if figures 3, 4, 7, 8, 9, 10, 15, 16, 21 and 22, the countries that stand out the most, showing a fairly steady downwards trend, are:

- Estonia
- Germany
- Great Britain
- Latvia
- Russia
- USA

The changes in fire fatalities per year, and in fire fatalities per 100 000 inhabitants per year, are shown in Table 1. The changes are estimated by linear regression, see Annex A, where the fit ratio (R^2) shown in the table indicates the amount of variability between the data and the linear trend line. The fit ratio can vary between 0 and 1, where 1 means that all data points fit the linear trend line perfectly. The countries selected for further study are the ones showing the largest reduction in fire fatalities per 100 000 inhabitants, in combination with a high fit ratio.

Table 1

	Fire death reduction (Linear change per year)	Fit Ratio (R^2)
Estonia	-9.6	0.69
Germany	-16.5	0.63
Great Britain	-20.8	0.92
Latvia	-16.4	0.89
Russia	-900	0.99
USA	-90	0.69
	Fire death reduction per 100 000 inhabitants (Linear change per year)	**Fit Ratio (R^2)**
Estonia	-0.70	0.67
Germany	-0.019	0.62
Great Britain	-0.038	0.93
Latvia	-0.66	0.86
Russia	-0.61	0.98
USA	-0.039	0.78

The number of deaths per year per 100 000 inhabitants for these countries are shown in Figure 23 and Figure 24. The former Soviet states all have significantly higher death rates per capita (9-14 in 2002) compared to the other European countries and the U.S (0.7-1.2 in 2002).

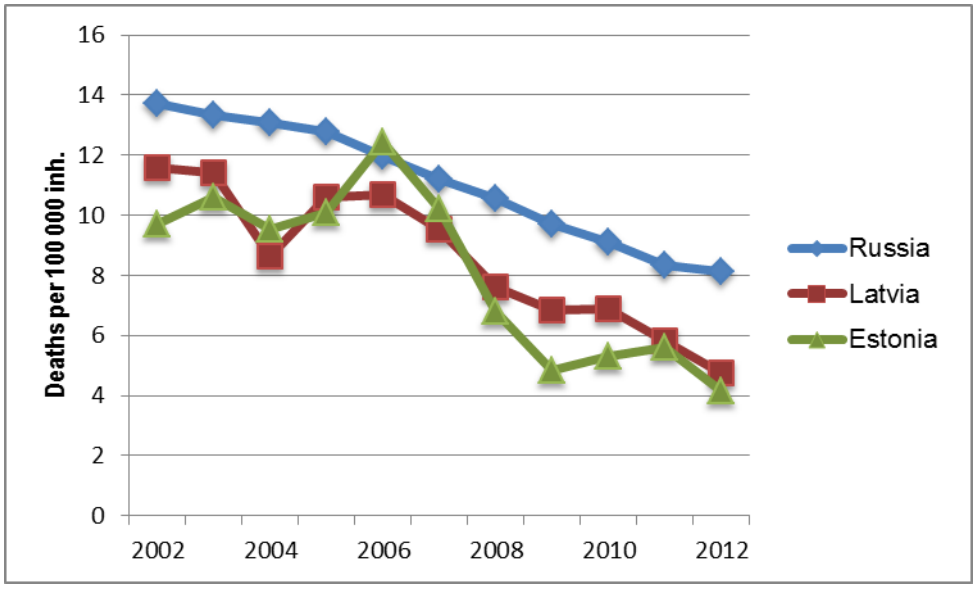

Figure 23 **Fire death rates per capita for the Former Soviet states [2, 3, 5, 6, 7].**

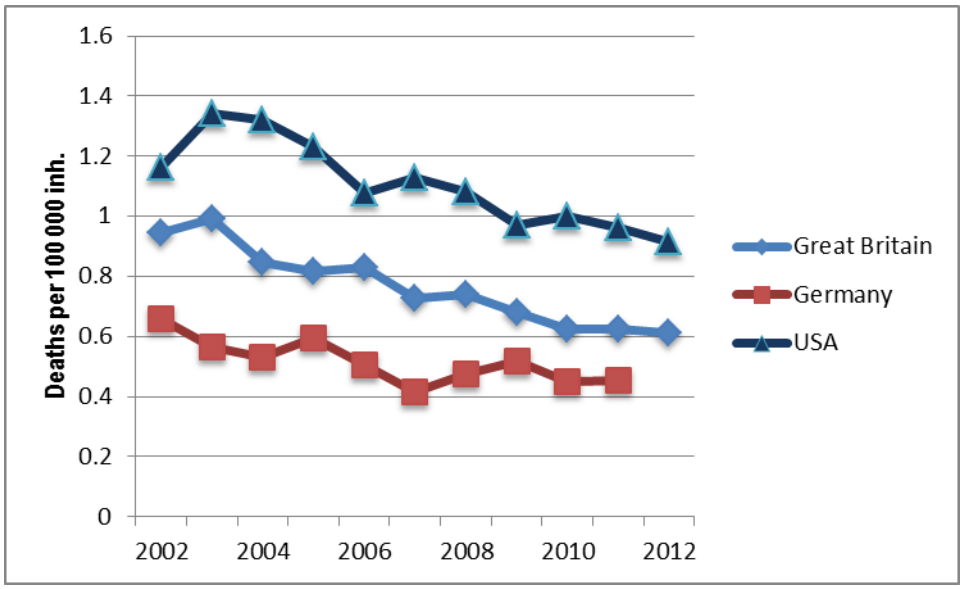

Figure 24 **Fire death rates per capita for the Great Britain, Germany and USA [2, 3, 5, 6, 7].**

The data from all countries might differ slightly depending on which source is studied. A comparison between data from CTIF and the World Fire Statistics Centre [8] is shown in Figure 25 – Figure 30. For Russia, there is a big difference between the two data sources, but a clear downward trend can still be seen. For Germany, Great Britain and USA, the downwards trend can be seen for two decades, and the data from the two sources match quite well. For Estonia, data from [9] has been included for the years 1989-1995.

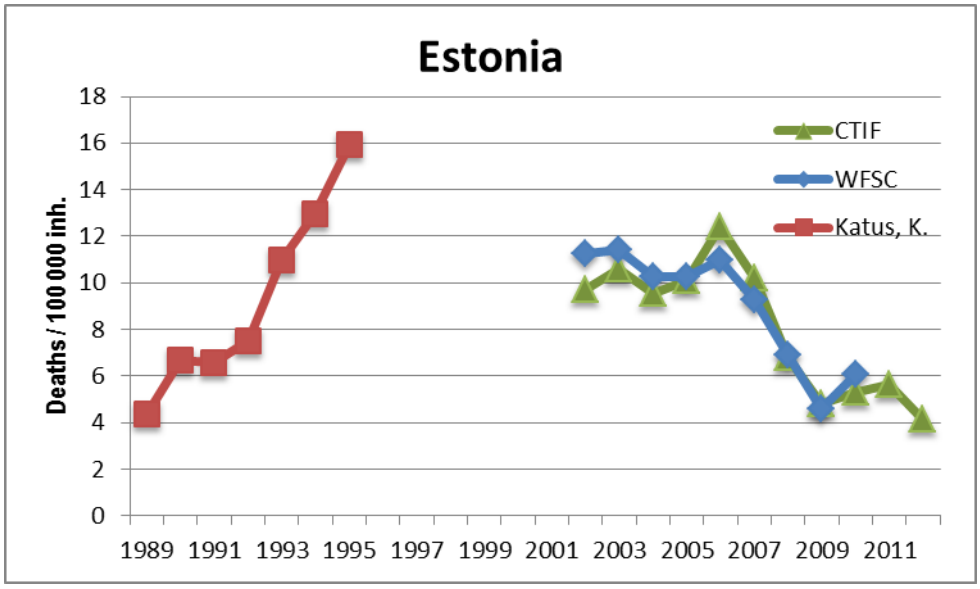

Figure 25 **Fire death rate per capita for Estonia [2, 3, 5, 6, 7, 9].**

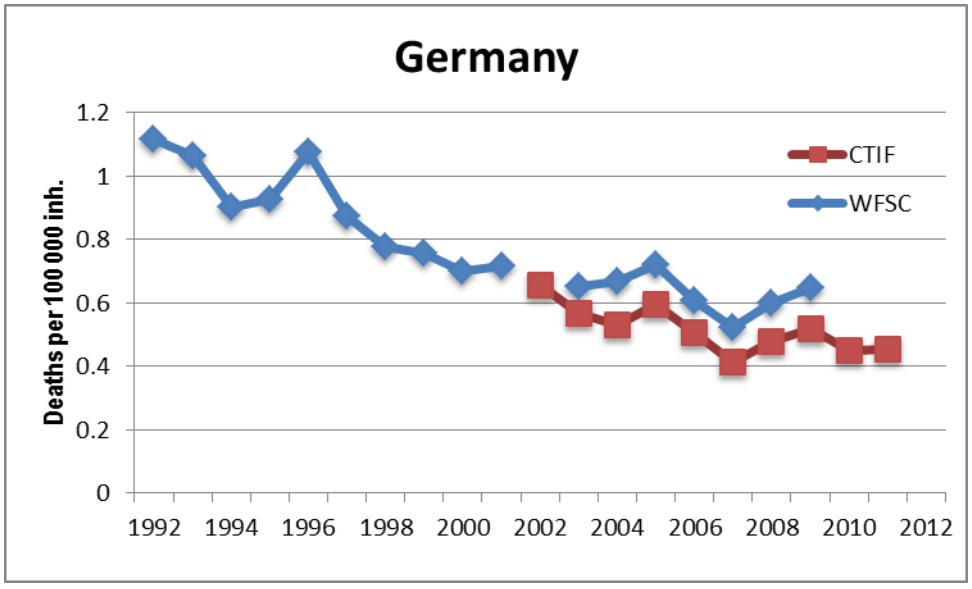

Figure 26 **Fire death rate per capita for Germany [2, 3, 5, 6, 7, 8].**

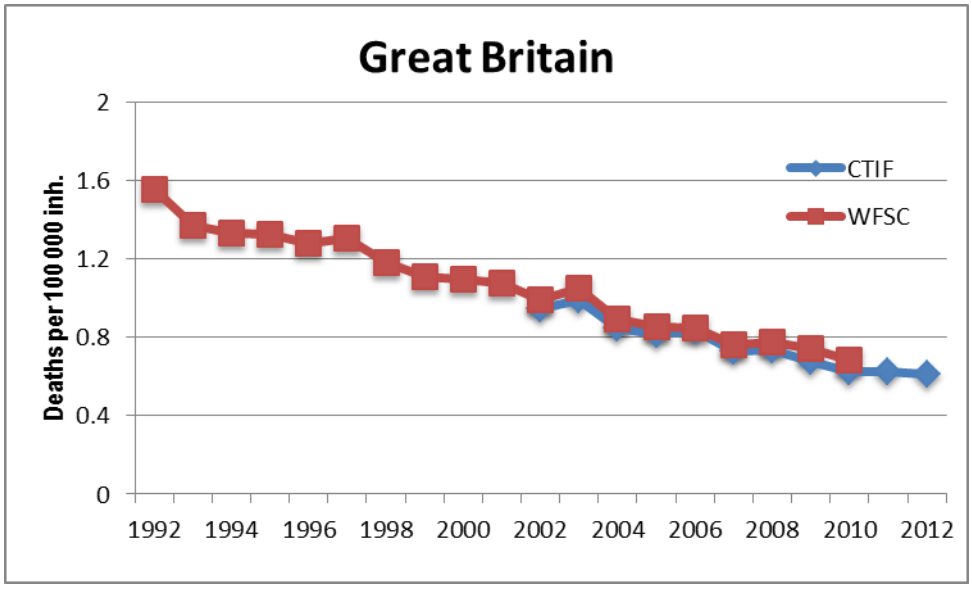

Figure 27 **Fire death rate per capita for Great Britain [2, 3, 5, 6, 7, 8].**

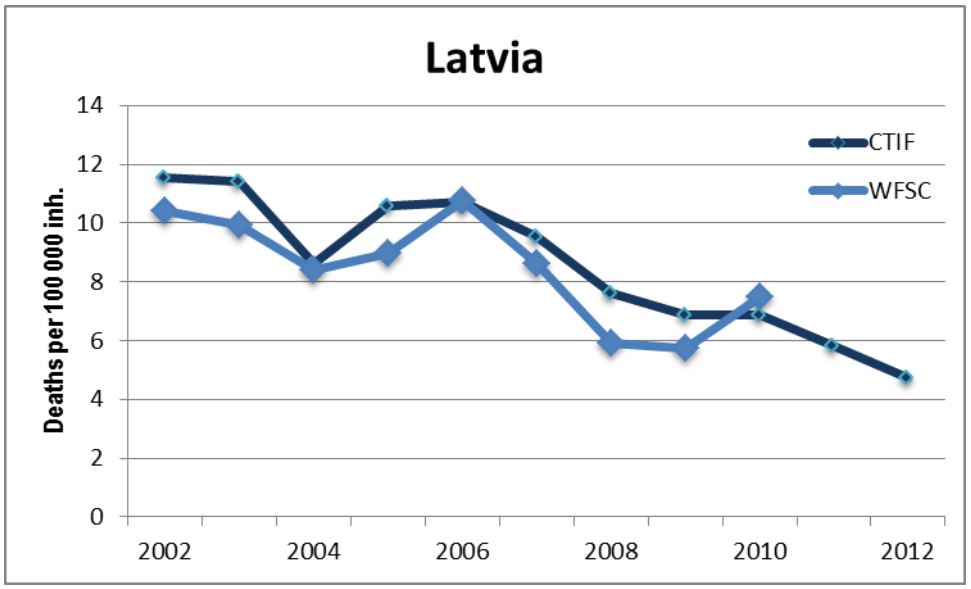

Figure 28 **Fire death rate per capita for Latvia [2, 3, 5, 6, 7, 8].**

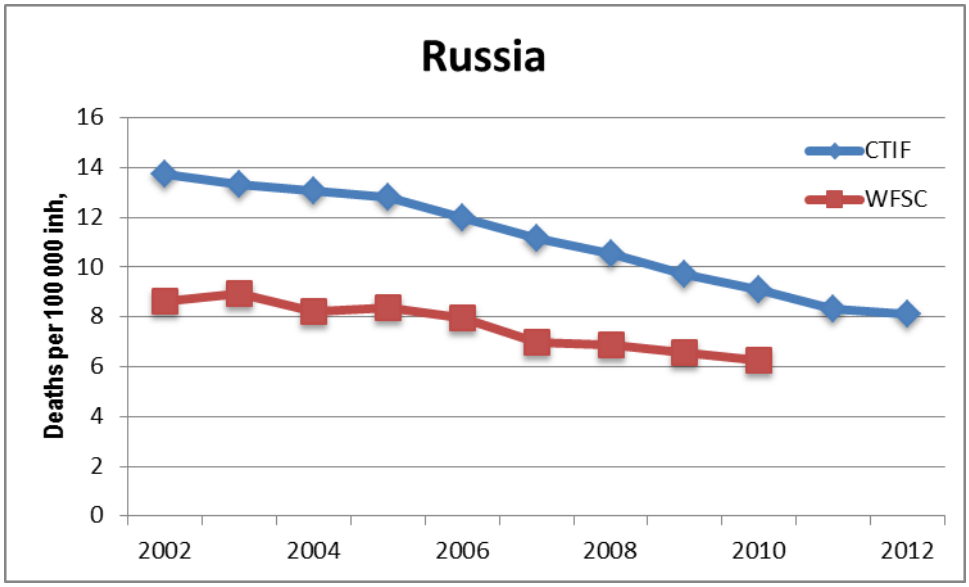

Figure 29 **Fire death rate per capita for Russia [2, 3, 5, 6, 7, 8].**

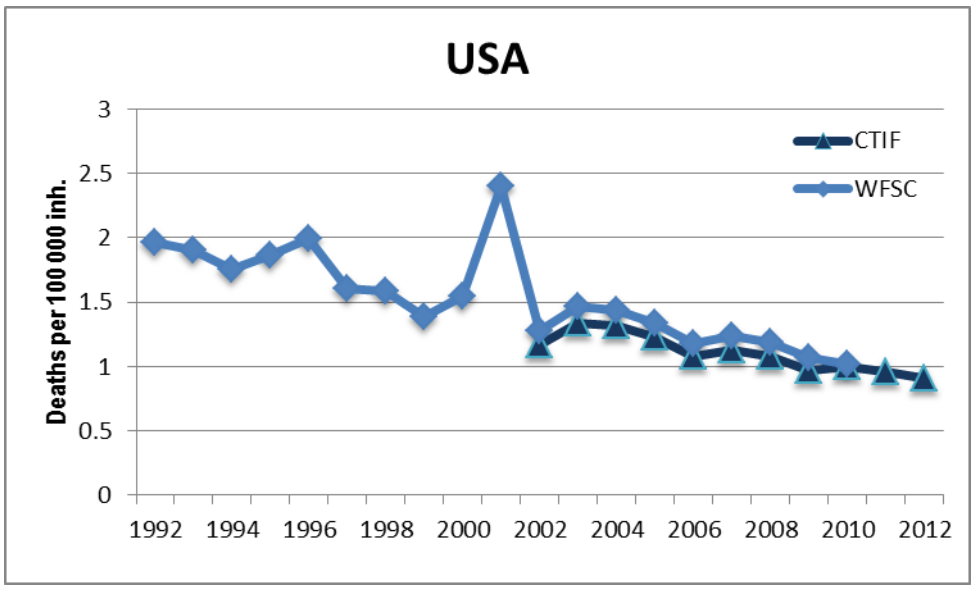

Figure 30 **Fire death rate per capita for USA [2, 3, 5, 6, 7, 8] (The peak in 2001 is due to 2791 deaths from 9/11).**

The trend in Estonia is quite interesting, where fire death rates rose steeply between 1991-1995. The same trend can be seen for other accidental fatalities for the same time period, e.g. drownings (95 % increase) and other injuries (122 % increase). The increase in accidents coincide with Estonia's independence from the Soviet Union, as well as an increase in smoking and alcohol consumption [9]. It is therefore likely that social factors have a much greater impact compared to the impact of changing dwelling characteristics during the short time period. Therefore, and also due to the limited available data for the former Soviet states, these countries are not analyzed further in this report. The death rate trends in Germany will be described in more detail in another report, and is therefore not discussed further in this report. Thus the study in this report focuses on the USA and UK as these showed both a significant decrease in fire deaths per capita and a high R2 fit-ratio.

3.1 USA

The number of fire deaths per 100 000 inhabitants decreases significantly between 1992 and 2012 with approximately 50 %. This trend, and the vast amount of available data from fires, makes the U.S. a very interesting country to examine closer.

The U.S. Fire Administration (USFA) uses the National Fire Incident Reporting System (NFIRS) and data from a variety of sources to provide information of the fire problem in the United states. Select data sets for the years 2000-2011 are presented on their website. They also provide the NFIRS Public Data Release (PDR), for each year from 1980 and forward. The PDR is a relational database of twenty tables tied together by a two, five or six variable key, and contains more than two million incidents per year. The raw data can be used, for example, to determine leading causes and factors of specific types of fire. However, it should not be used as a count of fires and associated deaths or injuries, since all fires are not reported into the system.

3.1.1 Differences at state level

There is a significant difference between the different states regarding the fire death rate per capita, which can be seen in Table 2. The death rate is more than four times higher in Mississippi and District of Columbia compared to California and Massachusetts. Geographically, the majority of the states with a relatively high death rate (>1.5 deaths per 100 000 inh.), belong to the American South, which can be seen in Figure 31. The southern states Florida and Virginia, however, are not consistent with this pattern. On the contrary, they belong to the top ten states with the lowest fire death rate. In a study of the state differences, several socioeconomic and behavioral factors show notable correlations, including poverty, smoking, rural and education [10].

Table 2 State Fire Fatalities and Fire Death Rates Per 100 000 Population (2011) [11]

State	Fire Deaths (2011)	Fire Death Rate Per 100 000 inh. (2011)	State	Fire Deaths (2011)	Fire Death Rate Per 100 000 inh. (2011)
California	234	0.62	**North Carolina**	132	1.37
Massachusetts	41	0.62	**South Carolina**	65	1.39
New Jersey	56	0.63	**North Dakota**	10	1.46
Florida	123	0.64	**Pennsylvania**	190	1.49
Utah	18	0.64	**Maine**	20	1.51
Idaho	11	0.69	**Rhode Island**	16	1.52
Arizona	50	0.77	**Arkansas**	45	1.53
Virginia	64	0.79	**Kentucky**	70	1.60
New Hampshire	11	0.83	**Missouri**	98	1.63
Colorado	43	0.84	**Alaska**	12	1.66
Maryland	50	0.86	**Georgia**	166	1.69
New York	170	0.87	**West Virginia**	32	1.72
Wisconsin	52	0.91	**Montana**	18	1.80
Nebraska	17	0.92	**South Dakota**	15	1.82
Washington	64	0.94	**Tennessee**	119	1.86
Connecticut	34	0.95	**Louisiana**	86	1.88
Illinois	131	1.02	**Oklahoma**	75	1.98
Texas	261	1.02	**Kansas**	57	1.99
Minnesota	56	1.05	**Alabama**	114	2.37
Nevada	29	1.07	**Mississippi**	81	2.72
Ohio	124	1.07	**District of Columbia**	17	2.74
New Mexico	23	1.11	**Delaware**	–	–
Indiana	79	1.21	**Hawaii**	–	–
Michigan	123	1.25	**Vermont**	–	–
Oregon	51	1.32	**Wyoming**	–	–
Iowa	41	1.34			

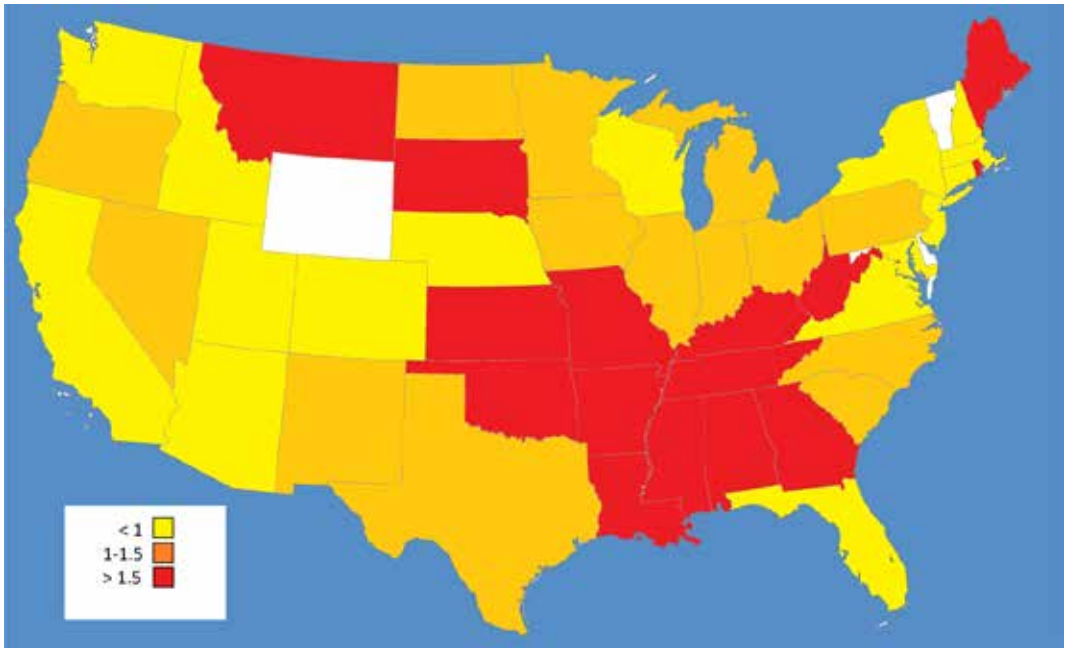

Figure 31 Fire death rates per 100 000 inhabitants in the different states [11].

3.1.2 Property type

The distribution between different property types where fire fatalities occur is shown in Figure 32, for 2011. The majority of fire fatalities occur in residential buildings. A further breakdown of the residential building property types is shown in Figure 33 and Figure 34, for the years 2003 – 2012. The number of fires each year are decreasing slowly in 1 & 2 Family and Multifamily properties. The number of fire fatalities are decreasing in all property types, and the biggest difference can be seen in 1 & 2 Family properties, where the number of fatalities have decreased by almost 25 % in 10 years.

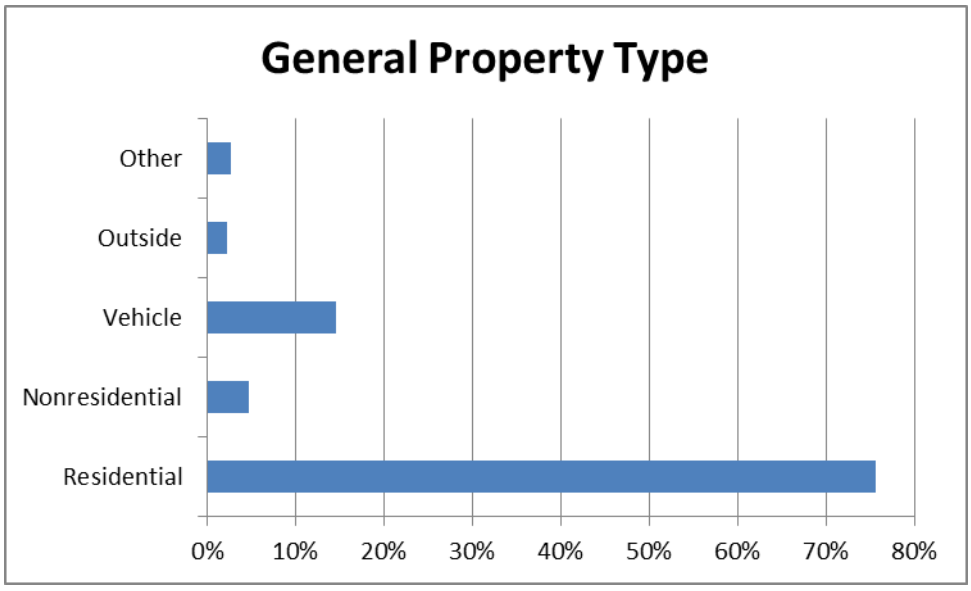

Figure 32 Distribution between property types where fire fatalities occur (2011) [12].

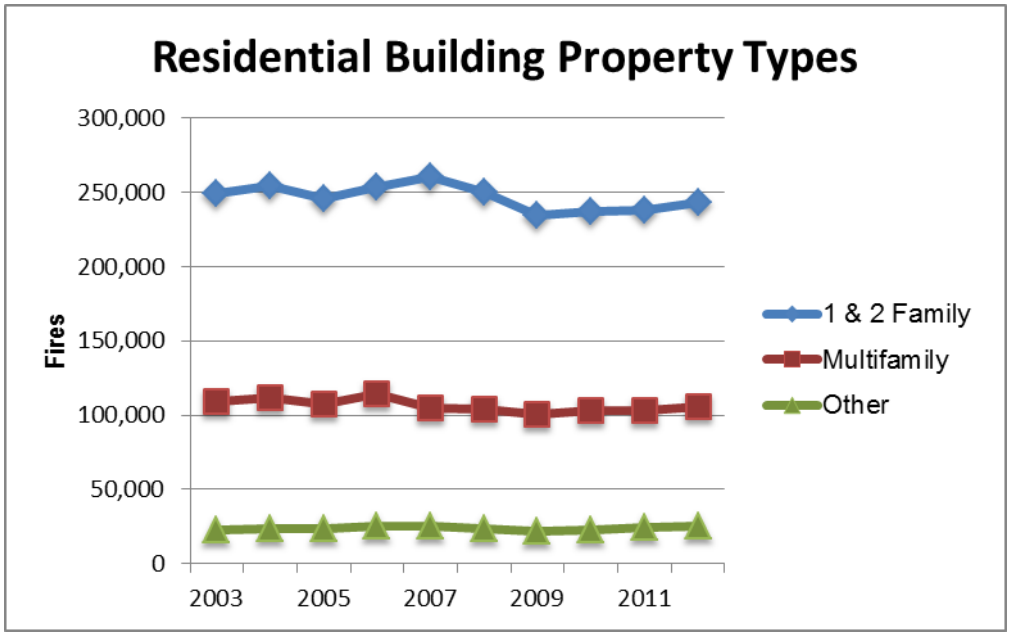

Figure 33 Number of fires in different residential property types [12].

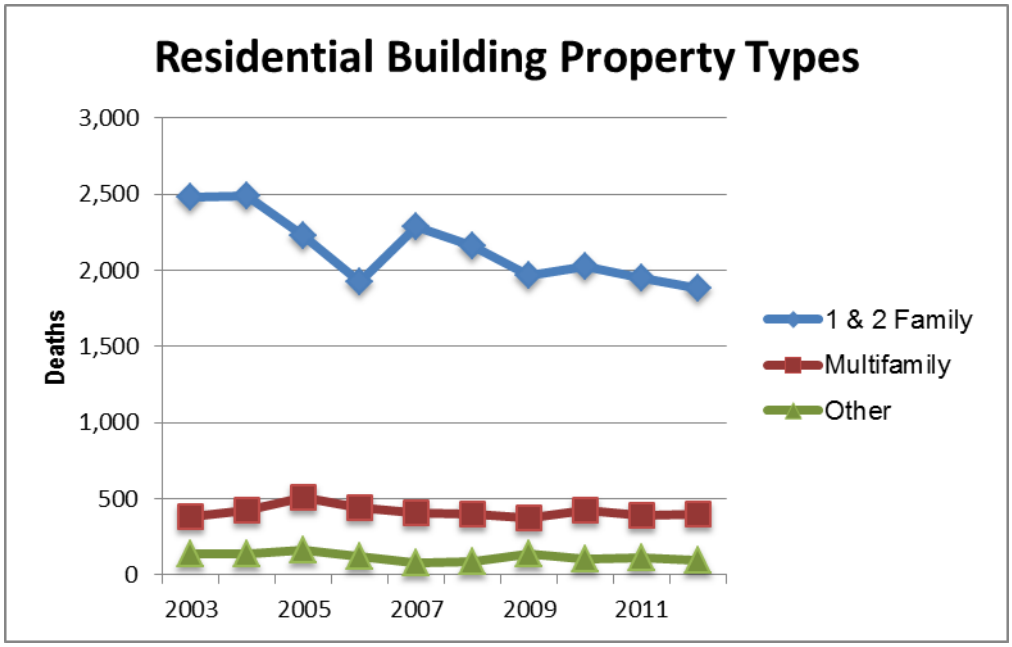

Figure 34 Number of fatalities in different residential property types [12].

Most fatalities do still occur in 1 & 2 Family properties, but this simply seems to be related to the fact that most people live in this type of property, see Figure 35. Some assumptions have been made in this report based on the demographics data from the National Multifamily Housing Council NHMC [13], since the categories of housing differ slightly from the categories used in the fire statistics: ,

- All owner-occupied households have been assumed to be in the category1 & 2 family housing. This might have a big impact on the result if there is a large amount of apartment style condominiums included in this category.
- 50 % of the renter households with 2 to 4 units have been assumed to be in the category 1 & 2 family housing. This has a limited impact, since the category contains less than 6 % of the total residents.

To account for this, the number of housing units from the 1990´s census [14] are also included in Figure 35. The number of units do not take into account that more than one person can live in the same unit, so the correct distribution is most likely somewhere in-between the demographics and the number of units. Regardless, the distribution of fire fatalities matches the housing distribution quite well.

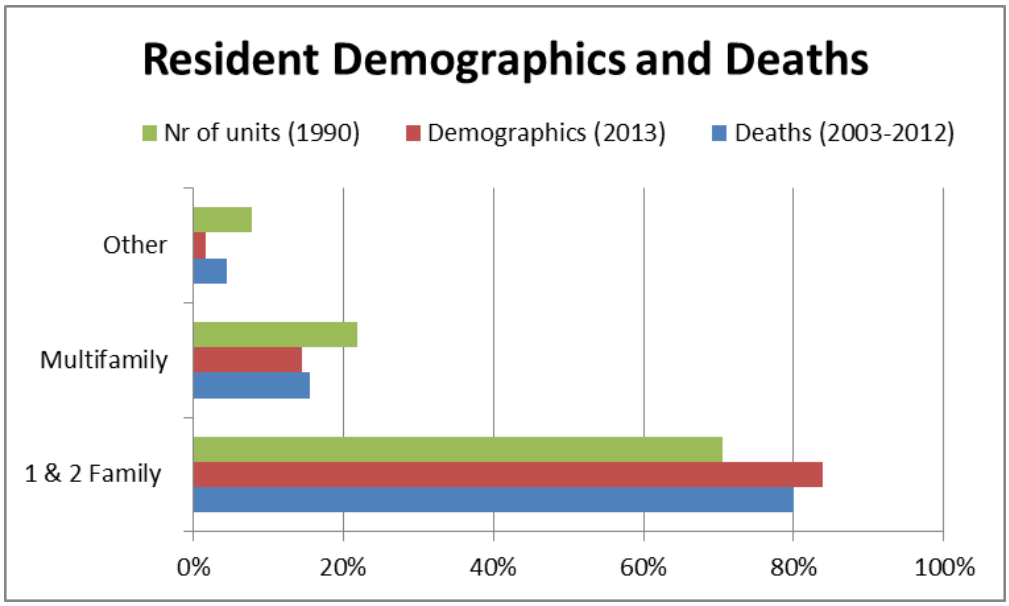

Figure 35 Resident Demographics and Fatalities [12, 13, 14].

3.1.3 Fire causes

The percentage of each reported fire cause for all fires in residential buildings, and for the fires where people have died, is shown in Figure 36 and Figure 37, with data for the years 2003-2012. Cooking is the most common fire cause, with almost 45 % of all fires. The percentage of fires caused by cooking has increased during the years as well, see Figure 45. However, only 5 % of the fatal fires are caused by cooking. With *smoking*, it is the other way around, with 2 % of all fires compared to 16 % of the fatal fires. *Intentional*, and *Other Unintentional, Careless,* also stand out as causes where the percentage of fatal fires is more than twice as high as the percentage of all fires.

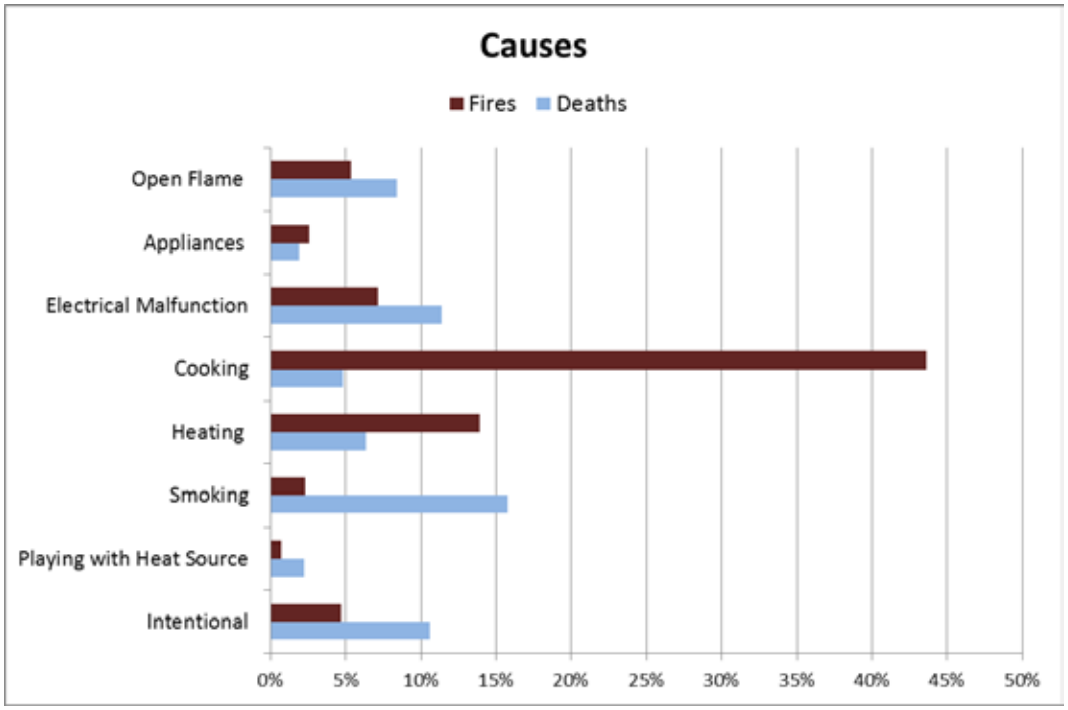

Figure 36 Fire causes, all fires and fatal fires (2003-2012) [12].

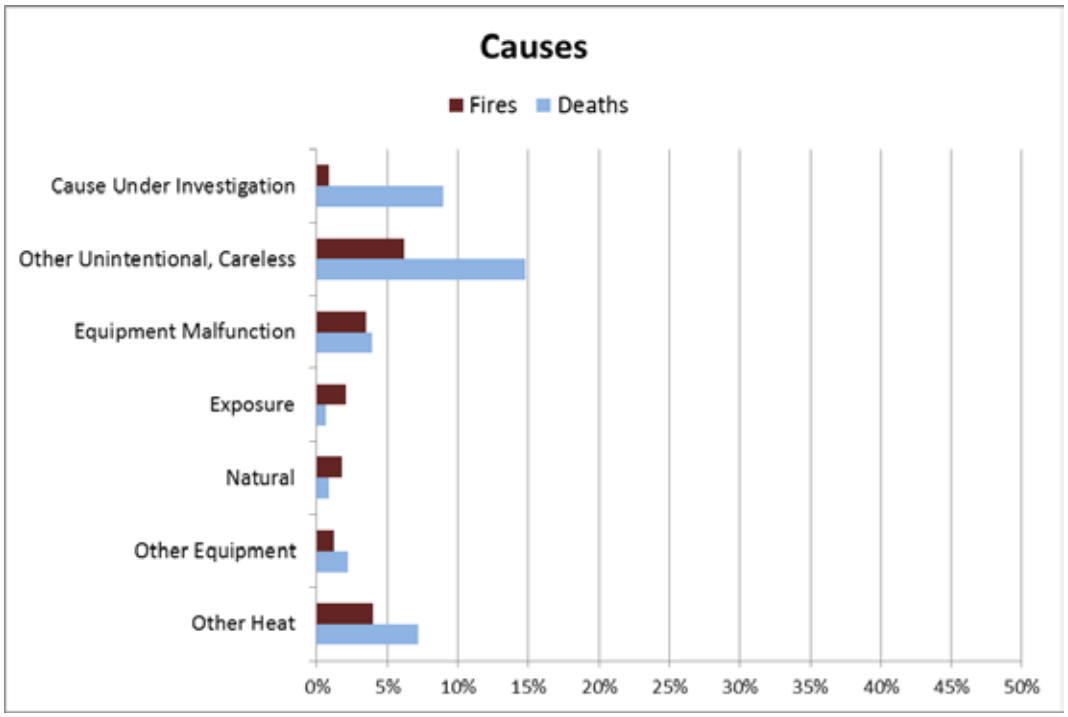

Figure 37 Fire causes, all fires and fatal fires (2003-2012) [12].

The number of fatal fires have decreased between 2003-2012, and the number of fatal fires for each cause has generally decreased as well, see Figure 38-Figure 40. *Smoking*, *Open flame*, and *Electrical malfunction* show the most clear downward trend, see Table 3, where the changes are estimated by linear regression. The number of *Causes Under Investigation* have increased steadily during the years, which could explain some of the decrease in all other categories. However, it is not enough to explain the entire decrease of fires caused by smoking. Cigarette ignition resistance of furniture and mattresses is

likely to be one cause of the decrease, but the fact that the number of smokers are decreasing is probably an important factor as well, see Figure 41.

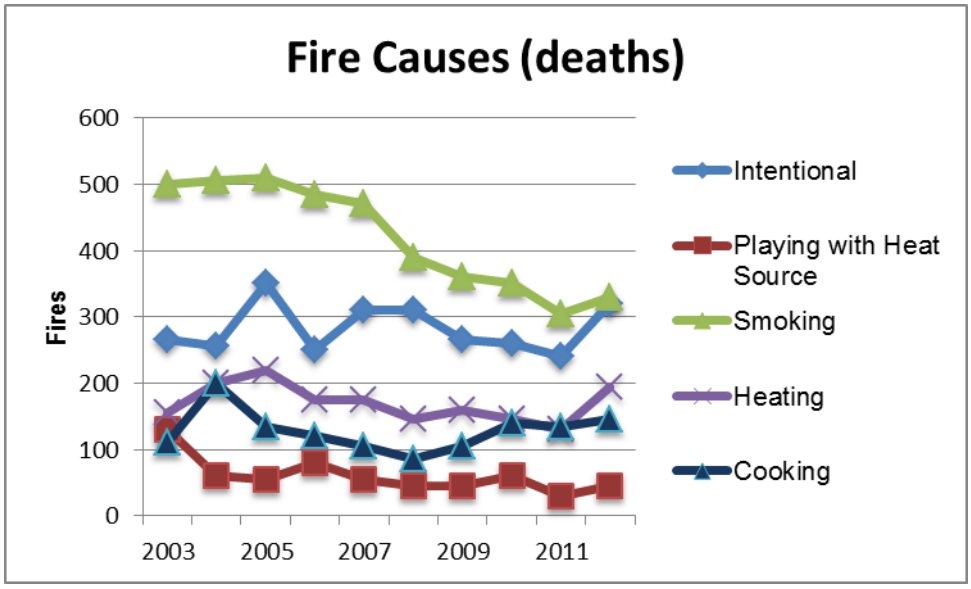

Figure 38 **Fire causes for fatal fires [12].**

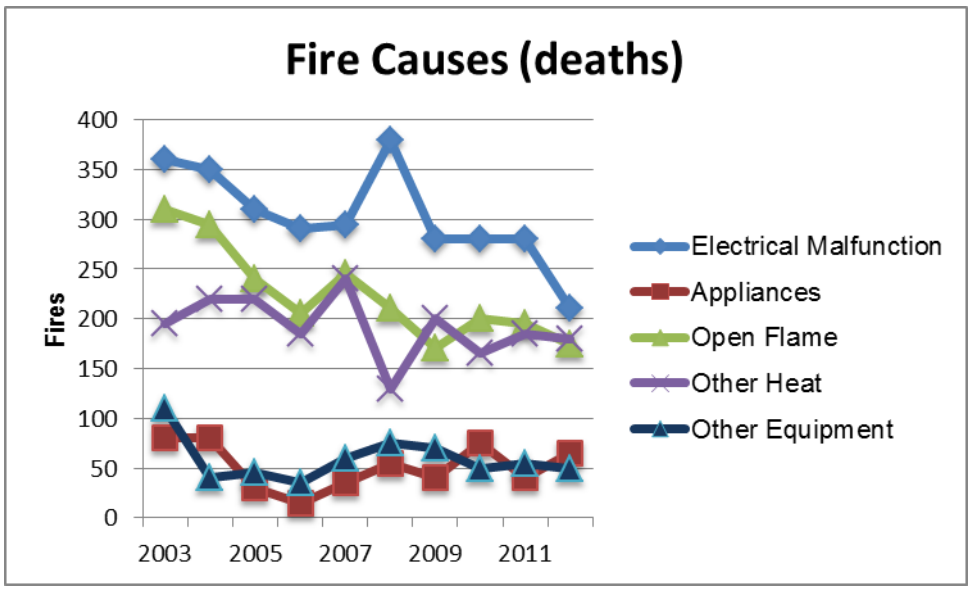

Figure 39 **Fire causes for fatal fires [12].**

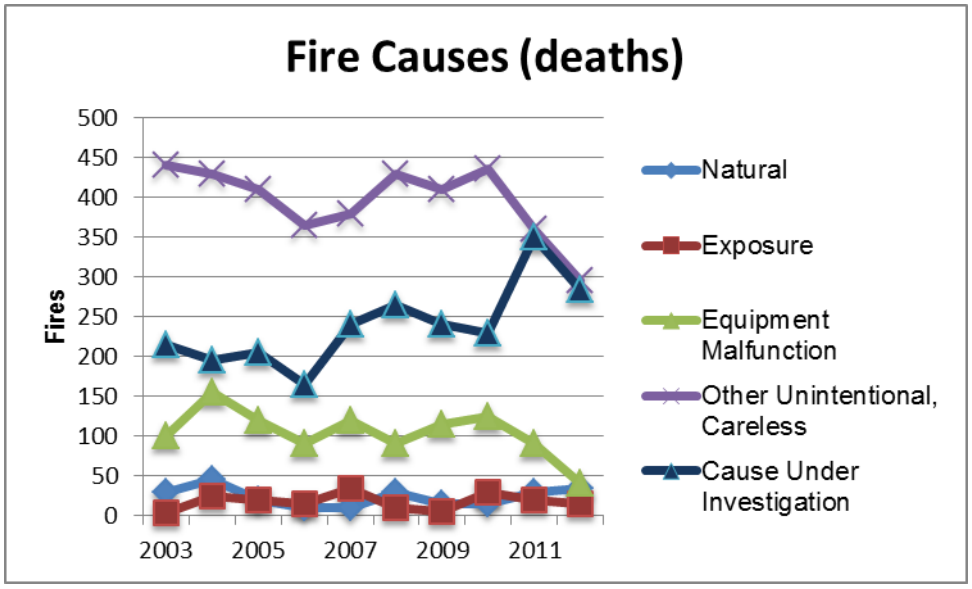

Figure 40 **Fire causes for fatal fires [12].**

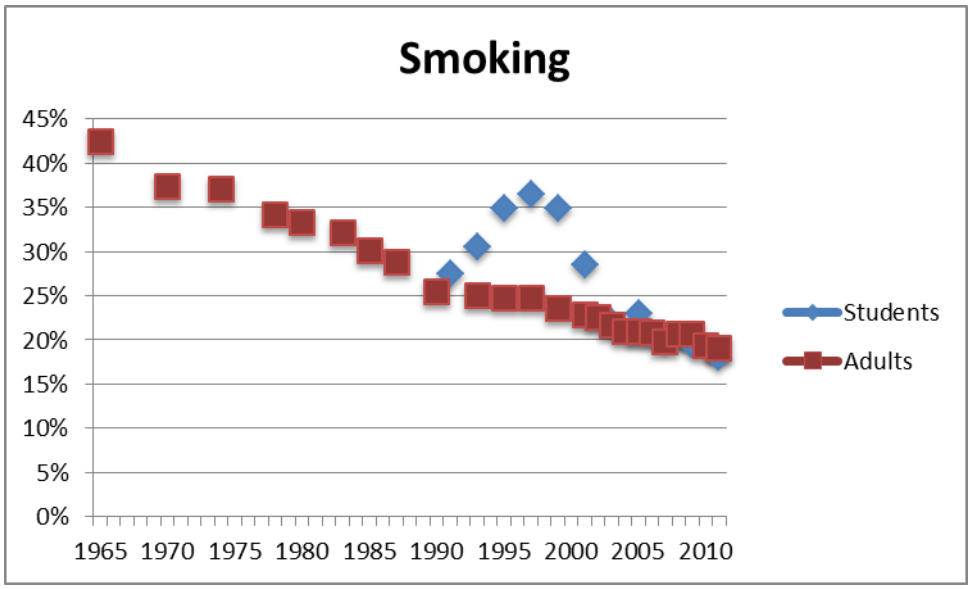

Figure 41 **Trends in cigarette smoking [15].**

Table 3 Linear regression of fire causes for fatal fires [12].

	Fire death reduction (-) or gain (+) (Linear change per year)	Fit Ratio (R^2)
Smoking	-25.4	0.90
Open Flame	-13.7	0.75
Electrical Malfunction	-11.7	0.52
Other Unintentional, Careless	-9	0.35
Playing with Heat Source	-6.45	0.50
Equipment Malfunction	-5.61	0.31
Other Heat	-4.46	0.18
Heating	-3.51	0.14
Other Equipment	-1.76	0.059
Cooking	-1.09	0.011
Appliances	-0.58	0.0058
Natural	-0.3	0.0061
Intentional	-0.09	0.00006
Exposure	0.41	0.0145
Cause Under Investigation	12.7	0.54

The trend for all fires is shown in Figure 42 –Figure 45, with linear regression values in Table 4. *Heating, Equipment malfunction, Open flame, and Other heat,* make up for approximately three quarters of the decrease in fires, with steady downward trends. However, the number of *Cooking* fires and *Causes Under Investigation* have increased.

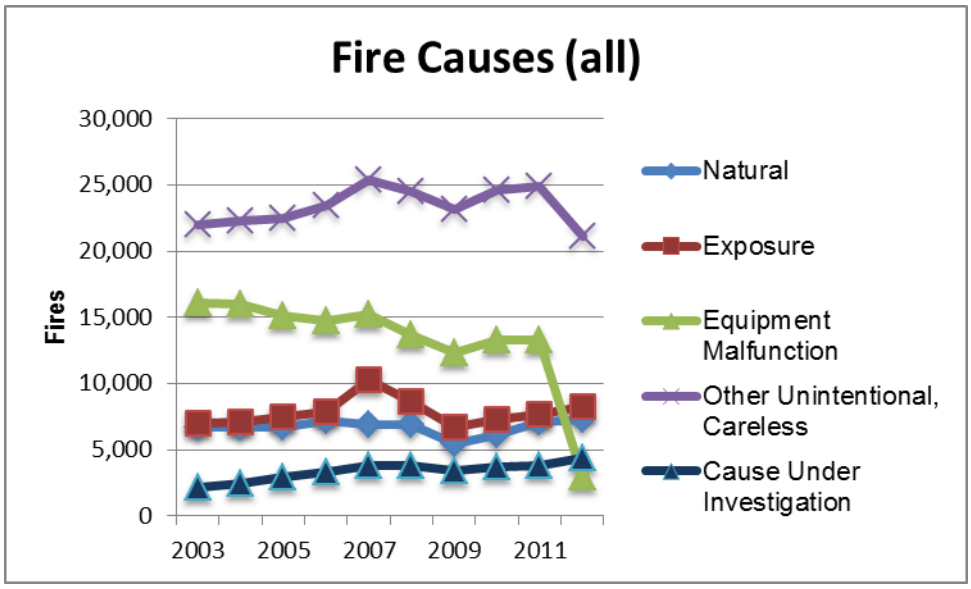

Figure 42 Fire causes for all fires [12].

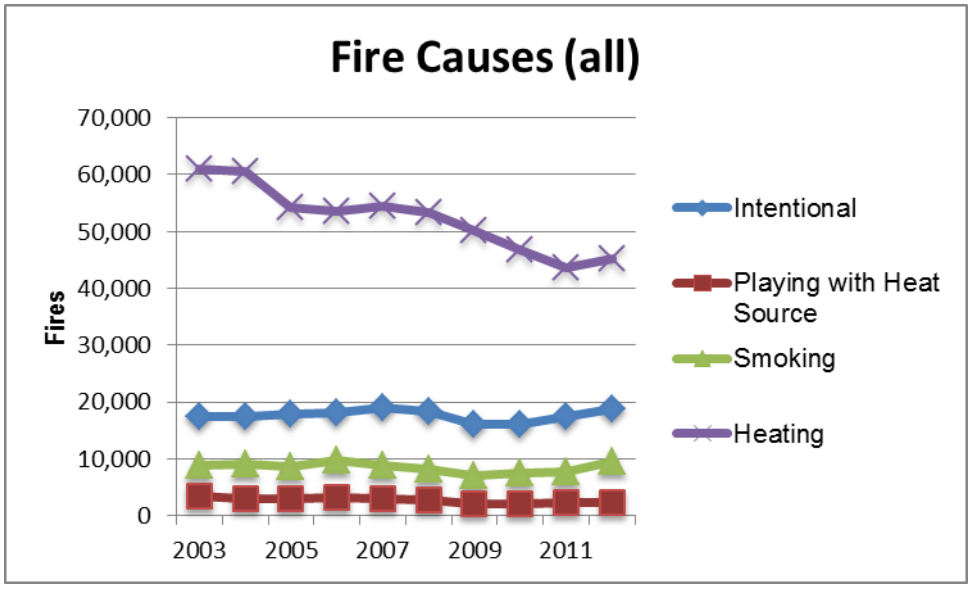

Figure 43 Fire causes for all fires [12].

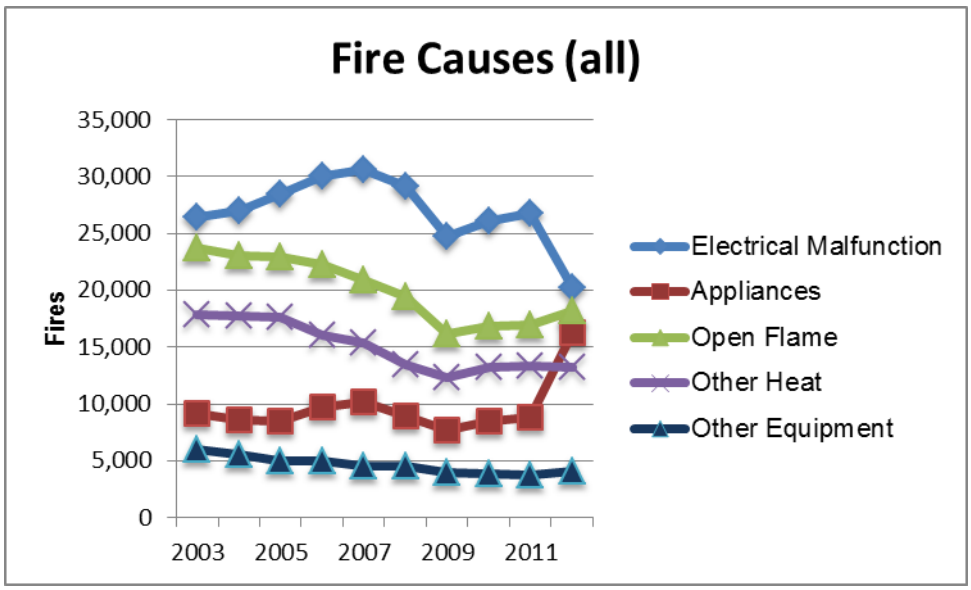

Figure 44. Fire causes for all fires [12].

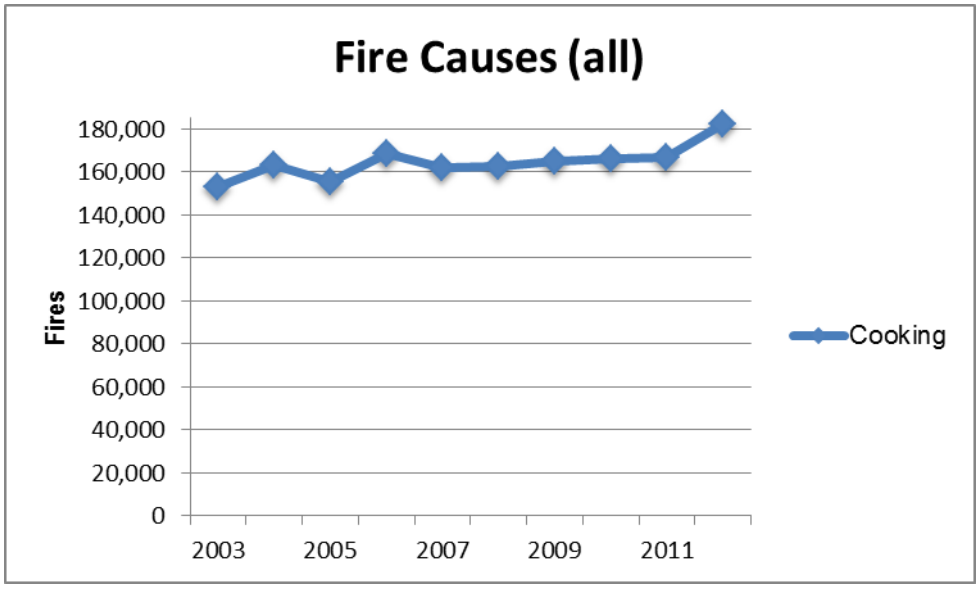

Figure 45 Fire causes for all fires [12].

Table 4 – Linear regression of fire causes for all fires [12]

	Fire reduction (-) or gain (+) (Linear change per year)	Fit Ratio (R^2)
Heating	-1877	0.92
Equipment Malfunction	-941	0.55
Open Flame	-863	0.82
Other Heat	-661	0.83
Electrical Malfunction	-524	0.28
Appliances	-352	0.19
Other Equipment	-232	0.89
Playing with Heat Source	-143	0.78
Other Unintentional, Careless	-114	0.059
Smoking	-98.8	0.12
Intentional	-27	0.0069
Natural	-1.2	0.00004
Exposure	+58	0.028
Cause Under Investigation	+205	0.82
Cooking	+1998	0.59

3.1.4 Smoke alarms and sprinkler systems

The usage of smoke alarms increased during the 80´s and 90's, and by 1998, 95 % of the homes in the U.S. had at least one smoke alarm [16]. This can be seen in the statistics for fatal fires as well, where the number of fires with no detectors present has decreased steadily, see Figure 46. The reason for the missing data points between 1998-2012 are due to malfunctioning or incompatible database files. The percentage of fatal fires where detectors operated increased during the same time period, as well as the percentage where detectors malfunctioned, as shown in Figure 47 and Figure 48 respectively. As seen in Figure 49, there were still many reports of detectors malfunctioning in 2013. The most

common reasons for this was a missing or disconnected battery, or a discharged battery, as seen in Figure 50.

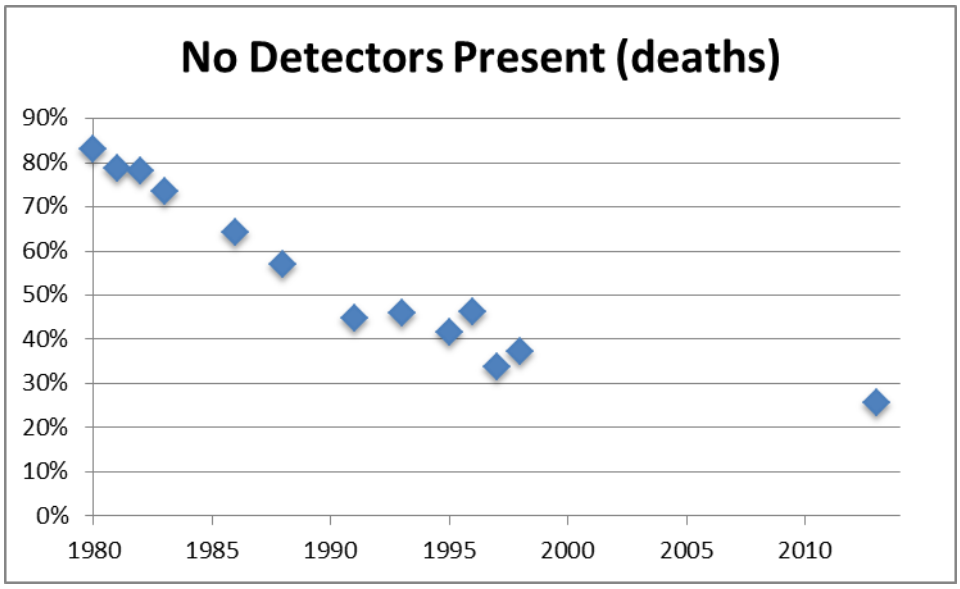

Figure 46 **Reported fatal fires where no smoke detectors were present [17].**

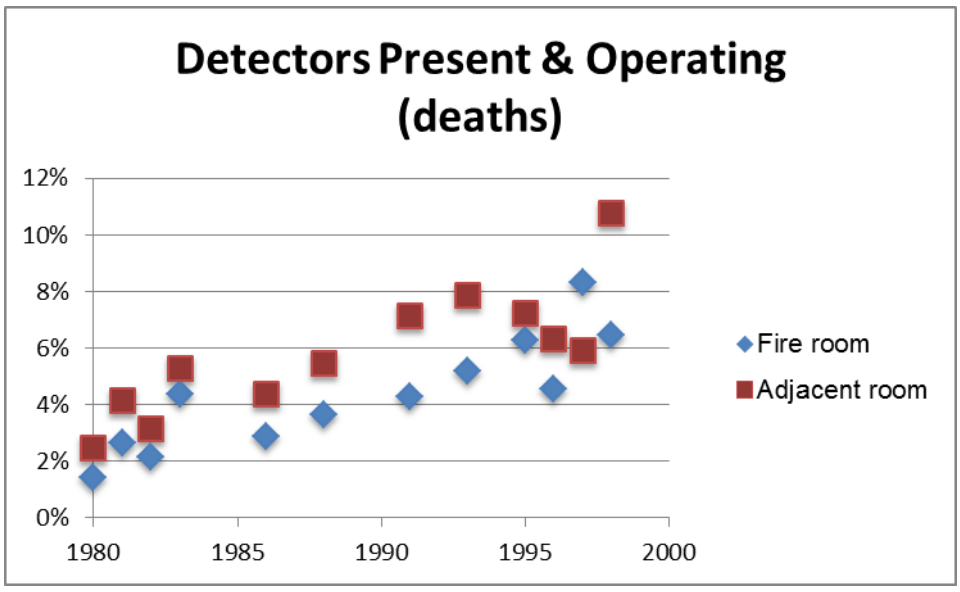

Figure 47 **Fatal fires where detectors were present and operating, and the placement of detectors [17].**

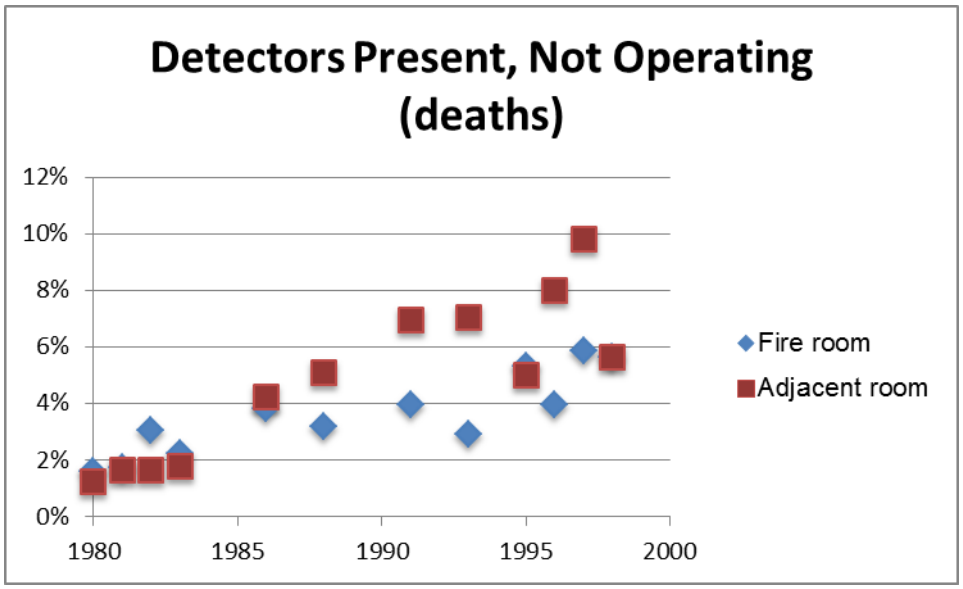

Figure 48 **Fatal fires where detectors were present but not operating, and the placement of detectors [17].**

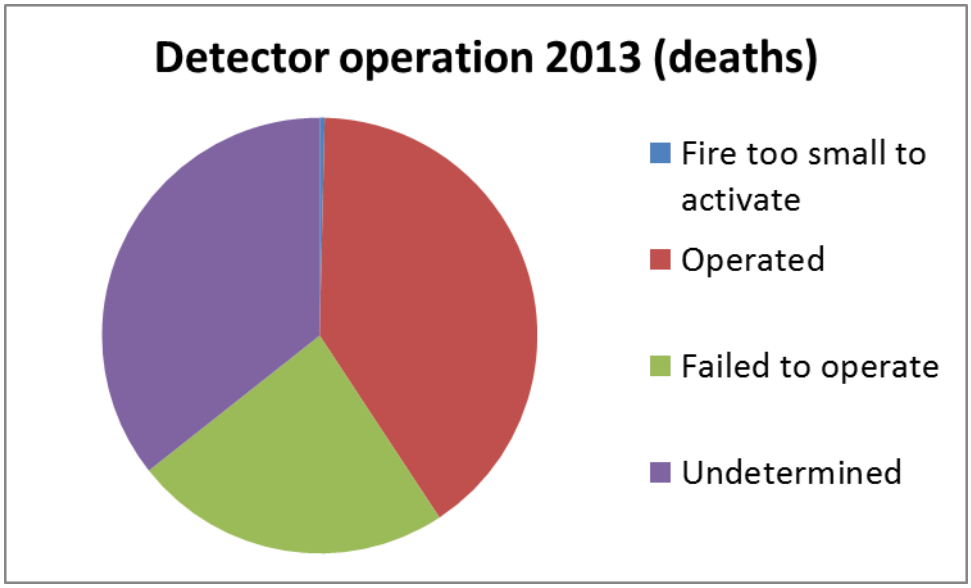

Figure 49 **Detector operation in fatal fires 2013 [17].**

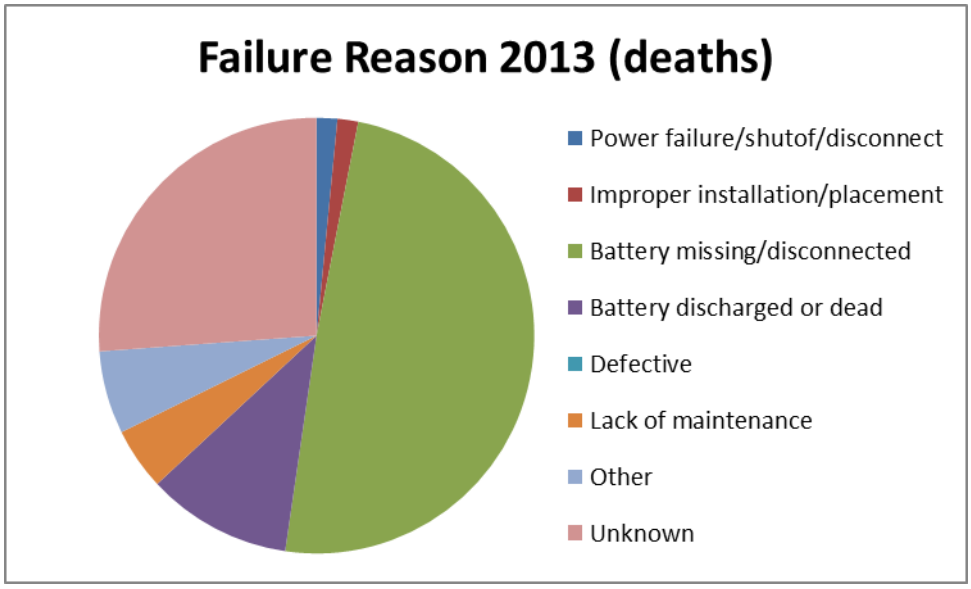

Figure 50 Reason for detector failure in fatal fires 2013 [17].

The use of automatic sprinkler systems has increased in residential buildings the last decade. In 2007 3.9 % of occupied homes had sprinkler and in 2009 the number had increased to 4.6 % [18]. The increase can be seen in the fire statistics as well, where the number of reported fires in buildings with sprinkler systems have increased rapidly, see Figure 51.

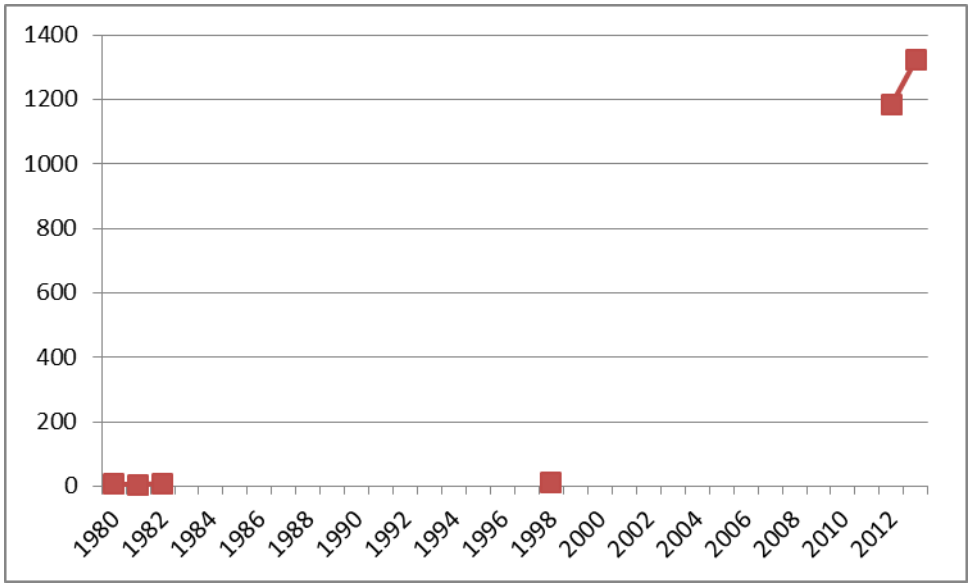

Figure 51 Number of fires reported in buildings where automatic sprinkler systems were installed [17].

3.1.5 Factors influencing the reduction of fire fatalities

It is difficult to point out a few single factors that can explain the decrease in the number of fire fatalities in the U.S. during the last decades. It should probably be seen as the result of the concerted efforts of many organizations and individuals. In 1974, the American Congress enacted the Federal Fire Prevention and Control Act, with the intent to attack the national fire problem by defining a Federal role for work in tandem with the States and municipalities. The Center for Fire Research (CFR) at NBS (the National

Bureau of Standards, currently NIST) was created, and the Act authorized basic and applied research on a broad range of topics, e.g. flame ignition, flame spread, flame extinguishment, fires in structures and control or prevention of fires. The goals of the CFR was to reduce the Nation's fire losses by half in 20 years, and sought to define the technical work needed to achieve this goal. NBS and later NIST and many other organizations contributed to the fire safety advances through enabling measurement science and other means such as education and training. The CFR approach was based on intervening in the principal fire loss scenarios, that were considered in terms of combinations of an ignition source, the first item ignited, and the occupancy type. [16]

The high-set goals of the CFR were met, and, as the statistics for the last two decades show, the reduction in fire losses has continued to decrease. Some key results of the research activities, that are likely to have had an impact on the fire losses in residential buildings, included the following:

- Smoke alarm siting and sensitivity standards, which led to an increase in sales and decrease in unit cost. By 1998, 95 % of homes in the U.S. had at least one smoke alarm.
- Automatic fire sprinkler standards.
- Test methods and standards for cigarette ignition resistance of upholstered furniture, that have been utilized by the upholstered furniture trade associations.
- Test methods and standards for cigarette ignition resistance of mattresses
- Children´s sleepwear standard, which eliminated a big fire problem with over 100 fatalities and many serious burn injuries annually.
- Installation standards for wood burning stoves, fireplace inserts, and chimneys.
- Smoke control: stairwell pressurization and zone smoke control technologies.
- Development of instruments and test methods for scientific characterization of material ignition, flammability and flame spread over materials and furniture.

It should be noted that the decrease in fire fatalities has not come without costs. Between 1980 and 2008, the costs due to fire protection used in construction has increased by about 87 %, after adjustment for inflation. The cost of career fire departments has increased even more, 145 % during the same time. [16]

3.2 Great Britain

The number of fire deaths per inhabitants has decreased more than 50% in Great Britain between 1992 and 2012 as can be seen in Figure 27.

The Department for Communities and Local Government publish annual bulletins (since 2008), presenting detailed statistics on fires, casualties and false alarms attended by fire and rescue services across Great Britain. The bulletins include analysis of the causes of fires, casualties and smoke alarms ownership and function. Time trends are shown, together with a breakdown of incidents by type of property and geographical location.

The latest bulletin show that there were 322 fire-related fatalities in 2013-14 (data is presented for the period between April to March the following year), the lowest recorded number of fatalities in the last fifty years. The highest number of fatalities recorded was 967 in 1885-86. [19]

Similar to the U.S., a majority of fire fatalities (80 % in 2013-2014) occur in dwellings. The main cause was careless handling of fire or hot substances e.g. careless disposal of cigarettes, which accounted for 39 % of all fatalities due to accidental causes. However, fires where the source of ignition was smokers´ material (i.e. cigarettes, cigars or pipe

tobacco but not including lighting implement such as matches and lighters) has declined by 41 % between 2001 and 2014. [19]

Similar to the U.S., cooking appliances were responsible for more than half of accidental dwelling fires, but only 0.2 % of them resulted in fatalities. [19]

3.2.1 Changes in regulations and standards

The number of UK fire related fatalities in residential buildings showed an increasing trend from the 1960s to the late 1980s. One action from the UK Government was the introduction of the Furniture and Furnishings (Fire) (Safety) Regulations 1988, which were later amended 1993 and 2010. The regulations require ignition resistance for filling materials, upholstery composites and covers for Furniture and Furnishings. It is estimated that the regulation saved a total of 710 lives, or perhaps even up to 1860 lives, between 1988 and 1997 [20]. The same report estimates that the average number of lives saved will be at least 12 per million of the population per year by 2030. Another report [21], estimated that the regulation saved 54 lives per year in the period 2003-2007 when the increased use of smoke alarms had been accounted for. However, it is stated that the decline in adult smokers probably accounted for some of the decline in furniture and furnishing fires and fatalities.

Another action was the Nightwear (Safety) Regulations 1985, with tougher performance requirements regarding flammability for children's nightdresses and nightgowns [22].

3.2.2 Smoke alarms and sprinkler systems

Between 1988 and 1995, the Home Office ran annual television advertising campaigns in England and Wales to promote smoke alarm installation [23]. Working smoke alarm ownership increased rapidly from 8% in 1988 to 70% in 1994, and has continued to rise in recent years to 88% in 2011. Nearly 40% of dwelling fire fatalities in Great Britain occurred in properties where no alarm was installed [19].

According to [20],the increase in smoke detectors has had little effect on post-1988 trends due to poor positioning and maintenance.

4 Discussion

Since data is not reported for every fire that occur, some of the statistics used in this report are based on estimates. Also, differences in how each country report fire fatalities, and possible different definitions of fire fatalities, makes direct comparisons between countries unsuitable. However, for the purpose of identifying changes and trends within a country, this is not a great issue, as long as the estimates and definitions are the same for the analyzed time period.

The work here is based on statistics publicly available but also on statistics retrieved from NFIRS Public Data Release (PDR). Due to malfunctioning or incompatible database files, many years' data, e.g. for sprinkler and smoke detector activation, is missing in this report. However, this does not influence any of the conclusions in this report as the trend over a large time period is studied.

This report only gives a brief overview of available statistics, and there are many aspects and parameters that could be chosen for a more detailed analysis, e.g. a more detailed study of fire cause, first item ignited and main fire object, and changes over time. A more comprehensive literature study, including more countries, could also be done. Additional

parameters that could be studied and compared between different countries is the time spent at home, how often cooking is done in the home, etc. to see if those parameters have any correlation with fire deaths. However, as the interesting thing in this report was to identify measures that have had a positive impact on the number of fatalities in residential fires internationally rather than determining the exact possible decrease per measure no further effort in this respect was made.

5 Conclusions

Many countries show a decline in fire fatalities during the last decades. USA and Great Britain are two of the countries that stand out with a steady downwards trend, and both countries now have a lower death rate per capita compared to Sweden. Except for an increased use of smoke alarms and sprinkler systems, which has been seen in Sweden as well during the same time period, both USA and Great Britain have introduced fire regulations for furniture and furnishings, and for children´s sleepwear. Evaluations of the regulations for furniture and furnishings show that a large part of the decline in fire fatalities can be attributed to these changes.

6 References

1. Andersson, P., Johansson, N., Strömgren, M., Characteristics of fatal residential fires in Sweden – SP Report 2015:53, 2016.
2. Centre of Fire Statistics of CTIF – World Fire Statistics 2006 – Report No. 11
3. Centre of Fire Statistics of CTIF – World Fire Statistics 2008 – Report No. 13
4. Centre of Fire Statistics of CTIF – World Fire Statistics 2011 – Report No. 16
5. Centre of Fire Statistics of CTIF – World Fire Statistics 2012 – Report No. 17
6. Centre of Fire Statistics of CTIF – World Fire Statistics 2013 – Report No. 18
7. World Population Prospects: The 2012 Revision. United Nations, Department of Economic and Social Affairs – Population Division. Available: http://esa.un.org/unpd/wpp/Excel-Data/population.htm visited 2015-05-20
8. The Geneva Association, World Fire Statistics Bulletin No.13-29, 1997-2014
9. Katus, K., Puur, A. Mortality Development and Economic Transition: Case of Estonia. Estonian Interuniversity Population Research Centre. 1997.
10. Hall, J.R., U.S Unintentional fire death rates by state, NFPA, 2012.
11. Select Data Sets, Fire loss in the United States (2000-2011), U.S. Fire Administration, available: http://www.usfa.fema.gov/data/statistics/order_download_data.html, visited 2015-08-06
12. Select Data Sets, Residential and nonresidential building fire loss estimates by property use and cause, U.S. Fire Administration, available: http://www.usfa.fema.gov/data/statistics/order_download_data.html visited 2015-08-06
13. NMHC – National Multifamily Housing Council, available: https://nmhc.org/Content.aspx?id=4708#Apartment_household_income visited 2015-05-20
14. Historical Census of Housing Tables, United States Census Bureau. Available: https://www.census.gov/hhes/www/housing/census/historic/units.html, visited 2015-08-06
15. Trends in Current Cigarette Smoking Among High School Students and Adults, United States, 1965-2011. CDC - Centers for Disease Control and Prevention. Available:http://www.cdc.gov/tobacco/data_statistics/tables/trends/cig_smoking/, visited 2015-08-06.
16. NIST Special Publication 1130, Reducing the Risk of Fire in Buildings and Communities: A Strategic Roadmap to Guide and Prioritize Research. NIST, 2012
17. NFIRS Public Data Release (SQL database), 1980-2013. U.S. Fire Administration.
18. Hall, John R. JR. U.S. Experience with sprinklers. NFPA, 2013.
19. Fire Statistics: Great Britain, April 2013 to March 2014. Department for Communities and Local Government.
20. Effectiveness of the Furniture and Furnishings (Fire) (Safety) Regulations 1988, Government Consumer Safety Research, Dept. of Trade and Industry (DTI), June 2000

21. A statistical report to investigate the effectiveness of the Furniture and Furnishings (Fire) (Safety) Regulations 1988, Department for Business, Innovation and Skills, 2009.
22. Nightwear Advisory Note, Department for Business Enterprise & Regulatory Reform, 2008.
23. DiGuiseppi, C., Roberts, I., Li, L. Smoke alarm ownership and house fire death rates in children. Journal of epidemiology and amp community healt, 1998.

Annex A – Linear Regression

Given a set of data (x_i,y_i) with n data points, the slope and y-intercept can be determined using the following:

$$m = \frac{n\sum(xy) - \sum x \sum y}{n\sum(x^2) - (\sum x)^2}$$

$$b = \frac{\sum y - m\sum x}{n}$$

It is also possible to determine the correlation coefficient, r, which gives a measure of the reliability of the linear relationship between the x and y values:

$$r = \frac{n\sum(xy) - \sum x \sum y}{\sqrt{[n\sum(x^2) - (\sum x)^2][n\sum(y^2) - (\sum y)^2]}}$$

A value of r = 1 indicates an exact linear relationship between x and y. Values of r close to 1 indicate excellent linear reliability. If the correlation coefficient is relatively far away from 1, the predictions based on the linear relationship will be less reliable.

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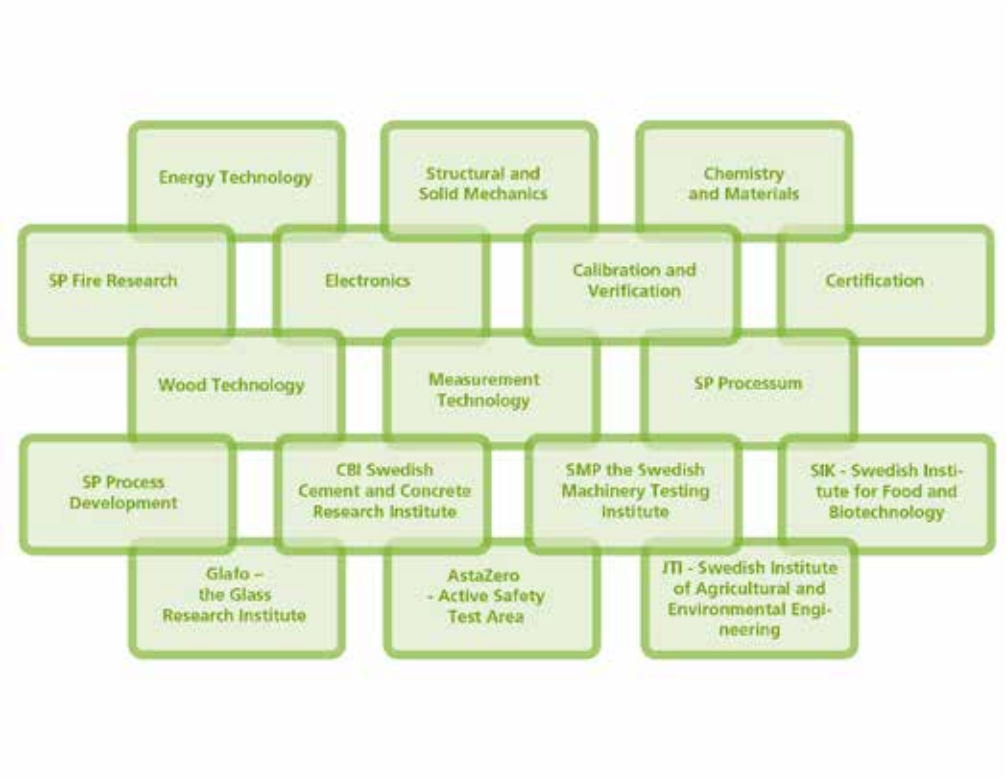

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