Report

Analysis of fatal fires in Norway in the 2005 – 2014 period

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RISE Fire Research
RISE report A17 20176:2

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VERSION	DATE
1	2017-10-09

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CLIENT(S)	CLIENT'S REF.
Norwegian Directorate for Civil Protection	Frode Sandvin Folkedal

PROJECT NO.	NO. PAGES AND APPENDICES:
20176	62 pages + 3 appendices

SUMMARY:
In this study, information from fire statistics and other sources has been analyzed to get more detailed knowledge than before about who dies in fires and why. This will help to implement more targeted measures in order to reduce the number of people perishing in fires.

The study attempted to answer the following questions:
1. What risk factors are associated with those who perish in fires in Norway?
2. What are the causes of fatal fires in Norway?
3. How can fatal fires best be prevented?

A total of 517 fires with 571 fatalities are registered in the official fire statistics in the 2005 – 2014 period. We have examined 347 police investigation reports, identified 387 deceased and extracted information from 248 medical records.

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REPORT NO.	CLASSIFICATION	CLASSIFICATION THIS PAGE
A17 20176:2	Unrestricted	Unrestriced

History

VERSION	DATE	VERSION DESCRIPTION
1	2017-10-09	English translation of RISE report A17 20176:1.

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Preface

This project was initiated in 2015, after ordering from the Norwegian Ministry of Justice and Public Security, and has been ongoing until today. For the involved project staff, there has been a professionally interesting project. At the same time, there has been a project that has given us insight into many fates, which has given afterthought. The work on this theme has been done with great respect for those who have perished in fire and their relatives. We hope the results of this project can help strengthen and focus the fire prevention efforts so that the number of people who die in fire will sink in the years to come.

We would like to thank the police districts who have provided investigation reports from the fires we have requested. At the same time, we also want to thank all medical doctors and staff at the doctor's offices who have forwarded and sent us medical records from old archives. Without their help, we would not have had access to essential information, which would have reduced the project's information and utility value.

In addition, we would like to thank medical student Anker Stubberud for good and effective work to review, extract and interpret information from nearly 250 patient records.

Christian Sesseng

Project manager

Trondheim, 2017-09-07

Summary

Background

The background for this project is described in NOU 2012: 4 *Trygg hjemme. Brannsikkerhet for utsatte grupper (Safe at home. Fire safety for vulnerable groups).* Report No. 35 to the Storting (2008 - 2009) *Fire safety. Prevention and Fire Brigade's Rescue Mission*. These documents point out that the knowledge of risk-exposed groups with regard to fire is limited and that more knowledge is needed about how the overall risk picture among vulnerable groups can be characterised.

This study is also based on a study conducted by RISE Fire Research (at the time SP Fire Research) in collaboration with NTNU Social Research Studio Apertura in 2015. The study, which resulted in the report entitled *Correct measures in the right place*, discussed how different agencies must collaborate, both with each other and with persons with increased fire risk and their relatives, to ensure a satisfactory level of fire safety. The report had a two-part perspective, one focusing on organisational conditions that affect the municipalities' ability to prevent fire affecting vulnerable groups, while the other perspective was aimed at technical measures that could be implemented for persons or groups with different risk factors.

Objectives

The aim of the project has been to analysis fire statistics and information from other sources to get more detailed knowledge than before about who dies in fires and why. Initially, the following questions were defined:

1. What risk factors are associated with those who perish in fires in Norway?
2. What are the causes of fatal fires in Norway?
3. How can fatal fires be best prevented?

Risk factors associated with those who perish in fires in Norway

All individuals who have died in fire cannot be divided into groups of common denominators, but there are some combinations of factors that we have seen repeatedly:

For those who have reached retirement age, we mainly see four risk factors: *reduced mobility, impaired cognitive ability, mental disorders* and *smoking*.

For those under retirement age, the risk factors are *known substance abuse*, *mental illness*, *alcoholic influence* and *smoking* that appear, either alone or in combination with each other.

There is an increasing risk of dying in a fire with increasing age. Generally speaking, men do not have a higher risk than women, but in some age groups, the risk of fatality is greater for men. There are more women than men in the 80+ age group who perish in fire, but taking

into account the gender distribution in this group the risk is equal. Alcohol constitutes a greater risk factor for men than for women.

There is a risk connected to being alone. The likelihood that the fire will be detected in time to survive is reduced, and it is more difficult to escape if you are alone. People living alone will probably be more often home alone than people living with others. Single residents therefore probably have an indirectly elevated risk.

The vast majority of the victims spoke Norwegian, so foreign language is not observed as a risk factor in our material.

Causes of fatalities

When we investigate where, why and when the fires have occurred, we see that human failure often causes fatalities. Human behaviour varies throughout the year, and thus also the risk of fire, which we see in the variations in fire causes between the winter and summer months. Open flame in connection with for example cigarettes and candles is a group of ignition sources that is reflected in the statistics. Fatal fires also occur most often in the rooms where we spend the most of the time: in the living room and in the bedroom.

Prevention of fatal fires

There is no simple answer to how fatal fires should be prevented. Since the causes of fires are so much dependent on the individual, preventive measures must also be adapted to individuals.

The report *Correct actions in the right place* gave suggestions for technical and organisational fire prevention measures. We hope that this report will provide professionals with the tools to identify individuals with increased risk so that appropriate actions can be taken for individuals and their specific conditions and challenges.

Based on the development of new materials used in clothing, consumer products and building materials, what we know today about fires and how they affect people may change over time. Development of technical measures for detection and mitigation of fires will provide opportunities for increasing fire safety in homes.

1 Introduction

1.1 Background

The background to this project is described in NOU 2012:4 *Trygg hjemme. Brannsikkerhet for utsatte grupper* [1] (*Safe at home. Fire safety for vulnerable groups*), and Report no. 35 to the Storting (2008 – 2009) *Fire Safety. Prevention and Fire Brigade's Rescue Mission* [2]. These documents point out that the knowledge of risk-exposed groups with regard to fire is limited, and that more knowledge is needed on what characterizes the overall risk picture for vulnerable groups.

This study is also based on a study conducted by RISE Fire Research (then SP Fire Research) in collaboration with NTNU Social Research Studio Apertura in 2015. The study, which resulted in the report titled *Correct measures in the right place* [3], discussed in what way different agencies must collaborate, both with each other and with persons with increased risk and their relatives, to ensure a satisfactory level of fire safety. The report had a two-part perspective, one focusing on organizational conditions that affect the municipalities' ability to prevent fire affecting vulnerable groups, while the other perspective was aimed at technical measures that could be implemented for persons or groups with different risk factors.

The report also underlines the importance of adopting a holistic perspective, which to a larger extent includes the individual's surroundings when working with fire safety in vulnerable groups, see Figure 1-1.

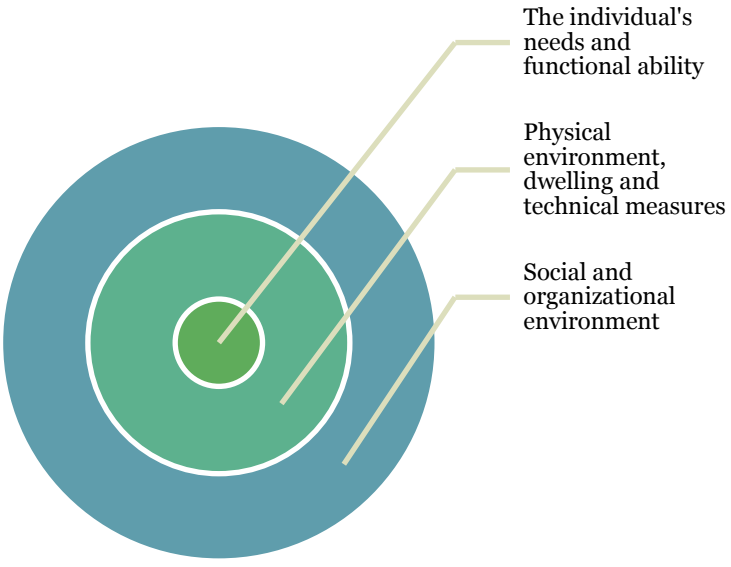

Figure 1-1 Conditions impacting on the risk of perishing in a fire at home [3].

However, the current study, whose objective was to identify the *actual* risk factors represented in fatal fires, focuses on the individual and some of the nearest physical surroundings, in order to identify any pattern at population level. The findings of the study

will provide important input to the procedure described in «Correct measures in the right place», and may help municipalities in their organized efforts to protect persons particularly exposed to perishing in fires.

1.2 Objectives

The aim of the project has been to analyze fire statistics and data from other sources to get more detailed knowledge than before about who dies in fires and why. This will help to implement more targeted measures in order to reduce the number of people perishing in fires.

The study attempted to answer the following questions:

1. What risk factors are associated with those who perish in fires in Norway?
2. What are the causes of fatal fires in Norway?
3. How can fatal fires best be prevented?

Answers to the two first questions will help to identify the factors where it will be the most imperative and appropriate to initiate action. In order to answer the last question, findings from questions 1 and 2 will be linked to the findings in the report entitled «Correct measures in the right place» [3], where diverse, potential measures aimed at persons with different risk factors are presented.

1.3 Scope

The study has sought to include all fatal fires occurring in Norway during the 2005 – 2014 period. We have charted information described in Police investigation reports, the fire victims' medical records, and the Norwegian Cause of Death Registry (NCoDR).

1.4 Ethical assessments

The study, including its ethical aspects, has been assessed and approved by the Regional Committee for Medical and Health Research Ethics (REC 2016/284), The Council for Confidentiality in Public Administration and Research, the Data Inspectorate, the Police Directorate, the Norwegian Institute for Public Health, and the Office of the Public Prosecutor.

1.5 Financing

The study is financed by the Ministry of Justice and Public Security, and the Directorate for Civil Protection and Emergency Planning (DSB).

2 Previous studies

Results from previous studies in Norway and other countries provided important data in designing the study, in the interpretation of results, and comparisons of the evolution of fatal fires over time. Demographical and cultural differences over time and between countries will amongst others impact on attitudes and risk behavior as concerns fires. Variations in the employment of various preventive measures will also be reflected in statistics on fatal fires.

2.1 Vulnerable groups

In the report titled *Correct measures in the right place* [3] we defined vulnerable groups as groups of people who for various reasons are more likely to start a fire or who have a limited ability to:

1. prevent a fire
2. detect a fire
3. alert and extinguish a fire
4. evacuate by his/her own means

Further we apply as basis that factors weakening the powers of reaction (intoxicants, mental or reduction of physical functions), combined with factors increasing the probability of a fire being started (e.g. smoking and the use of open fire), impair the fire safety level significantly [4]. This was the basis of the details we chose to examine in the data basis.

2.2 Statistics

There are a number of differences between the fire statistics of different countries, which makes it a challenge to compare them. E.g., differences exist as to how long after a fire a death needs to occur in order for the incident to be registered as a fatal fire. In Norway persons who perish in fires are registered within three months after the fire as a direct consequence of the fire. In Sweden this period is only one month. There are also variations as concerns the cause of death applied as basis in order for the victim to be registered in the fatal fire database. Factors that may impact on the proportion of registered victims in fatal fires are in what way and to what extent fires are investigated, plus the way in which fires are registered, and the thoroughness in which the consequences of a fires are followed up afterwards [5,6].

In Norway all fires must be investigated by the Police in order to identify the cause, even though there may not be any suspicion of a criminal offense [7]. DSB keeps an official fire statistics based on current reporting. Reports from the Police and the fire brigade form the basis of DSB's statistics on residential and structural fires. DSB's statistics on fatal fires

include all persons who have perished in Norway, regardless of whether the person is a resident of Norway, or has a Norwegian ID-number or not. Fire as a cause of death is defined when a person is supposed to have succumbed as a direct result of the fire, from burns or asphyxiation injury. Persons dying as a result of a stroke, impact, falling objects, fractures and similar are not defined as fire victims. The death must have occurred within three months after the date of fire in order to be included in the statistics. In addition to the reported cases, DSB searches for fire fatalities through monitoring various media, updating its statistics in line with the data found [5].

One way of handling the challenges relating to different practices of registering fatal fires, is to compare countries by studying trends separately in the fire statistic of each country. The report titled *International Fire Death Rate Trends* [8] presents the number of people perished in fires and death rate trends per 100 000 inhabitants for a number of countries during the 2002-2012 period. The report *Identification and evaluation of data on flame retardants in consumer products* [9] gathers an overview of the number of people perished in fatal fire per 1 000 000 inhabitants up to around 2008/2009 in several European countries. For some of the countries data collected from the 1980s are presented, for others the first data date from the 1990s, and for a small number of countries the data basis starts in the 2000s. Since the collection of data is not harmonized within the different countries, it is underlined that one needs to be cautious when comparing the results. Methods for data collection vary from one country to the next, as do practices for what is considered as fatal fires and burns.

There may be significant variations between countries when it comes to the cause of death. E.g., in the Norwegian report *Alkohol og brann* (*Alcohol and fire)* the categories are classified as "asphyxiation", "burn injuries" and "unknown cause of death". The study cites asphyxiation as the most common cause of death (74 %) in fatal fires, followed by burn injuries (17 %), and unknown cause of death (10 %).

In the US burns and asphyxiation stood for 90 % of causes of death in fatal fires during the 2012-2014 period. Here they also have a category which combines burns and asphyxiation. The distribution of these categories, related to burns and/or asphyxiation, was as follows [10]:

- Burns + asphyxiation in combination: 47 %
- Asphyxiation alone: 37 %
- Burns alone: 6 % (includes contract with flame, hot fluids, hot surfaces and other heat sources)

In Sweden it has been observed that there has been under-reporting as well as overlaps in the reporting of fatal fires. A comparison between the national fatal fire register kept by the Swedish authorities and other sources, such as the register showing cause of death, shows an under-underreporting of fatal fires at around 20-25 %. In particular, incidents where the fire brigade was not involved, e.g. a number of car fire incidents, and where the fire was restricted to only one person, were under-reported. It was also discovered that more persons died later in hospital than what was reported to the fatal fire register, which assumedly indicates poor communication between the fire brigade and the health services. Nor is a post-mortem examination performed on all fire victims after fires in Sweden [6].

2.3 Trends over time

Trends in several countries show a decline in the number of fatal fires. In Great Britain, e.g, the number of persons perishing in fire decreased by 50 % between 1992 and 2012. In Sweden one also sees a significant decline in the number of people perishing in fires over the last 60 years. Here the trend is particularly evident for children, and this trend is also being registered over a long period in Norway. However, one sees an increase in absolute numbers for elderly people (age 80+), which is probably due to the fact that the number of elderly people in society as a whole is on the increase. The general reduction is assumed to be founded on technical, social and economic developments. This signifies that fatal fires in Sweden is a "safety issue for elderly people". One believes that changes within childcare, with kindergartens and longer school days, has enhanced the safety level for small children, amongst other thanks to fire regulations for schools and public buildings, and because children are increasingly supervised by adults, spending less time entirely on their own. This may thereby have contributed to a significant reduction in the fatal fire statistics for children [8,11,12].

It is assumed that the increase in the use of synthetic materials in upholstered furniture has increased the risk of perishing in fires involving such products. Moreover, the results of studies support a hypothesis that victims primarily die from asphyxiation rather than burns in fires involving such products. In Sweden, a larger proportion of deaths than previously is at present due to CO-poisoning rather than burns [11].

Further, there has been a change in the materials used in clothing; a number of the modern, synthetic materials that have replaced cotton are less inflammable than cotton. This is assumed to have contributed to reducing mortality owing to burns in fire in clothing. Fire in clothing is assumed to be one of the most common burn related fatal fire causes in Sweden [11].

One has also seen an improvement in the health system's care of fire victims, which also largely has contributed to reducing mortality caused by burns. Since deaths owing to asphyxiation to a larger extent occurs in connection with the fire, and not afterwards in the hospital, improvements in hospital treatment will have the largest effect on the cause of death statistics related to burn injuries [11].

2.4 Time and place

Norway and countries that we compare ourselves with (Sweden, Denmark, the US and Great Britain) have in common that the majority of fatal fires are residential fires. Fatal fires occur most frequently during the winter months, in particular in December and January, and most often at weekends. The majority of residential fires (overall, also without fatalities) occur in the afternoon/early night, while the majority of fatal fires occur late at night/early morning, when most people are asleep, and the highest number on Saturdays and Sundays [5,8,12–15].

Norwegian Fire Protection Association's study *Alkohol og brann (Alcohol and fire),* examined the connection between alcoholic influence and fires in Norway by studying police

reports from 225 fatal fires from the 1993-2008 period. It found that at weekends the proportion of fatal fires with alcohol-impaired fire victims was larger (57 %) than on weekdays (34 %). Nights before weekends/public holidays had over the double amount of fatal fires involving alcohol-impaired fire victims as nights between workdays [16].

DSB's report *Kjennetegn og utviklingstrekk ved dødsbranner og omkomne i brann - En gjennomgang av DSB's statistikk over omkomne i brann 1986-2009* from 2010 shows that Finnmark stands out as a county with a high number of fatalities per inhabitant. A hypothesis of the report is that the reason for this may be attributed to the fact that the average response time for fire brigades in northern counties is higher owing to a more dispersed settlement than other parts of the country [5]. However, the hypothesis was not verified owing to a lack of data basis.

2.5 Personal characteristics

Previous studies have shown that men in nearly all age groups carry a higher risk of perishing in a fire. US statistics show that in 2014 it was around 1.5 times more likely for a man to die in a fire than it was for a woman. Studies from other countries show equivalent results [10,17].

As already mentioned the proportion of children perishing in fires has decreased both in Norway and Sweden. However, the chief risk factors associated with children are [17]:

- Escaping from a fire is difficult for small children, and they will normally need assistance.
- They lack the mental faculties required in order to understand the need for making an evacuation.
- They are more physically vulnerable, have thinner skin, and get burns more easily.
- They have little understanding of the risk relating to ignition sources, combined with curiosity this contributes to making "playing with fire" a cause of fire.

Even though fire statistics show a small number of children perishing in fires, it is still important to focus on fire protection measures to control these risk factors.

On the other hand, a number of reports establish that elderly people are the most vulnerable group, with the highest likelihood of being involved in a fatal fire. What with an ageing population the number of elderly people dying in fires will increase unless targeted measures are introduced. Statistics for 2014 show that elderly American adults (65+ years) were 2.6 times as likely to die in a fire as the population at large. The corresponding figure for age group 85+ was 4.1 times. Children 4 years or younger had a probability 30 % lower than the population seen as one. The probability of slightly older children perishing was even lower. For children between the age of 10 and 19 the probability was 70 % lower than the rest of the population. After the age of 19 the probability starts increasing. At the age of 50 the probability is higher than for the population as a whole [10,17].

Previous studies, referred to in [4,12] point to living alone and being single as a risk factor.

A study presented in article *Comparative investigation of 'survival' and fatality factors in accidental residential fires* analyzed and compared fatal fires with fires in which all residents survived without serious injuries requiring long-term hospitalization. Hundred-and-seventy-seven deaths and 183 survivors of residential fires in Australia were included in the study. Risk factors significantly more common for fatal fires than fires where everybody survived are (ranked) [18]:

1. Consumption of psychoactive drugs or sedatives
2. Cigarette residues
3. Single person
4. Age 70+
5. Asleep
6. Was in the room of origin when the fire started
7. Alcohol abuse

Nearly half of the victims had a history of mental disorder. For the survivors this information was based on interviews, and therefore not entirely commensurable. Factors related to fatal fires depart significantly from factors in fires where everyone survived. The victims' physical/mental condition was critical to the outcome, with a number of functional reductions being associated with fatal fires. The same applies to living alone, and being near the room of origin [18].

An American study shows that a large number of fatalities occur during escape or while the victim is asleep. Many victims try to escape through the burning area, which underlines the importance of having a rehearsed escape plan [10].

It is evident that the influence of alcohol is a determining factor in many fires. As concerns fires in Norway it has been identified that in many cases that the alcohol-impaired person was probably guilty of starting the fire, and he/she was unable to save himself/herself. The study *Alcohol and fire* [16] found that 47 % of the persons dying in the analyzed Norwegian fires occurring during the 1993-2008 period were under the influence of alcohol. Of all fatal fires included in the sample, 65 % were discovered by neighbors/passers-by, while of the fatal fires where the involved were under the influence of alcohol 74 % of fires were discovered by neighbors/passers-by. Risk behavior due to alcoholic influence also increases the risk of fire. According to the report alcohol-impaired fire victims were involved in 2/3 of fatal fires starting in the kitchen. Apart from that the sitting room was overall the most common point of origin in the analyzed fatal fires, however, 61 % of the victims in these cases were not under the influence of alcohol. As mentioned above, asphyxiation stood for 74 % of the causes of death in the sample of the study *Alcohol and fire*. Among the victims influenced by alcohol in this sample asphyxiation as cause of death was 85 % [15]. The report moreover establishes that alcohol and fire "primarily is a male issue ", in particular for persons aged 20-50 years. Eighty-five percent of the victims in fatal fires that could be related to alcohol were men. Alcohol appears to be a bigger problem in age groups 30-40, 40-50 and 50-60 among men than among women. Of women in all age groups there were more victims who were not under the influence of alcohol than those who were.

2.6 The fire

As concerns the cause of fire, the fire's start of origin and start object, fatal fires do not reflect the average residential fire. It is e.g. reported that the bulk of residential fires start in connection with cooking in the kitchen, but that the leading cause of death in fatal fires is smoking. The majority of fatal fires occurring in Norway, Sweden and Denmark start in the living room, followed by the bedroom as a common point of origin. In the US fatal fires usually start in the bedroom, followed by the living room. The bed and furniture are usually start objects in fatal fires, often related to ignition caused by cigarette smoking or use of open fire. A Swedish study showed that 17 % of fires starting in a bed were fatal. Electrical appliances are involved in many fires, both those resulting in fatalities and those without. During the 1986-2009 period cookers stand out in the Norwegian fatal fire statistics as the most common appliance when the cause of fire is a faulty electrical appliance, or incorrect use of such appliance [10,13–15,18–22].

US statistics have shown that human failure or influence were contributory causes in almost 50 % of fires with survivors, while the proportion was as much as 73 % in fatal fires. This signifies that it is more likely for fatal fires to be directly caused by humans than not [18].

It is being maintained that a large proportion of residential fires start as smoldering fires [22]. This is however hard to document, because the majority of fires develop into flaming fires, which makes it hard or impossible to identify the smoldering afterwards. The majority of fatal fires have grown big when the fire brigade arrives, and have spread to more rooms than the room in which the fire started [14]. However, it is a well-known fact that fires may start through smoldering in a number of materials, e.g. when upholstered furniture and mattresses are exposed to a smoldering cigarette, or through overheating in electrical installations near flammable insulation or wood. In media reports on fires we see, however, that fires are also being referred to as smoldering fires, but it is more likely that among these fires there are flaming fires that have extinguished by themselves owing to a lack of oxygen.

2.7 Prevention

The decrease in the number of fires and fatal fires caused by smoking in the US and Great Britain is assumed to be due to better resistance against ignition in furniture as well as a reduction in the number of smokers. Increased dissemination of smoke detectors is also assumed to have contributed to reducing the number of fatal fires. Other causes include development of standards for automatic sprinkler systems, test methods and cigarette test standards for upholstered furniture and mattresses, standards and requirements relating to children's nightwear, installation standard for chimneys and fireplaces, better technology for smoke control, improved instruments and test methods for characterization of materials' ignition, flammability and flame propagation ability [8]. An increase in the use of earth-leakage circuit-breakers, reducing the risk of flame arc and fault current is also assumed to have reduced the number of fires owing to defects in electrical facilities and faulty electrical products. However, adapters of low quality may lead to an increased risk of fire [24].

Swedish fire statistics show that families with children have a high probability of experiencing a fire, while the likelihood of their dying in a fire is much lower than for other groups, such as e.g. elderly people and persons with functional disabilities. This may signify that measures introduced for families with children are working [24].

The same study, which comprised 144 fatal fires in Sweden during the 2011-2014 period, estimated the potential efficiency of various technical barriers. In general thermally activated extinguishing systems (e.g. sprinkler system) are the most effective, followed by detection-activated extinguishing systems in bedroom and sitting room, and after that the use of smoke detectors. The article does not specify which type of detector that should be used. Specifically for smokers assisted by home care services, the authors hold that thermally activated extinguishing systems and smoke detectors are the most effective barriers. Extinguishing systems activated by heat have the largest potential for preventing fatal fires. However, such measures are not effective for preventing the person from perishing "in the start object" (e.g. bed, which is very common), not even in a flaming fire, since the fire will have grown too big when the sprinkler system is activated. Given optimally placed detectors and extinguishing systems the authors of the article assumes that a large part of the persons in this group would have been saved [24]. The study had few cases where the fatalities could have been prevented through sufficient fire resistance between fire cells. The overall majority of victims were found in the start fire cell [24].

For upholstered furniture the most common ignition source is cigarettes. Here a correct use of materials will constitute an adequate barrier against ignition in many cases, also without using flame retardant chemicals. For mattresses the requirements might be different, since a weak ignition protection in a mattress will not be adequate if the duvet and pillow are ignited first, which represents a large start fire [24,25].

It is unclear whether regulatory requirements for self-extinguishing cigarettes have had the desired effect on fire statistics. It has been shown that cigarettes fulfilling the harmonized European requirements for self-extinguishing properties introduced in 2011, to a large extent still burn out to their full length without extinguishing. For this reason they are nevertheless capable of igniting upholstered furniture [26].

An open flame is a common ignition source for fires starting in clothing. Synthetic fabrics are, unlike cellulose based fabrics, less flammable, as the material melt away from the flame. However, in exposure to larger ignition sources, the ability to melt may cause serious skin burns [24,27].

The comparative study including Australian fires and fatal fires, showed that in cases where the persons were asleep when the fire started, the proportion of functioning smoke detectors in fatal fires in the sample was the same as in the fires with survivors. However, those who survived were more prone to wake up from other signals caused by the fire, than by the smoke detector proper (e.g. breaking of glass, smell of smoke). An assumed contributory cause in the cases involving fatalities, is that either they did not awake from the signals of the fire or smoke detectors, or they were incapable of escaping by their own means owing to alcohol or drug impact [18]. Studies also show that smoke detectors may not be equally effective in arousing children as grown-ups. Children tend to sleep more heavily and are harder to arouse [17].

Sleeping with the bedroom closed may save people from dying in a fire, because this hinders the fire and smoke from spreading. Smoke detectors inside a closed bedroom will give early warning if a fire starts there.

Further, the results presented in the Australian study show that the procedure for preventing fatal fires must be related to human and social factors rather than purely technical measures and regulations, since the majority of fatal fires is associated with factors relating to the individual [18].

American authorities give the following general recommendations on the prevention of fatal fires [10]:

- Escape instead of trying to extinguish the fire. Let the fire brigade deal with extinguishing the fire. Escape to safety instead.
- Conduct escape drills, set up an escape plan which includes how to help children and elderly people. Many people perish when they try to evacuate.
- Have smoke detectors on all floors, inside and outside bedrooms.
- Automatic extinguishing system, residential sprinkler system.

Specifically for elderly people focused measures should be in place relating to lifestyle changes in the form of safe smoking, safe cooking, safe heating [17].

3 Description of method

3.1 Hypotheses

To answer the questions in paragraph 1.2, we used as basis a number of hypotheses defined in the report *Forprosjekt: Dødsbranner i Norge – Hvem omkommer og hvorfor?* from 2013 [28]:

1. Personal functional level will in different ways impact on the probability of a fire occurring, and in what way the fire is handled and responded to (i.e. the consequence of a fire). It is likely that individuals having died in fires to a large extent may be connected to
    a. physical function level.
    b. cognitive function level.

2. When living alone the probability of a fire being discovered in time is diminished, and it is more difficult to escape. Living alone is therefore associated with risk.

3. During the winter season we stay more at home, we use more candlelight amongst other and need more heating.
    a. There are more fatal fires during the winter months.
    b. The increase in winter months may be connected to ignition sources which we use more often in the winter season, e.g. candlelight and electrical heating (wrong use and faulty electrical facilities).

4. The influence of alcohol, medication and drugs is an important underlying cause of fatal fires.

5. It is overwhelmingly likely that individuals dying in a fire will be men under the influence of alcohol.

6. Elderly people women (80+ years) have an increased probability of dying in a fire compared with men of the same age.

7. The number of children perishing in fire is relatively low compared to the number of perishing in other age groups.

8. The county of Finnmark stands out with a large number of fatalities per number of inhabitants. The average response time of the fire brigade is more protracted than elsewhere in the country. This may either be due to a deviation from response time requirements stated in the *Dimensjoneringsforskriften* (dimensioning regulation), or requirements may have been met, but the fires may have occurred in sparsely populated areas, where a longer response time is allowed.

9. The introduction of a rule for self-extinguishing cigarettes in November 2011 has had a demonstrable effect on Norwegian fatal fire statistics.

3.2 Sample

This study surveys both fatal fires and persons having died in fires in Norway during the 2005 – 2014 period.

According to DSB's fire statistics 517 fatal fires occurred during this period. Of these we gained access to Police investigation reports in 351 cases, where all cases addressed fire in buildings. This constitutes a 68 % share of the total number of fatal fires. During the same period 571 deaths were registered. In the 351 cases we had access to there were 391 deaths, which corresponds to 68 % of the total number of fatalities.

The cases are geographically dispersed across the entire country, but we did not have access to the Police reports for Hordaland, Sogn og Fjordane or Finnmark.

Four fires involving four deaths from DSB's statistics basis were excluded from the study, as it turned out that in these incidents the persons had perished as a result of gas poisoning or burns (heat), without a fire occurring. All together the sample therefore includes 347 fires with 387 deaths.

3.3 Data collection

3.3.1 Sources

Our data material consisted of DSB's fire statistics, Police investigation reports, the fire victim's medical records, and the Cause of Death Registry (NCoDR) from the Norwegian Institute for Public Health. With few exceptions the investigation reports also include post-mortem reports.

DSB's statistics provided the basis for which cases we requested access to Police investigation reports. This entails that cases not listed in these statistics are not included in the study. Based on DBS's overview letters were sent to each Police district, requesting submission of the reports.

By means of the Police reports the fatalities were identified, which formed the basis for which medical records we asked to access, and for which persons we requested data from NCoDR. Each medical record resides with the person who was GP/family doctor at the time of death, which meant that Helfo had to help us in finding a key to connect each fatality and the GP/family doctor at the time of death.

3.3.2 Data registration and categorization

To register data from the various sources, a database was set up to handle the fire data and to link data on fire victims. DSB's fire statistics were imported directly into the database, and was used as a basis for the requests to access investigation reports sent to the Police districts. Additionally, variables to handle relevant data were added.

To ensure consistent extraction and storage of data from the various cases between project collaborators, an electronic form was prepared which was completed for each incident. Some of the spaces were pre-defined multi-choice categories. In addition to that a codebook was prepared which was applied as a basis on how data was to be interpreted and stored. This makes interpretations more objective, and it becomes easier to quantify qualitative data, see appendices A and B.

The extraction from NCoDR contained data on the cause of death for fatalities identified through Police investigation reports.

3.4 Statistical analysis

All data registered in the database mentioned in chapter 3.3.2 were exported to statistics program Statistica, version 12[1].

All relevant data in this study are presented descriptively. Additionally, statistical tests were conducted to test the hypotheses and examine apparent differences between sub-groups in the population. In all essentials non-parametric tests were employed, such as Mann-Whitney U-test, Fisher exact-test, chi-square test and regression analysis. For all analyses a significance limit of $p \leq 0{,}05$ was employed. A p-value between $0{,}10 \geq p > 0{,}05$ is considered as a trend.

Multiple Correspondence Analysis as analysis method was carried out in order to identify whether the various characteristics of the victims frequently occur simultaneously. E.g., this includes examining whether victims with an established substance abuse alto tend to be smokers. This method cannot quantify any similarities or dissimilarities, but it may provide a qualitative impression and give a basis for further analyses.

3.5 Critique of methodology

The Police reports vary when it comes to richness in detail, which may impact on our analysis. In some cases we see that investigation reports are highly inadequate, while in other cases they are exhaustive. This makes it difficult to draw categorical conclusions as regards some factors. We have taken care not to color the information with our own interpretations, but have in cases where some factors are not mentioned stated «unknown» to underline the

[1] Dell Inc. (2015). Dell Statistica (data analysis software system), version 12. software.dell.com.

lack of data. In a few number of cases where the Police concluded with an unknown cause of fire, but where we, based on a professional assessment, believe that one cause of fire is overwhelmingly likely, we have stated this as the cause. This was a conscious choice which we believe gives a more correct picture of the actual causes, even though it may give an imprecise picture of the Police's clearance rate as concerns fatal fires.

The medical records as well were in many cases very thin. In these cases the majority of categories were therefore marked as uncommented or unknown. Similarly, cases potentially relating to cognitive ability, substance abuse and mental illness were commented as unknown, as these conditions most often are not evaluated in cases where the doctor does not have any suspicion. It is therefore reasonable to assume that a large percentage of cases marked unknown entails that there does not exist impaired cognitive ability, known substance abuse or mental illness. In cases where the victim rarely had been to see the doctor, the medical records tended to be old with scarce updated information. The relevance of data has therefore been evaluated from one case to the next.

Based on information in the investigation reports and the post-mortem reports we registered whether the fire victims were under the influence of alcohol at the time of death. To which extent one is affected by a certain blood-alcohol level depends on a variety of factors, e.g. weight and the person's alcohol tolerance. We therefore chose not to differentiate between, or categorize the victims' deaths according to different blood-alcohol levels, but employed a category variable that we called *alcoholic influence* or *no alcoholic influence*. It can therefore not be stated with any certainty to which extent alcohol actually affected the victim and the outcome of the fire.

4 Results

This chapter presents the results of our analysis. As previously mentioned, several sources were employed in this work. DSB's fire statistics, Police investigation reports, the medical records of victims, and the Cause of Death Registry (NCoDR) of the Norwegian Institute for Public Health. We switched between using the different sources depending on which source that contained relevant data. This is also the reason for the varying number of observations (N) on which the various analyses are based.

4.1 Registration of fatalities

DSB's fire statistics, which during the period registered 517 fatal fires and 571 fatalities , contain some data on the fire itself, as well as the number of injured and the gender and age of the fire causalities. Requests for access to Police reports were made for all these fires, and we received 347 Police reports (68 % response) that were reviewed. Data from these reports were combined with data from DSB's statistics. From the Police reports 391 fatalities were registered, of whom four were dead before the start of fire. Those who died before the start of fire did per definition not die in a fatal fire and were therefore excluded from the study, which gave us a selection of 387 fatalities. The vast majority of these were identified through their ID-number, and a request for access to the medical records was sent to the respective GP/family doctor at the time of death. A small number lacked ID-number data and were consequently excluded from the analysis of medical records. There were also a number of cases where only the name and date of birth were stated, which often sufficed to find the medical records of the person in question. We received 248 medical records, which represents 64 % of the identified victims.

Extraction from NCoDR was also made for the identified persons. Of all the identified persons there were 29 persons with an incomplete ID-number (lack of information in the Police reports). Sixteen of these were found in NCoDR by means of their name. The remaining 13 persons were foreigners without a Norwegian ID-number or d-number who had died in Norway. The extraction from NCoDR was also imported into the database and linked to each separate person. Of the NCoDR data we got access to *underlying cause of death* and *injury code* were of largest interest.

Our client wished us to compare the number of registered deaths from fire in DSB's fire statistics and in NCoDR. NCoDR registers all fire victims in Norway with a Norwegian ID-number and gives the cause of death. The cause of death does not necessarily take into consideration which incident that caused the death. I.e., if making a search for all persons dying from «Intentional self-poisoning by and exposure to other gases and vapours» (see Table 4-11 and Table 4-12 in paragraph 4.3.4), of which, incidentally, there were 9 in our sample, the result would also include all persons committing suicide in this manner, but which was not necessarily related to a fire. The numbers would therefore be uncertain, since we did not have access to other information about such cases (e.g. the Police report). We therefore decided not to perform this exercise.

4.2 Fires

4.2.1 Geographical distribution

The 513 fatal fires that took place during the 2005 – 2014 period are distributed on the various counties as shown in Table 4-1. The highest number of fatal fires occurred in Akershus and Oslo, however, these are the counties with the highest number of inhabitants. By allowing for the county's population, one will see which county that deviates from the national median relating to the number of fatal fires per county over a 10-year period, see Figure 4-1.

Table 4-1 **Number of fatal fires in DSB's fire statistics from the 2005-2014 period distributed on county.**

County	Number of fatal fires
Østfold	29
Akershus	52
Oslo	50
Hedmark	14
Oppland	21
Buskerud	41
Vestfold	24
Telemark	21
Aust-Agder	13
Vest-Agder	12
Rogaland	41
Hordaland	32
Sogn og Fjordane	11
Møre og Romsdal	29
Sør-Trøndelag	33
Nord-Trøndelag	15
Nordland	33
Troms	21
Finnmark	21
TOTAL	**513**

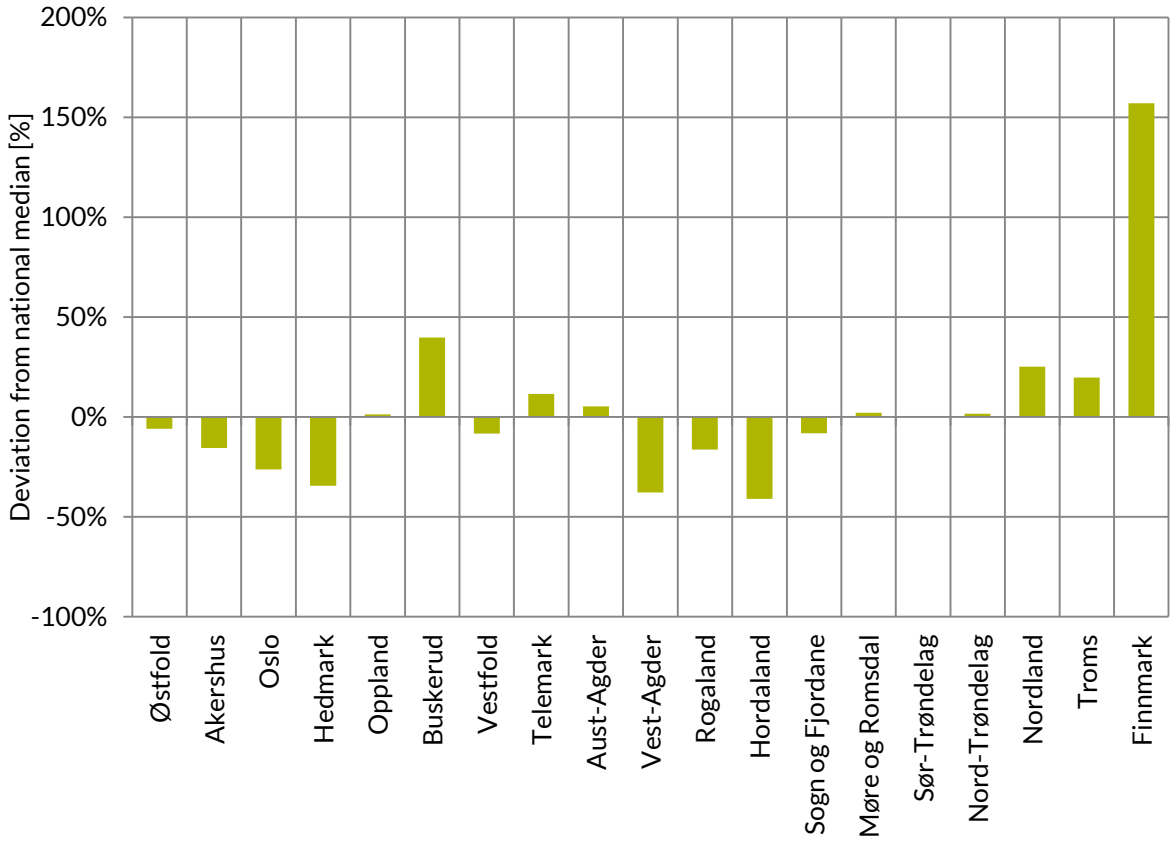

Figure 4-1 **Percentual deviation in the number of fatal fires during the 2005-2014 period compared to the national median (11.1 fatal fires per 100 000 inhabitants) when taking the county population per 2011 into consideration [29].**

The figure above shows deviations in the number of fatal fires in each county compared to the national median, which is 11.1 fatal fires per 100 000 inhabitants. Four counties are distinguished by having fewer fatal fires per inhabitant (number of fatal fires per 100 000 inhabitants in parenthesis): Oslo (8.2), Hedmark (7.3), Vest-Agder (6.9) and Hordaland (6.5). Additionally there are two counties which stand out with a higher number of fires per inhabitant, Buskerud (15.5) and Finnmark (28.5), of which the latter occupies an exceptional position by having 157 % more fatal fires per inhabitant than the national median.

It has been examined which factors that may explain Finnmark's excessive deviation, but no statistically significant difference was found in the distribution between Finnmark and the other counties as regards the number of fires in towns/densely populated areas, countries and wilderness[2]. Nor is there any statistically significant difference when it comes to the gender of fatalities[3]. Further, there is no difference in their age[4]. We have not had access to Police reports from Finnmark, and consequently no medical records from Finnmark either,

[2] Fisher exact-test, two-tailed, p = 0.558.a
[3] Fisher exact-test, two-tailed, p = 0.279.
[4] Mann-Whitney U-test, p = 0.134.

which means that we had a limited data basis for these fires. This makes it hard to suggest whether there are any other aspects connected to the deaths that may explain the large discrepancy.

4.2.2 Time: year, month and weekday

The number of fatal fires per year registered in DSB's statistics are distributed as shown in Figure 4-2. Previous studies typically divided the data in into 5-year periods, and compared the average of these periods. By employing the same method here, one gets on average of 55.6 fatal fires for 2005 – 2009, and 47.0 for 2010 – 2014, which is a significant decrease[5]. However, if one avoids this grouping, performing a regression analysis instead, which to a larger extent safeguards the information in the data basis, one can conclude that there is no significant decrease in the *number of fatal fires* over the period[6]. However, if one considers the *number of fatalities* during the period, adjusting for the number of inhabitants who during the period rose by around 500 000, one finds there is a downward trend (bordering on statistically significant) in the number of fatalities per 100 000 inhabitants[7], see Figure 4-3.

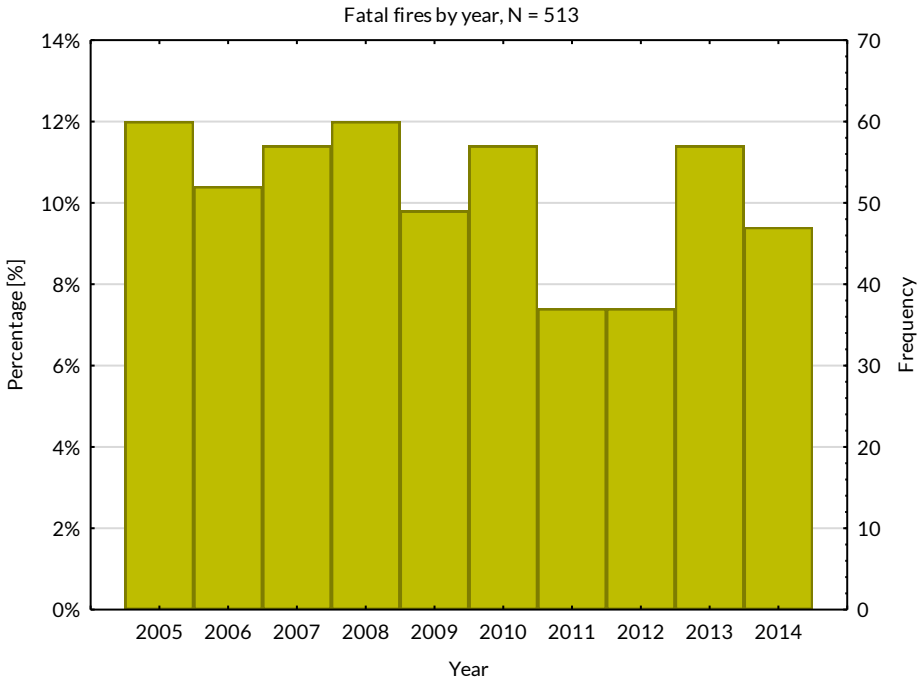

Figure 4-2 **Fatal fires in Norway distributed per year during the 2005-2014 period. The figure is based on DSB's statistics database.**

[5] Mann-Whitney U-test, p = 0.000.
[6] Regression analysis, p = 0.130.
[7] Regression analysis, p = 0.057.

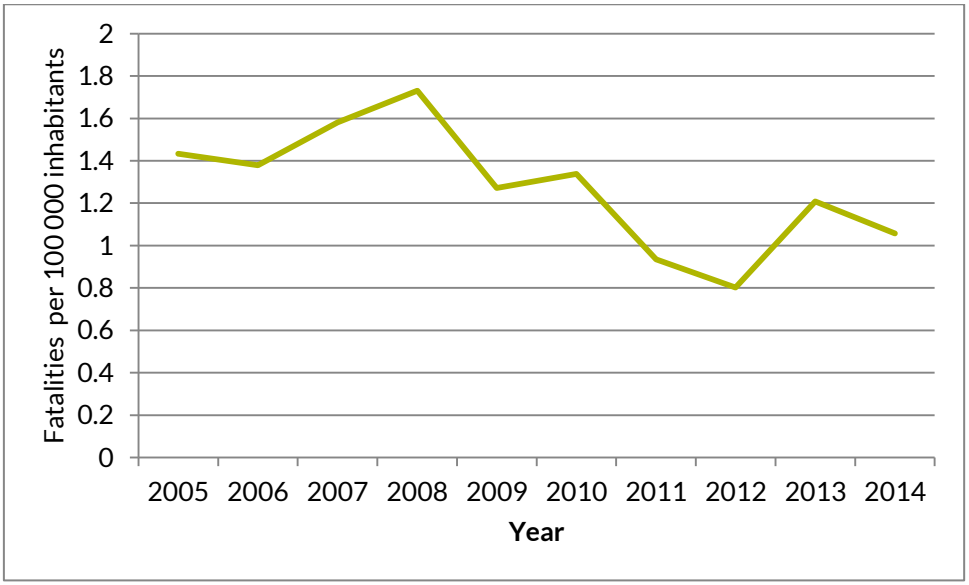

Figure 4-3 **Number of fatalities in fire per 100 000 inhabitants during the 2005-2014 period [30,31]. The high value in 2008 is amongst due to two fires which combined resulted in 13 fatalities.**

Figure 4-4 shows the number of fatal fires distributed on months, which goes to show that the majority of fires occur during the winter season. E.g., there are almost four times as many fires in December (which is the month with the highest number of fires) as in August (the month with fewest fires).

Further Figure 4-5 shows the number of fires distributed on weekdays. Fires are relatively evenly distributed on the weekdays, with the exception of Wednesday, which stands out positively, and Saturday which stands out negatively. Figure 4-6 shows the fires distributed on the time of day. There are fewer fatal fires during the daytime, and one sees an increase into the evening and night, to a level which is relatively stable, although somewhat fluctuating through the night and into the morning and until noon.

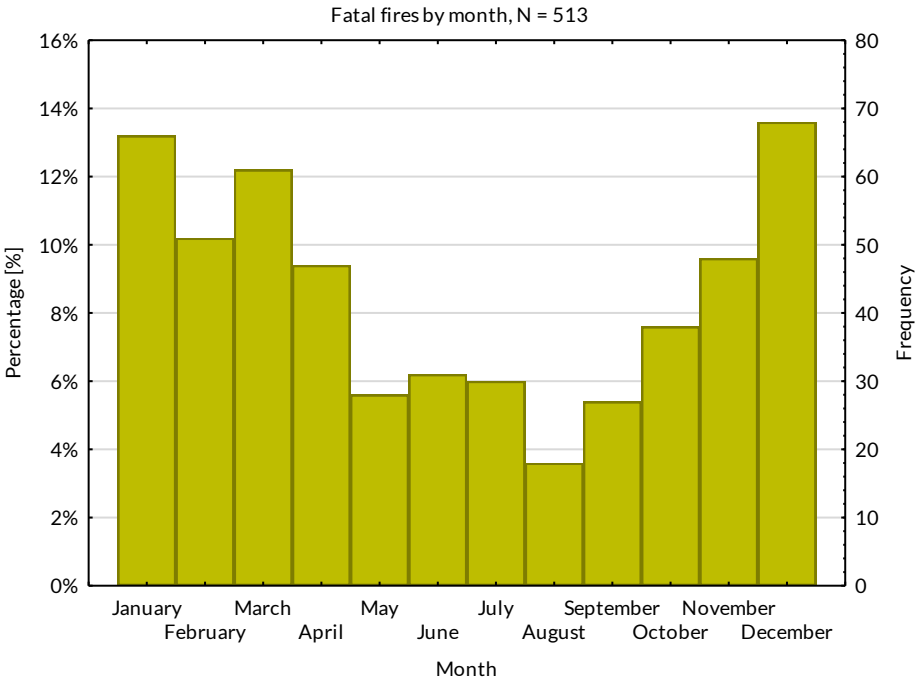

Figure 4-4 **Fatal fires during the 2005-2014 period distributed on the months of the year.**

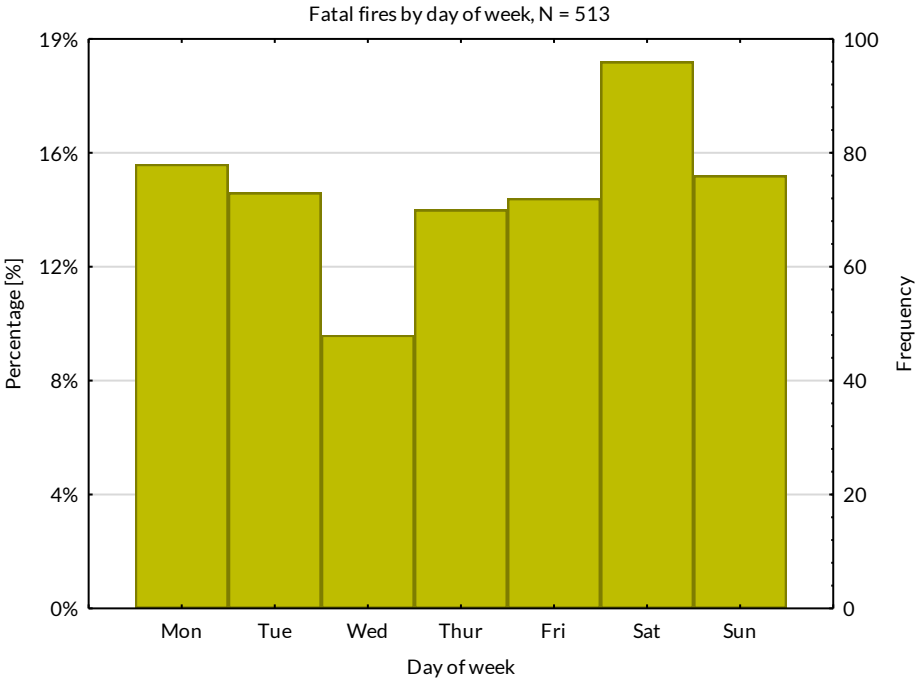

Figure 4-5 **Fatal fires during the 2005 – 2014 period distributed on weekdays.**

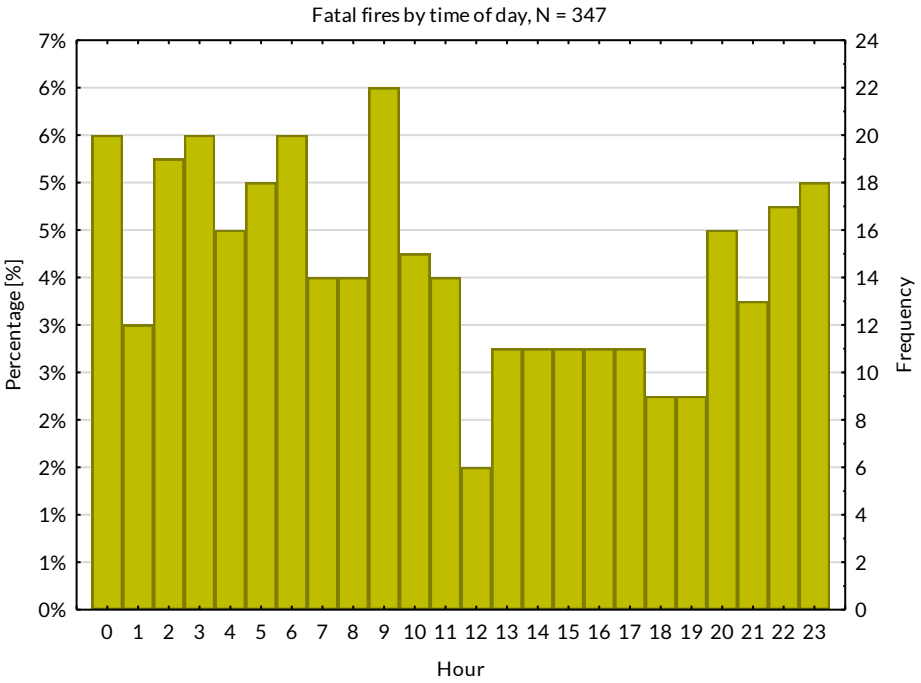

Figure 4-6 **Fatal fires during the 2005 – 2014 period distributed on the time of day.**

4.2.3 Type of building

Figure 4-7 gives an overview of the distribution on types of buildings for the 513 fatal fires.

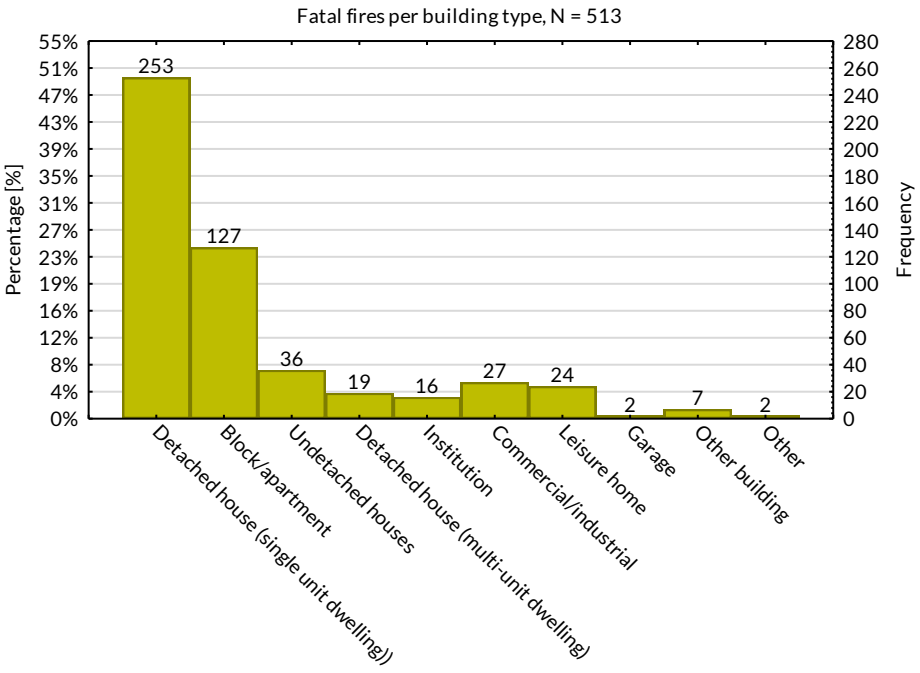

Figure 4-7 **Distribution between the various types of building in which the fatal fires during the 2005 – 2014 period took place.**

As the above figure goes to show fatal fires in residences represent 85 % of all fatal fires. Table 4-2 shows the distribution of fatal fires on the three most common residence categories, together with a distribution of all fires in these buildings, and the distribution of the Norwegian settlement pattern on the three types of building.

Table 4-2 **The three most common types of residence with fire fatalities during the 2005-2014 period, compared with the Norwegian settlement pattern per 2015 [32]. Number of fires in data basis: N = 435.**

	Detached house (single unit dwelling)	Undetached house /multi-unit dwelling	Block/apartment
Distribution of all residents	54 %	20 %	25 %
Distribution of all residential fires (period 2005-2009)	61 %	10 %	29 %
Distribution of 435 fatal fires (2005-2014 period)	54 %	15 %	31 %

A chi-square test shows there is no difference between the distributions for fatal fires and settlement pattern in these three types of building[8]. This means that the risk of perishing in a fire in any one of these types of building compared with the others has not been established.

4.2.4 Type and cause of fire

Table 4-3 goes to show that in almost all fatal fires there had been a flaming fire.

Table 4-3 **Distribution of registration of flaming fires and smoldering fires in fatal fires during the 2005-2014 period, and whether the fire spread from the room of origin of fire.**

Type of fire	Flaming fire 98.6 %	Smoldering fire 1.2 %	Unknown 0.2 %	N 345
Fire propagation from room of origin of fire	No 32.5 %	Yes 66.7 %	Unknown 0.8 %	N 345

[8]Chi-square test, p = 0.769.

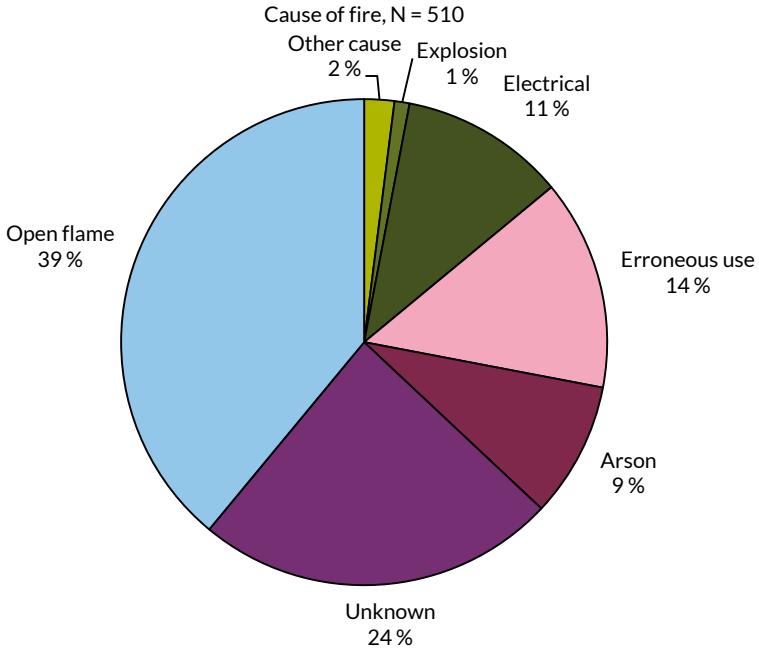

Figure 4-8 **Registered cause of fire for 510 fatal fires during the 2005 – 2014 period. Causes constituting < 1 % of all cases are excluded from this figure.**

Figure 4-8 shows the cause of 510 fatal fires occurring during the 2005 – 2014 period. The data was collected from DSB's fire statistics. In some cases, where the Police had stated *unknown* cause of fire, but where we, based on professional assessment, believe that one cause of fire is overwhelmingly likely, we employed this cause as causality in the further analysis. It appears from the figure that the chief causality category is «open fire». Open fire includes amongst other candlelight and smoking, constituting 7.3 % and 34.4 % respectively of sub-causes in this category, (for a complete overview of sub-causes, see attachment C).

The second largest causality category is «unknown». This causality is reported when the traces are so few that other causes cannot be substantiated.

The third largest causality category is «incorrect use ». This category comprises incorrect use of electrical equipment, e.g. food left on the cooker and heater coverings.

The fourth largest causality category is «electrical fault», which includes series and parallel arcs, overheating and other faults in electrical installations and appliances.

The fifth largest causality category is «arson». In 86 % of fires where arson was concluded, it was the perished person himself/herself who deliberately ignited the fire, and only 7 % of these fires were caused by others, N = 29.

No significant differences were identified in the distribution of causality between fires occurring on weekdays and those occurring during weekends[9].

Of 347 fatal fires 37 % were directly caused by the victim (inadvertently), while the other fires had started for other reasons (13 %) or it was unknown who or what causes the fire (50 %).

Previous studies (e.g. [5]) point out that the reason why there are more fatal fires in the winter season than in summer, may be that in winter people tend to stay more indoors, lightening candles, fireplaces and ovens, and they use more electrical heating than in summer. It was therefore examined whether this also results in causality differences between fires occurring in the summer season (May - October) and the winter season (November – April), see Figure 4-9. There is a significant variance in the distribution of cause of fire between the summer and winter seasons[10]. The difference is most pronounced as concerns open fire, which is a more frequent cause in winter, and arson, which is a more frequent cause in summer.

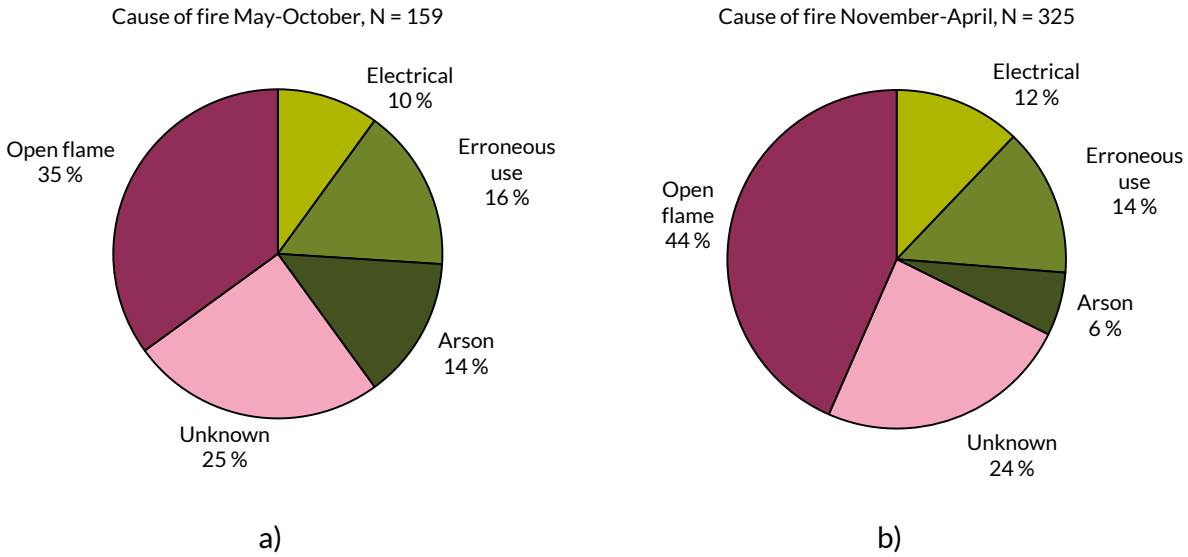

Figure 4-9 **Distribution of cause of fire for fatal fires occurring in a) summer season May- October and b) winter season November – April during the 2005-2014 period.**

Previous studies have shown that elderly people have an increased probability of dying in a fire, but there is no significant difference between the causes of fires with fatalities under the age of 67 and fires with fatalities who have reached pension age. There is, however, a trend suggesting that open fire is more frequently involved in fires where elderly people perish. See Figure 4-10.

[9] Chi-square test, p = 0.527, the most rare causes were excluded from the analysis.
[10] Chi-square test, p = 0.04.

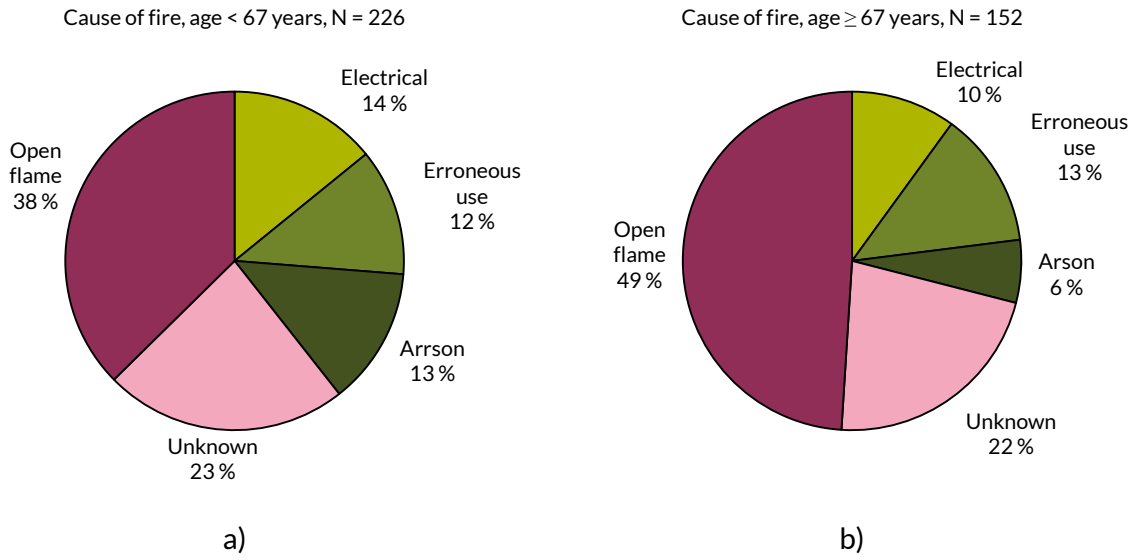

Figure 4-10 Distribution of causes of fire for fires involving fatalities a) <67 years and b) ≥67 years.

In November 2011 a law on self-extinguishing cigarettes was introduced in Norway and in the EU. Such cigarettes are designed so that they do not burn in all their length, but self-extinguish if they are left unattended. Figure 4-11 shows the trend as concerns smoking as the cause of fatal fires in our data basis for the 2005 – 2014 period, and one cannot see any decreasing trend in such cases. Overall our data basis registered 52 fatal fires that were caused by smoking.

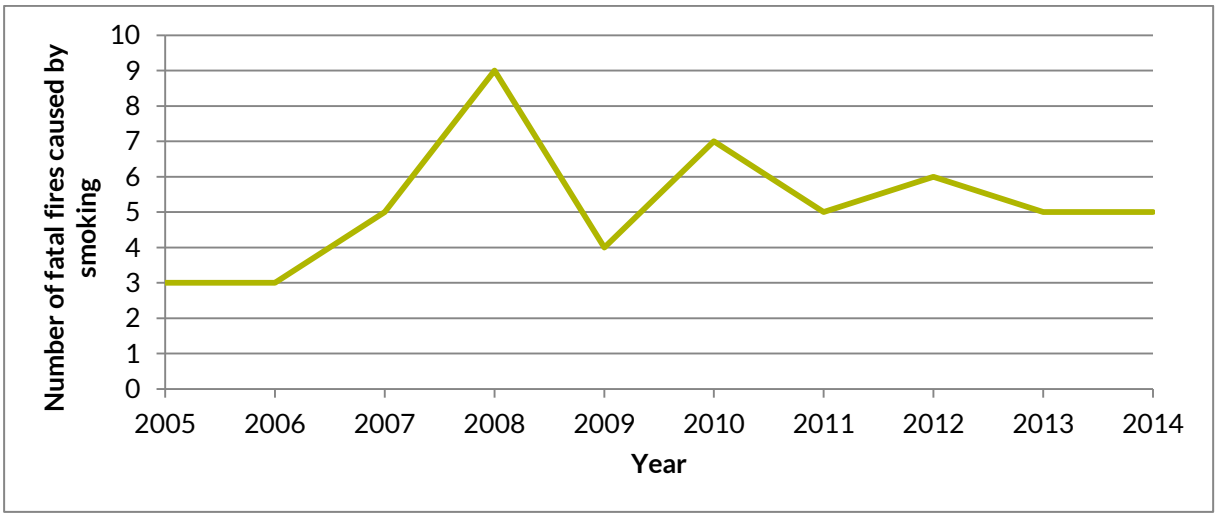

Figure 4-11 Trend in the number of fatal fires caused by smoking during the 2005-2014 period. Overall there were 52 such cases in our data basis.

4.2.5 Point of origin

According to Police report data the sitting room is the most frequent room of origin in fatal fires, followed by the kitchen and bedroom. These three rooms constitute 68.5 % of the point

of origin in all fatal fires, see Table 4-4. The «others» category comprises around twenty other categories with only a few observations.

Table 4-4 **Distribution of room of origin for fatal fires during the 2005-2014 period. The «others» comprises around twenty categories with only a few observations.**

Point/room of origin	Proportion [%]	N
Sitting room	37.0	128
Kitchen	18.8	65
Bedroom	12.7	44
Unknown	11.0	38
Others	20.5	71

4.2.6 Consequences

From the Police reports we retrieved data on the number of people present in the building or living unit when the fire started, the number of persons perished or injured, where fatalities were found, the number who tried to escape, and the number who succeeded in escaping. The results, presented in Table 4-5 and Table 4-6, show that in the majority of fire only one person was present at start of fire, and that in over nine of ten there was only one mortality. A large percentage of the fatalities (40.1 %) were found in the same room as the point of origin.

Further one sees that the number of fatal fires where persons managed to escape on their own are relatively few (20,1 %), and in even fewer fatal fires there were persons saved by the fire brigade (6.1 %) and by other persons who came to the assistance (5.2 %).

Table 4-5 **Distribution of number of persons present at fire start, number of fatalities and injured, and where victims were found, for fatal fires during the 2005-2014 period*).**

Number present at start of fire	1 person 71.1 %	2 persons 15.2 %	3 persons 5.0 %	≥ 4 persons 8.7 %	N 342
Number of fatalities	1 person 92.6 %	2 persons 5.7 %	3 persons 1.2 %	≥ 4 persons 0.5 %	N 513
Number of injured in addition to fatalities	0 persons 86.1 %	1 person 8.1 %	2 persons 3.5 %	≥ 3 persons 2.3 %	N 347
Where victims were found	Point of origin 40.1 %	Neighboring room of point of origin 11,3 %	Other room in living unit 42.7 %	Outside living unit 5.9 %	N 354

*) Note that these numbers are fraught with some uncertainty as such data were not registered in all Police reports.

Table 4-6 **Distribution of fatal fires where persons tried to escape, succeeded in escaping, or were saved during the 2005-2014 period*).**

Escape without assistance	0 persons 79.1 %	1 person 9.6 %	2 persons 4.4 %	≥ 3 persons 6.9 %	N 344
Escape attempt)**	No 39.0 %	Yes 20.9 %	Unknown 40.1 %		N 387
Escape with assistance of others than fire brigade	0 persons 94.8 %	1 person 3.8 %	2 persons 0.3 %	≥ 3 persons 1.1 %	N 343
Escape with assistance of fire brigade	0 persons 93.9 %	1 person 3.8 %	2 persons 1.2 %	≥ 3 persons 1.1 %	N 343

*) Note that these numbers are fraught with some uncertainty as such data were not registered in all Police reports.
**) Made by the victim

4.2.7 Fire protection measures

Table 4-7 shows data on fire protection measures registered in connection with fatal fires.

Table 4-7 Fire protection measures installed in residences [*)] registered for fatal fires during the 2005-2014 period.

Smoke detector installed	No 4.3 %	Yes 47.7 %	Unknown 48.0 %	N 346
Smoke detector heard	No 19.4 %	Yes 30.3 %	Unknown 50.3 %	N 346
Automatic extinguishing system installed	No 91.0 %	Yes 0.9 %	Unknown 8.1 %	N 347

[*)] Institutions are also included in this basis

The above table shows that in around fifty percent of fires it is uncertain whether a smoke detector was installed, and if, whether it was in functioning order. The reason for this may either be that it does not appear from the Police reports, or that smoke detector had burnt up in the fire. This means that there is considerable uncertainty associated with these numbers. The *Yes*-categories on whether a smoke detector was installed, and whether the alarm was heard, are reliable as a minimum level, as these data appear explicitly from the Police reports.

There is no significant difference[11] between day and night when it comes to whether survivors or persons outside the living unit heard the smoke detector.

According to the table an automatic extinguishing system was installed in 0.9 % of the burning buildings. This applied to three fatal fires in institutions. In none of these cases had the fire grown big enough to trigger off the extinguishing system.

Figure 4-12 and Figure 4-13 present the status of fire at the point when the fire brigade arrived at the fire. The figures show the status for all fatal fires, and the fatal fires where the fire spread from the room of origin. The main categories are «fire in part of the building» and «fire in major parts of the building».

[11] Chi-square test, p = 0,887.

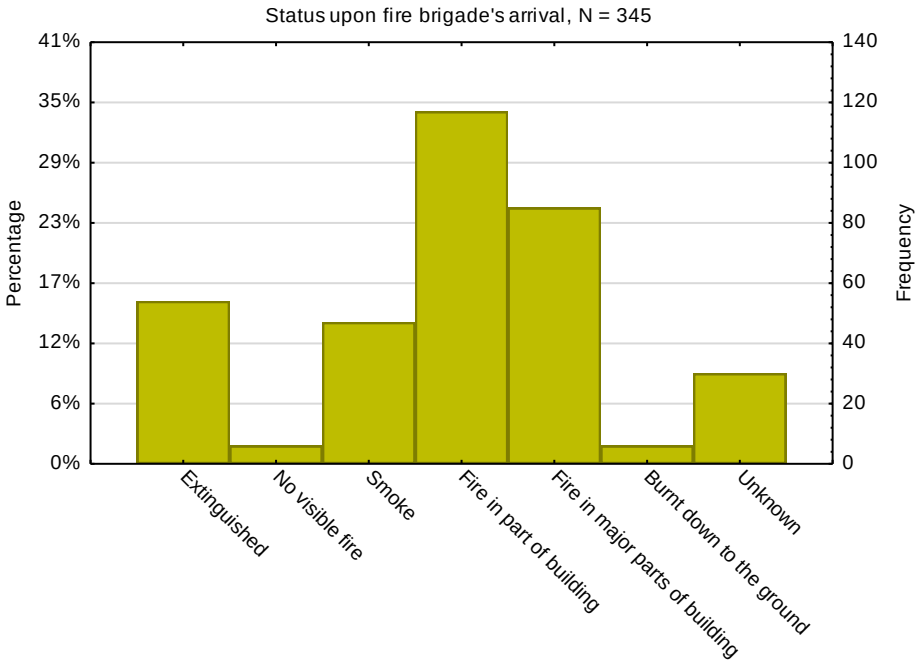

Figure 4-12 **Situation status at arrival of fire brigades for 345 fatal fires during the 2005-2014 period.**

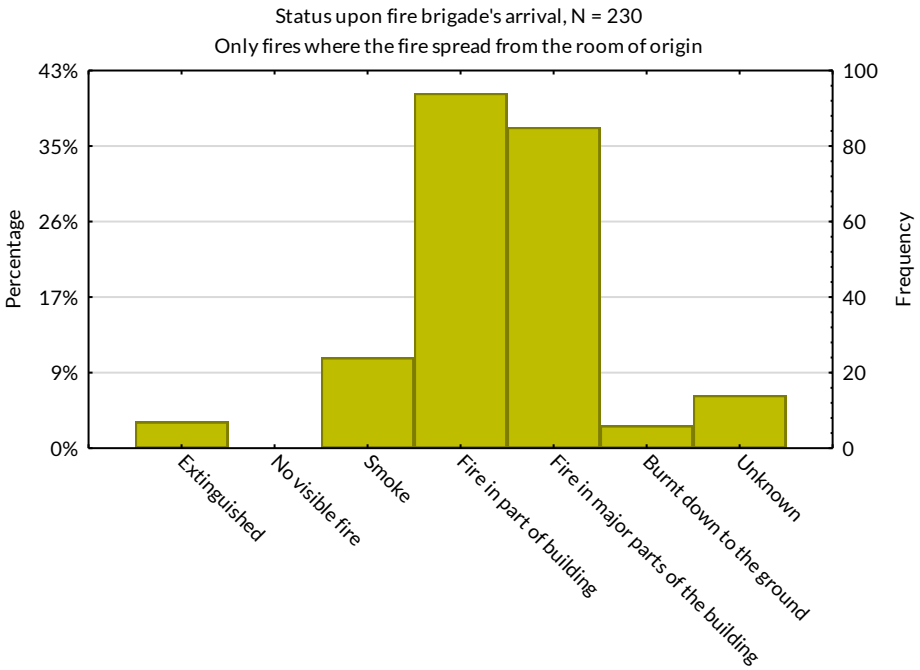

Figure 4-13 **Situation status at the arrival of fire brigades in fires spreading from the room of origin in fatal fires during the 2005 – 2014 period.**

4.3 The fatalities

4.3.1 Sample description

Table 4-8 shows the distribution of various characteristics of the fatalities in fatal fires during the 2005-2014 period.

Table 4-8 Distribution of gender, age and language for fatalities in fatal fires during the 2005-2014 period.

Gender	Man 56.1 %	Woman 43.9 %		N 387
Age	Median 59	Interquartile range 44 - 78	Min - Max 1 - 97	N 386
Non-native speaker	No 88.6 %	Yes 7,8 %	Unknown 3.6 %	N 387

As concerns the category «non-native speaker », it is meant to include persons who are assumed not to communicate adequately in a Nordic language or English, and who it will be difficult to reach by relevant information in connection with preventive fire safety. According to Statistics Norway's (SSB) report titled *Innvandring og innvandrere 2010 (Immigration and Immigrants 2010)* around 460 000 foreign-born immigrants were living in Norway as of 1 January 2010, which constituted 9.5 % of the Norwegian population in 2010 [33]. The largest groups derived from Poland, Sweden, Germany, and Iraq. Around 180 000 of immigrants were from the EU/EEA, US, Canada, Australia, and New Zealand. Asylum seekers come in addition, and as of 1 January 2014 Norwegian asylum centers held 16 000 residents [34]. According to a rough estimate there were 5-6 % non-native speakers (to a varying extent) in Norway in 2014.

4.3.2 Age

Distribution of age among fatalities in fatal fires during the 2005-2014 period is shown in Figure 4-14 below.

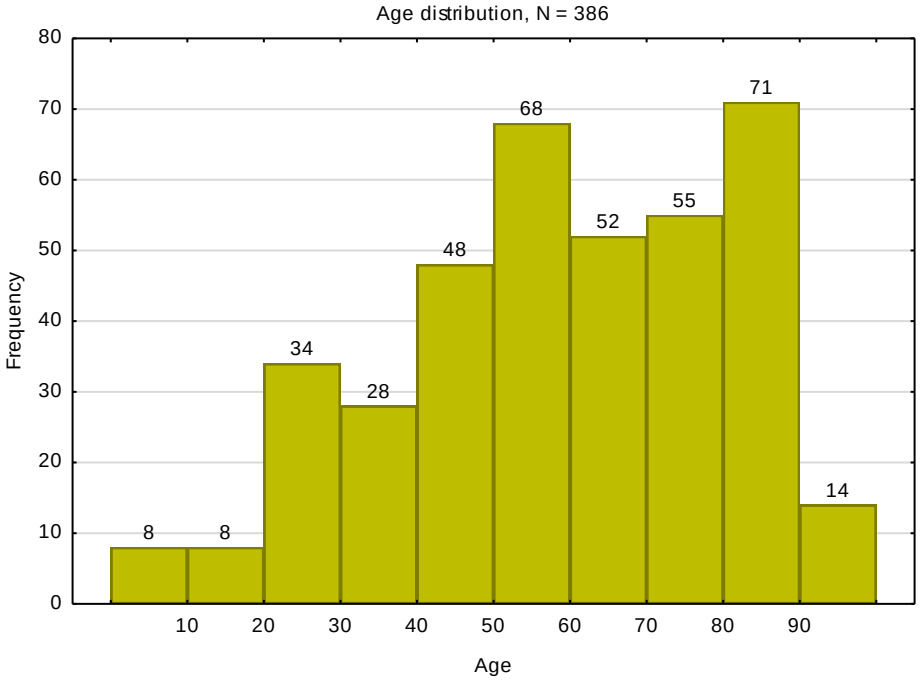

Figure 4-14 Age distribution for fatalities in 386 fatal fires during the 2005-2014 period.

Age distribution for fatalities distributed on gender is shown in Figure 4-15.

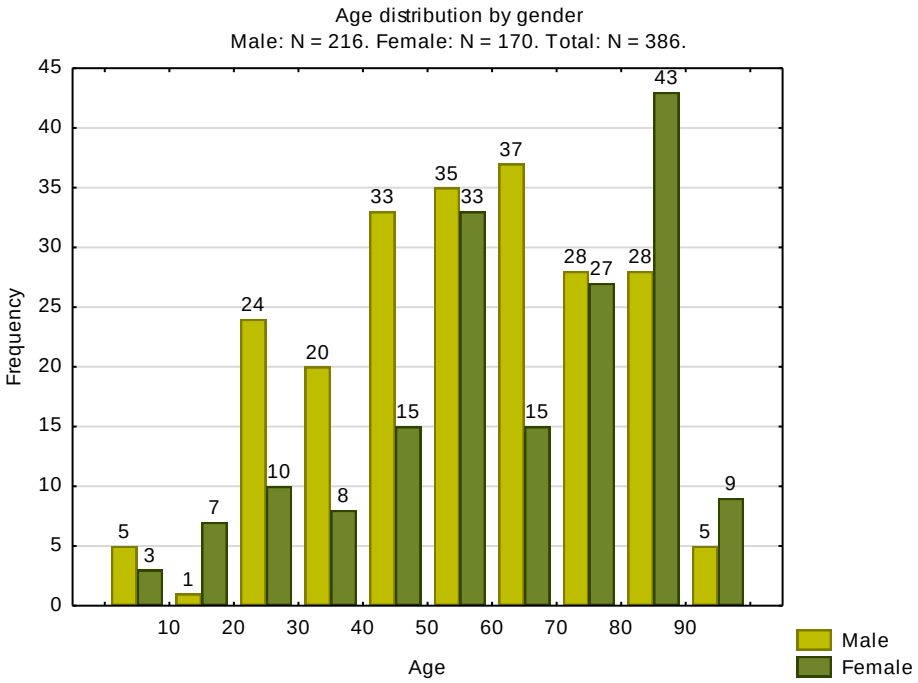

Figure 4-15 Age distributed on gender for 386 fatalities in fatal fires during the 2005-2014 period.

During the 2005-2014 period more men than women perished (56 % of casualties were men). According to SSB, in 2007 there were about as many men as women around the age of 63 in Norway. After this age the proportion of women rises, and with age the surplus of women continues to rise. Among persons over the age of 80 around two thirds were women, and among those over 90 years three fourths were women [35].

The persons who perished were in all essentials well into their adulthood. Half of fatalities had an age between 44 – 78 years, see Table 4-9 and Figure 4-15 showing the age distribution of the fatalities.

Table 4-9 **Number of inhabitants in each age group per 2011 [36], compared with the number of fatalities in fatal fires during the 2005-2014 period.**

Age group	Number of inhabitants	Average number of fatalities per year	Number of fatalities per 100 000 inhabitants in age group
0-9	611 148	0.8	0.13
10-19	637 300	0.8	0.13
20-29	650 708	3.4	0.52
30-39	677 249	2.8	0.41
40-49	723 728	4.8	0.66
50-59	627 064	6.8	1.08
60-69	533 770	5.2	0.97
70-79	296 889	5.5	1.85
80+	222 099	8.5	3.83
All	4 979 955	57	0.78

Figure 4-16 **The graph shows the ratio between number of fatalities and number of inhabitants in each age group for fatal fires during the 2005-2014 period.**

When taking the number of people in each age group into consideration, one sees there is almost an exponential connection between age and the number of fatalities in fires, see Table 4-9 and Figure 4-16.

4.3.3 Risk factors

Table 4-10 shows the registered risk factors linked to the fatalities in fatal fires during the 2005-2014 period. The results go to show that the majority of fatalities had normal vision as well as hearing. On the other hand, we see that half of the fatalities at pension age had reduced mobility. Further, 1/3 in the same age group had impaired cognitive abilities, and an equally large share suffered from mental illness. For the younger age group we see that half of the fatalities had a reputation for substance abuse. Equally many suffered from mental illness, and an equal proportion was under the influence of alcohol during the fire.

When examining the fatalities confirmed being under the influence of alcohol or not being under the influence at time of death, regardless of age, we find no difference as to the time of day they perished when dividing the day into four 6-hour parts (00-06, 06-12, 12-18 and 18-24)[12]. Even though there is no statistically significant difference between morning/day and night (06-18 and 18-06), there is a trend suggesting that more persons are intoxicated at night time[13].

There is a significant variance between women and men when it comes to being under the influence of alcohol during the fire[14]. When disregarding the cases where it was not possible to neither prove or disprove that there was alcohol in body fluids, one sees that around 2/3 of all male fatalities were under alcoholic influence . The case is the opposite for women, only 1/3 were under the influence of alcohol. There is no significant difference in the distribution of cause of fires in fires where the victim was under alcoholic influence compared with fires where the victims were not under alcoholic influence[15].

To conduct a «Multiple Correspondence Analysis» the population was divided into two sub-groups; persons below the age of 67, and 67-year old persons or older (pension age). Further, analyses were made of factors representing somatic ailments and factors relating to intoxication, psychiatry and lifestyle. The reason why psychiatry is placed in the same category as substance abuse, smoking and alcoholic influence during the fire, is because psychiatric cases may be triggered off by drug abuse, and therefore drug abuse and psychiatry occur simultaneously in many cases.

For the fatality group 67 years or older the material shows that persons with mental illness also frequently are smokers. Moreover, we have seen that being under the influence of alcohol during a fire does not appear in combination with other factors (no pattern). As regards somatic ailments we do not see any evident patterns. This may signify that combinations of e.g. reduced mobility and vision impairment are not overrepresented in the fatal fire statistics for this group. Nevertheless, 61 % of this group have either impaired vision, hearing, or mobility, which may have contributed to the death.

[12] Chi-square test, p = 0.147.
[13] Chi-square test, p = 0.052.
[14] Chi-square test, p = 0.000.
[15] Chi-square test, p = 0.433, the rarest categories were excluded from the analysis

Table 4-10 **Registered risk factors related to fatalities in fatal fires during the 2005-2014 period. Note that the «unknown» category means that the medical records hold no data. This may signify that the person in question did not have any problems with the relevant risk factor. Green cells mark a high proportion of observations of risk factor for persons above the age of 67, while blue cells mark the same for persons below the age of 67.**

Vision	Normal/not commented	Visually impaired	Blind	N
All	86,8 %	13,2 %	0,0 %	257
<67 years	92,4 %	7,6 %	0,0 %	145
≥67 years	79,5 %	20,5 %	0,0 %	112
Hearing	Normal/not commented	Hearing impaired	Deaf	N
All	89,9 %	10,1 %	0,0 %	257
<67 years	95,2 %	4,8 %	0,0 %	145
≥67 years	83,0 %	17,0 %	0,0 %	112
Reduced mobility	Normal/not commented	Reduced, but mobile	Immobile	N
All	69,2 %	27,4 %	3,4 %	266
<67 years	84,6 %	12,1 %	3,4 %	149
≥67 years	49,6 %	47,0 %	3,4 %	117
Impaired cognitive abilities	No	Yes	Unknown	N
All	16,0 %	18,7 %	65,3 %	262
<67 years	20,7 %	7,6 %	71,7 %	145
≥67 years	10,3 %	32,5 %	57,3 %	117
Known substance abuse	No	Yes	Unknown	N
All	9,1 %	36,5 %	54,4 %	263
<67 years	9,2 %	54,0 %	46,1 %	152
≥67 years	9,0 %	25,2 %	64,8 %	111
Mental illness	No	Yes	Unknown	N
All	6,5 %	44,3 %	49,2 %	262
<67 years	6,6 %	51,7 %	41,7 %	151
≥67 years	6,3 %	34,2 %	59,5 %	111
Alcoholic influence	No	Yes	Unknown	N
All	38,9 %	41,2 %	19,9 %	386
<67 years	28,4 %	59,0 %	12,7 %	229
≥67 years	54,1 %	15,3 %	30,6 %	157
Women	50,0 %	27,6 %	22,4 %	170
Men	30,1 %	51,9 %	18,1 %	216
Smoker	No	Yes	Unknown	N
All	9,3 %	34,6 %	56,1 %	387
<67 years	6,6 %	35,8 %	57,6 %	229
≥67 years	13,4 %	32,5 %	54,1 %	157

For the group of fatalities below the age of 67 our data material plainly shows that factors «known substance abuse», «alcoholic influence in fire », «mental illness » and «smoking» often occur together. Figure 4-17 shows how many of these factors were registered for fatalities below the age of 67. Only 13 % of fatalities in this age group had none of the mentioned factors, while the majority (66 %) had various combinations of two or more factors.

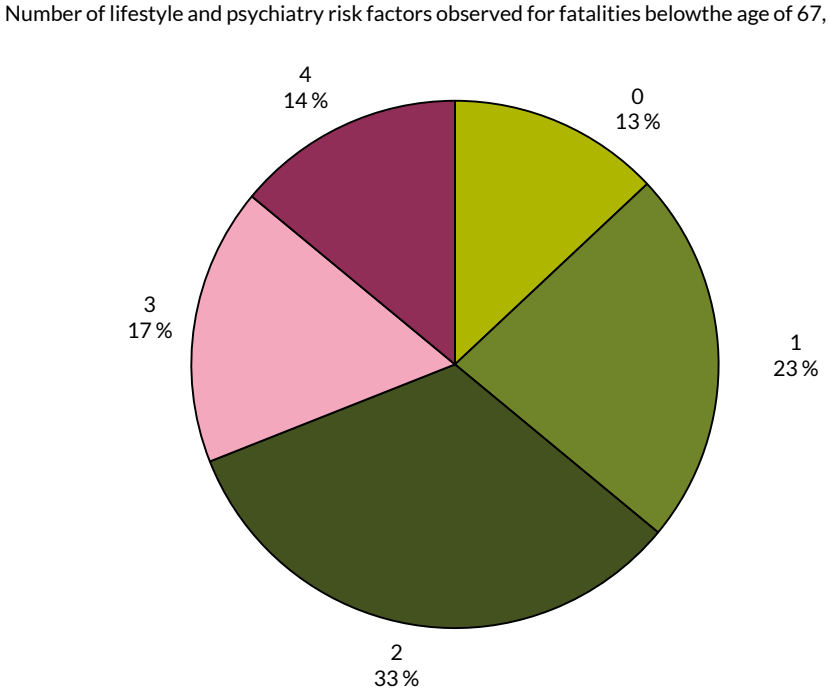

Figure 4-17 **Distribution of how many factors of *known substance abuse*, *alcoholic influence in fire*, *smoking* and *mental illness* for registered for fatalities below the age of 67 in fatal fires during the 2005-2014 period.**

As concerns somatic functional impairment no pattern is identified, except from the fact that factors normal mobility, normal vision, and non-reduced cognitive ability often occur together.

4.3.4 Cause of death

Figure 4-18 shows the distribution of cause of death for the fatalities in the sample. Asphyxiation is the chief cause (57 %), followed by burns (15 %). In addition to that a combination of asphyxiation and burns was concluded in 10 % of cases. In 13 % of cases the cause of death is unknown, which may be attributed to the fact that the victim was so heavily burnt that it was difficult to carry out an examination or draw some conclusions.

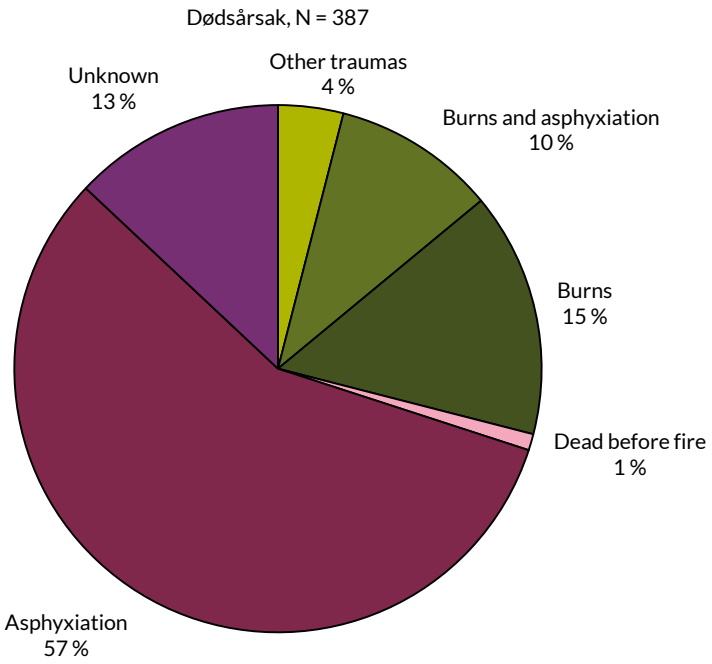

Figure 4-18 Cause of death for fatalities in fatal fires during the 2005-2014 period.

Table 4-11 and Table 4-12 present underlying causes of death, and injury codes registered in NCoDR, respectively. The underlying causes of death say something about the incident leading to the person's death (e.g. exposure to fire), while the injury codes say something about the cause of death (e.g. burn). The tables lack information on victims whose ID-number was inaccessible to us (13).

The tables show several sub-categories and a variety of detail for the same incident and injury category. From Table 4-11 one sees that exposure to various forms of fire stands for 88.4 % of all incidents, and that 5.8 % of incidents involved intentional self-harm (suicide). Correspondingly, one sees from Table 4-12 that one form of asphyxiation or other stands for 74.7 % of the causes of death, while some form of burn stands for 21.6 % of the causes of death. The asphyxiation rate in NCoDR (74.7 %) is somewhat higher than what was registered from post-mortem reports (57 %). By adding the dead where it was concluded that the cause of death was a combination of fire injury and asphyxiation, one gets a rate of (67 %), which is still somewhat lower than in NCoDR. From Table 4-12 it appears that some of the fatalities are registered with causes that are not directly fire-related. E.g., there is one case of hypothermia (low body temperature), and some cases are registered with injury codes indicating consumption of alcohol and other intoxicants. For practical reasons no comparison was made between injury codes in NCoDR and Police report data.

The reason why the number of persons included in tables is lower than the number of persons in our sample is that the ID-number was not stated for some of the persons. This included foreign nationals who did not have a Norwegian ID-number.

Table 4-11 **Frequency of various underlying causes of death registered in the Cause of Death Register for fatalities in fatal fires during the 2005-2014 period.**

ICD-code	Frequency	Percentage
G409: Epilepsy, unspecified	1	0.3
I249: Acute ischaemic heart disease, unspecified	1	0.3
I251: Atherosclerotic heart disease	4	1.1
I258: Other forms of chronic ischaemic heart disease	1	0.3
I639: Cerebral infarction, unspecified	1	0.3
I709: Generalized and unspecified atherosclerosis	1	0.3
J180: Bronchopneumonia, unspecified	1	0.3
W13: Fall from, out of or through building or structure	1	0.3
X00: Exposure to uncontrolled fire in building or structure	288	79.6
X02: Exposure to controlled fire in building or structure	2	0.6
X04: Exposure to ignition of highly flammable material	1	0.3
X06: Exposure to ignition or melting of other clothing and apparel	4	1.1
X08: Exposure to other specified smoke, fire and flames	9	2.5
X09: Exposure to unspecified smoke, fire and flames	16	4.4
X41: Accidental poisoning by and exposure to [...] drugs, not elsewhere classified	2	0.6
X45: Accidental poisoning by and exposure to alcohol	4	1.1
X47: Accidental poisoning by and exposure to other gases and vapours	2	0.6
X49: Accidental poisoning by and exposure to other [...] substances	1	0.3
X67: Intentional self-poisoning by and exposure to other gases and vapours	9	2.5
X74: Intentional self-harm by other and unspecified firearm discharge	1	0.3
X76: Intentional self-harm by smoke, fire and flames	11	3.0
X97: Assault by smoke, fire and flames	1	0.3
SUM	**362**	**100**

Table 4-12 Frequency of various injury codes registered in the Cause of Death Register for fatalities in fatal fires during the 2005-2014 period.

ICD-code	Frequency	Percentage
S099: Unspecified injury of head	1	0.3
S122: Fracture or other specified cervical vertebra	1	0.3
T149: Injury, unspecified	2	0.6
T273: Burn of respiratory tract, part unspecified	1	0.3
T290: Burns of multiple regions, unspecified degree	4	1.1
T293: Burns of multiple regions, at least one burn of third degree mentioned	1	0.3
T300: Burn of unspecified body region, unspecified degree	55	15.6
T303: Burn of third degree, body region unspecified	7	2.0
T307: Corrosion of third degree, body region unspecified	1	0.3
T311: Burns involving 10-19% of body surface	1	0.3
T315: Burns involving 50-59% of body surface	1	0.3
T316: Burns involving 60-69% of body surface	3	0.9
T317: Burns involving 70-79% of body surface	2	0.6
T318: Burns involving 80-89% of body surface	1	0.3
T426: Other antiepileptic and sedative-hypnotic drugs	2	0.6
T510: Ethanol	3	0.9
T519: Alcohol, unspecified	1	0.3
T58: Toxic effect of carbon monoxide	261	74.1
T598: Other specified gases, fumes and vapours	1	0.3
T599: Gases, fumes and vapours, unspecified	1	0.3
T68: Hypothermia	1	0.3
T71: Asphyxiation	1	0.3
SUM	**352**	**100**

5 Discussion

The purpose of this project was to identify risk factors that may contribute to a more refined prevention of fatal fires. Based on experience gained from previous studies and studies abroad we searched for factors that could be connected to vulnerability of perishing in fire. Looking for common denominators and groups based on personal characteristics may appear stigmatizing to individuals sharing some of the same descriptions. E.g., high age does not involve a hazard in itself, but by being aware of the factors associated with the risk of perishing in a fire, individuals needing extras follow-up may be identified. The below paragraphs discuss the results of the analyses.

5.1 Scene of fire

Surroundings and living conditions impact on the risk of fire. Studies conducted in other countries establish that areas with a large proportion of people with low income and a low education level carry an increased risk of fire. Other important factors can be a large number of empty buildings or a high density of such buildings, a large number of rented dwellings, and many old buildings in a poor condition [4]. The current study did not look into socio economic factors to any large extent.

Statistics show that there are far more people perishing in fires in single-family houses than in block flats and terrace houses. However, when allowing for the settlement pattern in Norway, one sees that neither of the three types of residence, single-family house, flat or un-detached house is associated with a higher risk of fatal fire than the others, see chapter 4.2.3.

There are geographic variations in the Norwegian fire statistics when comparing the different counties. Naturally enough, there are more fatal fires in counties with the highest number of inhabitants, but there also variations between counties when taking the number of fatalities per number of inhabitants into consideration.

Hypothesis 8: *Finnmark stands out with a large number of fatalities per inhabitant. This is attributed to the average response time for fire brigades, which is longer in Finnmark than elsewhere in the country. This again may be related to deviations from response time requirements as laid down in the dimensioning regulation, or it may be that requirements are met, but that fires have occurred in sparsely populated regions where a long response time is permitted.*

During the 2005-2014 period Finnmark had 157 % more fatal fires per inhabitant than the national median. Unfortunately, we have an inadequate basis for stating why this is so. Since we did not receive the Police reports, and therefore no medical records, we lack data on e.g. the fire brigades' response time, and details about the fatalities. Analyses having been conducted, however, show there are no more fires in sparsely populated regions in Finnmark than in the country at large, but that the distribution of fires in towns, communities and on the countryside is relatively equal to the country at large. By using this distribution as an

estimate of response time, i.e. one assumes that the response time for urban areas in Finnmark on average is equal to the one applying in urban areas in the rest of the country, one can say that Hypothesis 8 is partly falsified. A British survey observed that the response time in most fatal fires was low, and it was concluded that a shorter response time would not necessarily save more lives, and that preventive measures will have the largest effect [37]. It is therefore not certain that large distances in Finnmark are a significant factor as concerns the number of fatal fires. Owing to a lack of data on fatal fires in Finnmark, we cannot comment on the other formulations in hypothesis 8.

We recommend later studies to try and collect data from fatal fires in Finnmark, in order that it may be verified whether there are personal characteristics that cause the high occurrence of fatal fires, or whether there are other causes.

5.2 Time of year and day

There is no significant decrease in the *number of fatal fires* over the 2005-2014 period, but one sees a decreasing trend when relating the number of fatal fires to the population increase in the same period, i.e. the number of fatal fires per inhabitant.

Hypothesis 3: *In the winter season we stay more indoors, we light candles and need more heating*.

a. *There are more fatal fires in the winter months.*
b. *The increase in the winter months may be connected to ignition sources of which use more in the winter season, e.g. candlelight and electrical heating (incorrect use and faulty electrical facility).*

Distributed across the year, it is correct that most fatal fires occur in the winter season, with a peak in December/January. August has the lowest number of fires. Hypothesis 3a) can therefore be confirmed. As regards hypothesis 3b) it is particularly the rate of open fires that increases in the distribution of cause of fires in the winter season compared with the summer season. This includes both smoking and candles. However, it does not appear that electrical heating to any great extent contributes to the increase in the winter season, which in previous studies has been proposed as a potential explanation to the increase in the number of fatal fires in winter [5]; both the proportion of "incorrect use" and "electrical cause" is relatively constant. We therefore partially corroborate hypothesis 3b, i.e. that the increase in the number of fires may be connected to ignition sources being used more frequently in winter (open fire, candlelight etc.).

The distribution on weekdays shows a peak on Saturday and a low on Wednesday, with a relatively equal distribution on the other days. This is in line with the results of previous Norwegian studies, including studies conducted abroad. The same applies as concerns the time of day when the fatal fires occur; the majority are registered as occurring in the evening until early morning. A previous study where we analyzed fires in cookers concluded amongst

others that those who die in such fires are typically young men dying at night time, often at weekends. This is often associated with alcoholic influence [38]. This may to some extent explain the increase seen at weekends, but we do not have an adequate explanation to the decrease seen on Wednesdays.

5.3 Cause of death

Asphyxia was corroborated as the cause of death for 57 % of the fatalities where we had access to the Police report. Of causes of death only related to a fire injury and/or asphyxia (82 % of all fatalities), asphyxia alone stands for almost 70 %, asphyxia in combination with burns stands for around 12 %, and burns alone for around 18 %. These numbers are in stark contrast to the corresponding American numbers for 2012-2014, see paragraph 2.6, where e.g. asphyxia alone stood for 37 % of the causes of death. We are unaware of the reason for these differences, but an assumption is that the causes of death are defined and registered differently in the US compared to Norway. This emphasizes the uncertainty of making such comparisons between countries.

The content in fire smoke is complex, consisting of a number of components which have various effects on humans. Asphyxia may occur at an early stage in the course of a fire, even before the fire has developed enough to have a visible flame. In order to prevent deaths caused by asphyxia it is therefore important to focus on preventing fires from arising in the first place, and to ensure that outbreaks of fire are detected and extinguished as early as possible. Inflammable materials should be avoided, and an adequate control of potential ignition sources should be in place.

5.4 Number of fatalities in fires

As mentioned in paragraph 2.2 underreporting and overlaps have been shown in the reporting of 20-25 % of fatal fires in Sweden. This was established by comparing the national fatal fire register with other sources, such as the Cause of Death Register. It has been asked whether such underreporting occurs in other countries as well, including Norway.

We received access to NCoDR in order to examine whether the number of fatalities in fires registered in NCoDR corresponds to the number of fatalities registered in DSB's fire statistics. As it turned out, it was difficult to make a general search for fatalities from fires in NCoDR, because this would include cases where the person perished from burns and injuries caused by smoke that were non-related to fire. Instead we gained access to an overview of registered cause of death of the persons in the data material where we knew the ID-number. According to Table 4-11 and Table 4-12 in paragraph 4.3.4 it appears that some of the victims registered as having perished in a fire in the DSB's statistics in NCoDR are registered with other causes of death than fire. We have, however, not had the opportunity to check these cases more thoroughly. It may, however, appear that there may be fewer variations in the number of fatalities in the two sources. At the same time we believe that the basis of DSB's statistics appears to be reliable with basis in the methods applied to collect the statistics. We do not suspect that there is a large number of unregistered fatalities from fires in Norway.

5.5 Causes of fire and risk factors

When it is impossible to identify the cause of fire, the cause of fire is categorized as «unknown» in statistics. The number of fires where the cause of fire is unknown constitutes approximately ¼ of all fatal fires, which makes it the largest causality category. The fact that so many fatal fires end with an unknown cause can be logical, as these fires in some cases are so big and intense as to leave few traces of the cause of fire.

The study divides the population into different sub-populations, e.g. fatalities below the age of 67 and fatalities 67 years or more. This makes it possible to identify the factors that often recur for these groups. These results should be used by home care services, the GP/family doctor and other agencies who are in contact with the inhabitants of the municipality, and who provide care or fire prevention measures, in order to implement the right actions for the individual. The subsequent sub-chapters deal with the various risk factors.

5.5.1 Age and health

Several studies establish that elderly people are more exposed to perishing in a fire than younger persons, and we have found the same in our study. Half of the fatalities are 59 years old or older. When taking into account the persons within the various age groups, one finds an exponential increase in the in the number of fatalities for increasing age. The increase is particularly noticeable for age groups 70-79 years and 80+. E.g., the latter group has a 9.3 times higher probability of perishing in a fire than persons between 30-39 years according to our material. DSB's study of fatal fires during the 1986-2009 period showed that elderly people over the age of 70 had a probability of perishing in a fire around that was 4 times higher than the population as a whole [5]. Figures from the US show that elderly people (age 85+) had a 4.1 times higher probability of perishing in a fire than the population at large. The corresponding figure from our study is 4.9 times, which must be said to be comparable.

High age definitely correlates with an increased probability of perishing in a fire. What with an anticipated population growth and growth in the proportion of elderly people (67+), it will be important to target preventive measures toward this group in society, in particular in view of the fact that more of them will live longer in their own homes than before, and often also alone. Until date the number of places in nursing homes and similar in recent years have remained rather stable [39]. Nursing and care services have changed from being provided in nursing homes and similar to being provided at home, while places in nursing homes mainly are being offered to the most sickly of elderly people. There is reason to believe that this trend will continue [40].

For those who have reached pension age we principally see four recurring risk factors: reduced mobility (47 %), impaired cognitive ability[16] (33 %), mental illness (34 %) and smoking (33 %). However, no recurring patterns of combinations of various risk factors were identified, except mental illness and smoking. The report entitled *Correct measures in the right place* does not define age as a risk factor in itself, but argues that age may involve physical and cognitive challenges [3]. The thought behind such an approach is that one should not see elderly people as a homogeneous group facing the same challenges, but rather implement safety measures meeting individual challenges. The results of this study of fatal fires support this perspective. The fact that these analyze group persons having reached pensionable age in a separate group does not signify that one must or should introduce measures targeting all elderly people, but one should rather be particularly attentive to the risk factors that stand out for this age group.

For those below pensionable age the most conspicuous risk factors are known substance abuse (54 %), mental illness (52 %), alcoholic influence (59 %) and smoking (36 %) It was also found that these risk factors often occur simultaneously for this age group. This shows that some of those who perish in a fire in this age group carry several risk factors, which increases the risk of perishing in a fire. Actually, 87 % of the fatalities in this group have one or more of the mentioned risk factors. Without having any basis for asserting it in this study, it cannot be excluded that these factors may affect their independent living skills, and consequently also the risk of a fire occurring in their living unit.

Hypothesis 7: *The number of children perishing in fires is relatively low compared to the number of fatalities in other age groups.*

During the 2005-2014 period seven children aged 0-7 years died in a fire, which constitutes 2,2 % of the fatalities. Six of the children died in fires occurring during the night while the family was asleep. In comparison 15.1 % of all fatalities during the 1970-1979 period were children aged 0-7 years, and for the 1990 to 1992 period the rate was 4.5 % [28]. This means it can be confirmed that the number of children perishing in fires is comparatively low and that it has decreased since the 1970s. Just like in Sweden childcare in Norway has undergone major changes since the 1970s. Children spend less time on their own and more time in buildings with high fire safety standards (schools and kindergartens), which probably has contributed to improving fire safety, thereby reducing the risk of children perishing in a fire. At the same time there is reason to believe that many parents of young children focus on safety, also when it comes to fire safety in the home.

5.5.2 Gender

More men than women perish in fires. Overall, men constitute 56 % of fatalities for the 2005-2014 period. However, the gender distribution varies for the different age groups. In age groups 20-49 and 60-69 there are around twice as many men perishing than women, while

[16] The elderly people who fell into this category often had Alzheimer's disease or other forms of dementia.

there is an overweight of women in age group 80+ and between 10 and 19 years. Possibly the variations between women and men for some age groups may be explained by population distribution and risk behavior.

The variations also show us that being male is not a risk factor, there is still a high proportion of women who perish in fires, and prevention measures must be directed toward this group on an equal footing with men.

Hypothesis 6: *Elderly women (80+ years) have an increased probability of perishing in a fire compared with men of the same age.*

Also for the 80+ age group the picture is more nuanced when taking the population into consideration. 62.1 % of the fatalities in age group 80+ are women. Figures from SSB show that the proportion of women in this age group is 62.3 % [41]. However, these figures are from 2017, which is a few years after the focus period of this study, but from what we know there is nothing to suggest that the gender composition has changed considerably during these years. Thus one may conclude that women of this age group probably do not carry a heightened risk of dying in a fire than men.

5.5.3 Smoking

Thirty-five percent of the fatalities were smokers and approximately 13 % of fires were caused by smoking. In comparison, figures from SSB show that the rate of daily smokers in Norway has gone from around 25 % to 13 % during the period we studied [39]. It therefore appears that smoking is a risk factor.

Hypothesis 10: *The introduction of a rule for self-extinguishing cigarettes November 2011 has had a demonstrable effect on Norwegian fatal fire statistics.*

From the analysis results we cannot see a trend of any decrease in smoking as a causality of fatal fires. The new rules on self-extinguishing cigarettes have to date not had demonstrable effect on the Norwegian fatal fire statistics. As mentioned in paragraph 2.7 surveys show that these cigarettes do not necessarily self-extinguish, which means it is uncertain what the fire prevention effect is.

5.5.4 Influence of alcohol and intoxication

Hypothesis 4: *The influence of alcohol, medicines and drugs are an important underlying cause of fatal fires.*

The fact that known substance abuse and mental illness are relatively common occurrence factors in fatal fires is not surprising, but coincides with previous studies made in Norway

and abroad. Studies show that fatal fires more often than other fires are caused by the victim himself/herself; in our data basis the fire was directly caused by the victim in almost 40 % of the fires. This points to the importance of being able to prevent and handle a fire, and it shows that the probability of fatal fire increases when these abilities are limited. Substance abuse and some mental illnesses may lead to impaired judgment, both as concerns the incidents leading up to fire start, and in connection with the fire itself.

Hypothesis 5: *It is likely that individuals perishing in fire to a large extent will be men under alcoholic influence.*

In around 40 % of the fatalities the post-mortem examination identified traces of alcohol in the body fluids, while no alcohol was found in an equally large proportion. As concerns the last 20 % this is uncertain, as it was not reported in the post-mortem reports, or the post-mortem report was unavailable. The figures also show that there are variations between women and men. By disregarding the proportion of «unknown», which is around the same for both genders, one sees that around 2/3 of all male victims were under the influence of alcohol when they died in the fire, while 1/3 were not under influence. With women the figures are the opposite: 1/3 were under the influence while 2/3 were not.

When considering men in isolation, one finds that the figures are not dissimilar to the ones presented in the report *Alcohol and fire* [16]. There is, however, a larger discrepancy between the mentioned report and our figures where women are concerned. It is reported that only 20 % of women were under influence of alcohol during the fire, while our figures show a proportion almost twice as big (36 %).

An explanation to this discrepancy may be that «Alcohol and fire » examined fires from the 1993 – 2008 period, while this study concentrated on fires occurring during the 2005-2014 period. If this is so, it may point to a change in the drinking pattern of women (frequency and volume) over the period. However, we did not examine this aspect any further.

5.5.5 Single persons

Hypothesis 2: *When living alone the likelihood of the fire being detected in time to survive is reduced, making it more difficult to escape. There is therefore risk connected to living alone.*

In over 70 % of the fires in our data basis there was only one person present at fire start. Forty percent of the victims were found in the room of origin, which suggests that the victims had few opportunities of handling the fire and escaping at an early stage of the fire.

Based on information about situational status at the arrival of the fire brigades, we find that in almost 2/3 of the fires the fire had enveloped a part of or large parts of the building, or the building had completely burnt down. When a fire has developed as far as that, and given that the victim of the fire is not capable of escaping on his/her own, the fire brigade will probably have very limited opportunities for saving the person.

These figures show that there is an inherent risk to *being alone*. The likelihood of the fire being detected in time to survive is reduced, and it is harder to escape if one is alone at the start of fire. Persons living alone are probably more often alone in the living unit than persons living with others. This means that there is probably an indirect, increased risk associated with living alone.

5.5.6 Culture, attitudes and language

Attitudes to fire safety impact on the likelihood of an occurrence of fire. Attitudes may be related to risk behavior, the willingness to use preventive equipment, and tidiness and maintenance. Our study registered whether the victim was a non-native speaker, which was not common. The background was amongst other to examine whether the ability to read and communicate in the Norwegian language had any large impact on the risk of perishing in fire. We did not register any detectable connection between being a non-national speaker and the risk of perishing in a fire.

Examinations of socio-economic factors (income, education, ethnicity, profession, etc.) were not part of this study.

5.6 Safety measures

The statistics show that there had been a flaming fire in almost all fatal fires. Nevertheless, the case may be that some of the fires started as a smoldering fire, but gradually evolved into a flaming fire. It may also be that some of the victims succumbed while the fire was still at a smoldering stage, but we are unable to quantify how many this may apply to. The time it takes from the start of a smoldering fire until it develops into a flaming fire may vary and it may take a very long time. Such fires may be difficult to detect singled-handedly, and smoke detectors will not be able to detect such fires until they have run much of their course. This is a factor one needs to be aware of when considering technical preventive measures. The best measures in such cases will be to prevent smoldering fires from arising, e.g. preventing fires from starting in upholstered furniture and mattresses, and owing to overheating in electrical facilities (which often are concealed in walls).

Our data basis shows that in nearly half of all fatal fires it was uncertain whether a smoke detector was installed in the living unit or the building where the fire started. In an equivalent proportion of fatal fires it is unknown whether the smoke detectors was in working order. The large number of cases where it was unknown whether a smoke detector was installed may derive from the fact that the extent of the fire made it difficult to verify whether smoke detectors existed in the building. The smoke detector may have fallen down and become so damaged as to make it hard to identify. Nor can it be excluded that the Police investigator was not conscious about looking for it.

From a study made in 2015, where RISE surveyed the use of smoke detectors in Norway [42], we know that 98.2 % of examined living units had at least one smoke detector installed.

These were dwellings with a fireplace looked after by chimney sweepers. It is uncertain whether this figure is valid for the dwellings where fatal fires occurred. In our statistical basis smoke detectors were installed in 47.7 % of the living units, while 4.3 % of the living units were without a fire detection system. Since the proportion where it is unknown whether a smoke detector was installed or not is large (48 %) , any definite conclusion cannot be drawn, but it may appear that the prevalence of smoke detectors is somewhat lower in living units where fires with a fatal outcome occurred.

For the future it would have been an advantage if the Police in its fire investigation focused more on identifying whether smoke detectors were installed, either by means of technical findings or taking statements from persons familiar with the scene of the fire.

As concerns automatic extinguishing systems, the proportion of fatal fires where an extinguishing system was installed is quite negligible (0.9 %). In all likelihood, this is because the majority of fatal fires occur in the home, and half of them occur in single-family houses where there is no mandatory requirement for an extinguishing system. Further, ¼ of fatal fires occur in blocks of flats and flats, where there is no mandatory requirements for an extinguishing system unless the block has three or more floors and was designed after 2010[17]. The cases in our data basis where an extinguishing system was installed occurred in institutions, and in some of the cases the fire had not developed enough to release the system.

It cannot be excluded that a mandatory automatic extinguishing system in all dwellings would have a considerable impact on the number of fatalities in fires. In the US 83 % fewer fatalities are reported in buildings with an automatic extinguishing system during the 2004-2013 period [3,43,44]. A more pointed alternative to permanently installed automatic extinguishing systems could be to enhance the arrangement adopted by some municipalities, where mobile automatic extinguishing systems are installed with persons with a heightened risk of fire.

[17] Requirements for extinguishing systems in such buildings were introduced in 2010 through regulation TEK10.

6 Conclusions

The aim of the project has been to analysis fire statistics and information from other sources to get more detailed knowledge than before about who dies in fires and why. Initially, the following questions were defined:

1. What risk factors are associated with those who perish in fires in Norway?
2. What are the causes of fatal fires in Norway?
3. How can fatal fires be best prevented?

Risk factors associated with those who perish in fires in Norway

All individuals who have died in fire cannot be divided into groups of common denominators, but there are some combinations of factors that we have seen repeatedly:

For those who have reached retirement age, we mainly see four risk factors: *reduced mobility, impaired cognitive ability, mental disorders* and *smoking*.

For those under retirement age, the risk factors are *known substance abuse*, *mental illness*, *alcoholic influence* and *smoking* that appear, either alone or in combination with each other.

There is an increasing risk of dying in a fire with increasing age. Generally speaking, men do not have a higher risk than women, but in some age groups, the risk of fatality is greater for men. There are more women than men in the 80+ age group who perish in fire, but taking into account the gender distribution in this group the risk is equal. Alcohol constitutes a greater risk factor for men than for women.

There is a risk connected to being alone. The likelihood that the fire will be detected in time to survive is reduced, and it is more difficult to escape if you are alone. People living alone will probably be more often home alone than people living with others. Single residents therefore probably have an indirectly elevated risk.

The vast majority of the victims spoke Norwegian, so foreign language is not observed as a risk factor in our material.

Causes of fatalities

When we investigate where, why and when the fires have occurred, we see that human failure often causes fatalities. Human behaviour varies throughout the year, and thus also the risk of fire, which we see in the variations in fire causes between the winter and summer months. Open flame in connection with for example cigarettes and candles is a group of ignition sources that is reflected in the statistics. Fatal fires also occur most often in the rooms where we spend the most of the time: in the living room and in the bedroom.

Prevention of fatal fires

There is no simple answer to how fatal fires should be prevented. Since the causes of fires are so much dependent on the individual, preventive measures must also be adapted to individuals.

The report *Correct measures in the right place* gave suggestions for technical and organisational fire prevention measures. We hope that this report will provide professionals with the tools to identify individuals with increased risk so that appropriate actions can be taken for individuals and their specific conditions and challenges.

Based on the development of new materials used in clothing, consumer products and building materials, what we know today about fires and how they affect people may change over time. Development of technical measures for detection and mitigation of fires will provide opportunities for increasing fire safety in homes.

7 Recommendations and suggestions for further work

Finnmark has 157 % more fatal fires than the national median. In this study we did not have access to investigation reports or medical records from fatal fires in Finnmark to enable us to throw further light on this issue. A similar exercise to the one presented in this report ought therefore to be carried out for fatal fires in Finnmark, in order to try and explore the direct and underlying causes of the high number of fatal fires.

We have experienced that it is no simple matter to compare data from NCoDR with data from the fatal fire register. A recommendation for further work is to try and coordinate the data of these registers, so that they give the same number of fatalities in fire.

The results show that 39 % of all fatal fires are caused by open fire, and 34 % of these are caused by smoking. This constitutes around 13% of all fires. The Storting in 2016 adopted to repeal the ban against the marketing of e-cigarettes containing nicotine in Norway, with changes becoming effective in the first half of 2018 [45]. From a fire safety perspective we see that it may be suitable for persons with risk factors as listed below to use e-cigarettes instead of conventional cigarettes.

- Elderly persons: reduced mobility, impaired cognitive ability and mental illness.
- Younger persons: known substance abuse, mental illness and alcoholic influence.

Otherwise, we see there is a large potential for making furniture and textiles less liable to catch fire, as it has been shown that furniture in combination with smoking has led to numerous fatal fires. Traditionally, this issue of concern has been related to the use of fire retardant fabrics, which in some cases have been found to be hazardous to the environment and injurious to health. One should initiate a study, where one in cooperation with the industry explores the potential for developing production methods that will make furniture more fireproof without increasing the environmental impact. A continuation of this would be to introduce an arrangement for labeling furniture in terms of fire safety. This would inform consumers of the level of fire safety of each piece of furniture, and it would contribute to enhancing consumer awareness showing that they have a choice when it comes to the level of fire safety desired in their home.

Since policies are to provide for more elderly people living longer in their own homes, and it is unlikely that that these to any large extent are going to replace their furniture with safer alternatives, we also recommend that resources be spent on developing and providing for cost efficient fire protection of existing furniture and furnishing. This could e.g. be in the form of physical fire barriers, mobile extinguishing systems and individually adapted guidance and supervision. The guidance should also include counseling and adaptations with the view of reducing the risk of fire in clothing. This could e.g. be to avoid the use of easily flammable materials near ignition sources.

A large number of the persons who died during the 2005-2014 period were persons with physical and/or cognitive challenges who might have benefited from early fire detection. A study conducted by Sesseng et al. showed that combination detectors with amongst other CO-sensors might give considerably earlier detection (in terms of hours) than conventional smoke detectors in smoldering fires [46,47]. This might provide a significantly longer time

available for escape, either single-handedly or by the assistance of others. We therefore believe that smoke detectors with integrated CO-sensor should be recommended in general, and in particular for persons with risk factors.

Elderly people have a greatly increased risk of perishing in a fire. The Norwegian Fire Protection Association in cooperation with KLP have launched a campaign, *Bry deg før det brenner,* ("Care before it burns"), focusing on the fire safety of elderly people. In our opinion such campaigns are important. Such campaigns should be continued, either in cooperation with foundations, organizations and private businesses, or under the auspices of the public sector. The campaigns should point to concrete hazards and provide specific recommendations in order to reduce fire risk. Potential channels for distributing such information could be GPs, home care services, and pensioner clubs.

Focus needs to be maintained on the different parties working together, as described in our previous report *Correct measures in the right place* [3]. A good example of work going on, is DSB's guideline *Samarbeid mellom kommunale tjenesteytere om brannsikkerhet for risikoutsatte grupper* [48], which amongst others addresses the municipality's responsibility when it comes to fire regulations and legislation relating to health and care.

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A Codebook for investigation reports

Time and place

- Time
  - Use the time on the main document list.
  - If the reports indicated a different time of detection, this is corrected.
- Type of place
  - Use Google Maps – Satellite view. Assessment.

Building and fire details

- Number of affect living units
  - How many living units were directly affected by the fire?
  - Several flats/bed-sitting rooms damaged, and/or there were persons who perished or became injured in these, in a single family house, to be included.
  - Number of flats in block/multi-family house/terrace house damaged by fire/smoke to be included.
- Number of occupants
  - Single family house (without rentals): Number of persons living in the house
  - Single family house (with rentals /several flats): Only those staying in the living where the fire started?
  - Multi-family house: Number of persons in living unit where fire started.
  - Terrace house: Number of persons in relevant living unit.
  - Block of flats: Number of persons in relevant living unit.
  - Commercial buildings of various kinds: Write -999
  - Visitors are not included.
- Number of floors:
  - Number of floors excluding attic and basement if these are not used for overnight lodging.
- Start of origin of fire:
  - Room where the fire started. E.g.: Living room.
- Floor of origin of fire:
  - Floor where the fire started. Seen against the number of floors being used.
  - Basement is counted as one floor.
    - Cellar: -1
    - Basement: 0
    - Ground floor / principal plane : 1
- Cause 1:
  - This is often already defined.
  - Is updated if other information is given in report.
- Cause 2:
  - This is updated based on information in report. Conclusion strength is defined as a separate field.
  - Apply professional competence.
- Type of fire:
  - Has there been heat = flaming fire.
  - Note that under-ventilated fires may look like a smoldering fire, but which turn out to be a flaming fire, as temperatures have been high.

- Status at arrival of fire brigade:
  - Often not stated. Then write unknown.
- Did the fire spread from the room of origin?
  - Yes: If confirmed in report.
  - No: If confirmed in report.
  - Unknown: Not described in report.

Fatalities, injured persons and evacuees

- Number of persons at fire start
  - Number of persons in living unit where the fire started, and other living units where there were injured persons or fatalities.
  - Visitors are included.
  - These are called **Directly involved persons**
- Directly involved persons helped out by fire brigade
  - Only survivors.
- Directly involved persons helped out by others
  - Only survivors.
- Directly involved persons who escaped on their own
  - Only survivors.
- Number of fatalities
  - See free text field: Extent of injury.
- Number of injured persons
  - See free text field: Extent of injury.

Alert and extinguishing

- Fire alerted by
- Smoke detector installed
  - Yes: If confirmed in report, or it is confirmed that someone heard the smoke detector.
  - No: If explicitly written in report that there was no smoke detector.
  - Unknown: If no information is provided.
- Smoke detector heard:
  - Yes: If anybody, either occupants or external persons, heard the smoke detector and this is explicitly written in report.
  - No: If explicitly confirmed in report.
  - Unknown: If no information is provided.
- Attempts made to extinguish the fire:
  - If anybody, except fire brigade, tried to extinguish the fire, answer Yes.
  - If dead persons are found in bed or similar, and have fallen asleep, answer No.
  - Hard to say what dead persons tried to do, but unless there are visible traces of attempts at extinguishing, answer Unknown.
- Aut. extinguishing system installed
  - If not mentioned in report, and it is a single family house or similar, we may assume it was not installed.

- Aut. extinguishing system released
    - Yes: if confirmed.
- Conclusion strength
    - Certain: if the Police is certain about their conclusion (likely, most likely), or, we with our expertise, believe it is an open-and-shut case.
    - Assumed: If the Police use «can be », or similar expressions about their conclusion.
    - N/A: if cause is unknown.

Fatalities

- ID-number
    - If lacking
        - Female: oooooo ooooo
        - Male: 111111 11111
- Non-native speaker:
    - Norwegian name is assumed as No.
    - Yes, if explicitly written in report that it was challenging to communicate and to understand instructions (fire preventive measures) owing to language problems.
    - Unknown if the person has a foreign name or citizenship, but it is not commented any further.
- Orange spaces may be filled in if information is in report, but comment on diagnoses, etc.
- Position at fire start
    - Hard to say something about this, only if person was found asleep in bed etc.
    - If it is entirely clear where the person found himself/herself at fire start (om point of origin?) answer Yes.
    - Otherwise unknown.
- Found in room
    - Compared to the room of origin.
- Escape attempt
    - Did the dead person try to escape?
    - If it appears that the dead persona tried to move from «position at fire start», answer Yes.
        - This needs to be discussed after the event.
        - Maybe they tried to find an extinguisher.
    - If dead persons are found in bed or similar, and have fallen asleep, answer No.
    - Hard to say what dead persons tried to do, but unless there are visible traces of escape attempts, answer Unknown.
- Date of death
    - Taken from post-mortem report.
    - If post-mortem report is not available, find information in Police report.
    - Be aware that the person may have perished at a later point of time than the fire itself.
- Cause of death
    - Taken from post-mortem report
    - Asphyxia:
        - Carbon monoxide poisoning, etc.

- Burns:
  - Thermal stress
- Fire injury and asphyxia
  - Only if post-mortem report holds both causes are equally likely.
- Other trauma
  - Fall, hit by object, etc.
- Dead before fire start
  - Homicide, natural cause of death before fire, etc.
  - Post-mortem report will say something about this.
- Unknown
  - If post-mortem report cannot conclude or information is lacking.

- Under the influence of alcohol in fire
  - If post-mortem report shows traces of ethanol (> 0) in blood, urine, eye fluid, etc.
- Is direct cause of fire?
  - Is the dead person directly guilty of starting the fire?
  - Yes: guilty of open fire, dry-out, covering, etc.
  - No: defect on electrical system, self-ignition, etc.
  - Unknown: if no cause of fire is stated.

B Codebook for medical records

Hearing

- Normal/not commented
  - In cases where the medical record reports normal hearing, no comments are available, or where there is no information in the medical record about the patient's hearing.
- Hearing impaired
  - In cases where the medical record reports signs of hearing impairment. This may e.g. be audiogram findings, use of hearing aid, subjective perception of impaired hearing, age-related hearing impairment, strong tinnitus or deafness in one ear.
- Deaf
  - Information in medical record suggesting that the patient is deaf.

Vision

- Normal/not commented
  - In cases where the medical record reports normal vision, no comments are available, or there is no information in the medical record about the patient's vision.
- Visually impaired
  - In cases where the medical record reports signs of visual impairment. This may e.g. be considerably impaired vision, loss of driving license owing to poor vision, or one blind eye. Impaired vision corrected by spectacles/lenses is not enough in itself. A large number of elderly patients have undergone a cataract operation resulting in a satisfactory vision, and these are classified as normal/not commented.
- Blind
  - Information in medical record stating that the patient is blind.

Mobility

- Normal/not commented
  - In cases where the medical record reports normal, no comments are available, there is no information in the medical record about the patient's mobility, or there is no suspicion of reduced mobility (e.g. young/youngish persons without comprehensive illnesses).
- Reduced mobility
  - In cases where the medical record contains information indicating that the illness is of such severity as to entail reduced mobility. Examples include heart-lung disease, head injuries, stroke and other cerebrovascular diseases, muscle-skeletal diseases (hip surgery, amputations, and similar) and use of rollator and similar aids. The presence of illness, such as heart-lung disease, without information confirming that this entails reduced mobility is not sufficient.

- Immobile
    - Wheelchair-bound or bedbound.

Impaired cognitive ability

- Yes
    - In cases where it is clearly stated that the patient has impaired cognitive ability. This may e.g. be reduced cognitive scoring, confirmed degenerative brain disease (dementia, Alzheimer, Parkinson etc.), or comparative information about cognitive ability.
- Unknown
    - In cases where there is no information speaking for or against impaired cognitive ability.
- No
    - In cases where there is no reason to suspect that the patient has a cognitive failure based on the information in the medical record, which presupposes a medical record of some size which may provide convincing signs suggesting that cognitive failure does not exist; or in cases where testing for cognitive function has been performed without findings.

Known substance abuse

- Yes
    - In cases where the medical record reports on known substance abuse. This includes alcohol, illegal intoxicants, drugs and other intoxicants.
- Unknown
    - In cases where there is no information speaking for or against substance abuse.
- No
    - In cases where the medical record confirms that the patient did not have or does not have a substance abuse problem.

Mental illness

- Yes
    - In cases where the medical record confirms the presence of mental illness which may be assumed being active at time of death. Thus, a single depressive episode 10 years prior to the time of death will not lead to «yes».
- Unknown
    - In cases where there is no information speaking for or against mental illness.
- No
    - In cases where the medical record confirms that the patient did not have or has a mental illness.

Smoking

- Must be present smoker in order to tick off yes.
- Previous smokers are commented in comment space.

C Causality categories

- Other cause
  - Other
  - Friction
  - Radiation and conduction
  - Unknown
  - Equipment for liquid /gaseous fuel
- Explosion
  - Other explosion
  - Gas
  - Dust
  - Unknown
- Electrical cause
  - Other electrical cause
  - Earth fault
  - Component failure
  - Short circuit arc/parallel arc
  - Leakage current
  - Line break
  - Transient overvoltage
  - Series arc
  - Unknown
- Incorrect use
  - Other incorrect use
  - Incorrect installation
  - Lack of maintenance
  - Radiation
  - Covering
  - Dry-out/overheating
  - Unknown
- Not reported
  - Not reported
- Natural phenomena
  - Other natural phenomena
  - Lightning
  - Unknown
- Incendiary fire
  - Other incendiary fire
  - Unknown
  - Open fire
- Self-ignition
  - Other self-ignition
  - Biological
  - Physical

    - Chemical
    - Unknown
- Unknown
    - Unknown
- Open fire
    - Other open fire
    - Ash, cinders and hot waste
    - Creosote
    - Matches/lighter
    - Fireworks
    - Candlelight
    - Smoking
    - Unknown
    - Back-puffing from fireplace /chimney
    - Heat work/welding/cutting/soldering

RISE Fire Research AS

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