AN ANALYSIS OF RESIDENTIAL BUILDING FIRE RESCUES: THE DIFFERENCE BETWEEN FATAL AND NONFATAL CASUALTIES

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ABSTRACT

Given the rapid fire development in modern residential buildings, there is discussion on the extent to which someone can be rescued by the fire brigade. To gain insight into the probability of rescue, the Fire Service Academy and the Netherlands Fire Service gathered information about nonfatal residential building fires with an asserted rescue. The findings of this exploratory study are compared to the findings of a long-term study by the Fire Service Academy on fatal residential building fires, in order to analyse the differences between fatal and nonfatal casualties. The comparison shows that there is a reasonable probability to rescue victims out of a room of fire origin. Also an important finding is that fatality in residential buildings fires is strongly related to human features in terms of a reduced mobility and a reduced awareness of mobile persons. The probability to survive a fire rescue, on the other hand, is strongly related to building features, since they more frequently take place in apartment buildings and most of the victims need to be rescued because of a blocked escape route. These, and other findings, are more extensively presented in this paper.

INTRODUCTION

Recent research [1] demonstrate that the fire development in residential buildings has become faster over time, because of influential changes in modern residential buildings, such as increased synthetic fuel loads and changing construction materials (i.e. insulation). This change in fire dynamics has impact on firefighter response times and operational time frames. These findings fuel the current discussion in the Netherlands on the extent to which someone can be rescued by the fire brigade. In this discussion, first of all, the definition of rescue plays an important role. For example, it is claimed that people are rarely rescued out of a room on fire. The fire brigades, on the other hand, claim that people are indeed being rescued alive out of a room on fire. Moreover, results from experimental fire research on fire development in homes and the survivability of victims, conducted in 2014 by the Fire Service Academy [2, 3], shows that the duration of survivability is greatly influenced by the conditions in the residential building (such as doors that are opened or closed, the degree of smoke development, the value of fire load), and that it can be much longer than just a few minutes. Furthermore, it is conceivable that there are also people rescued from residential building fires who are not in a room on fire, although they are certainly in an unsafe situation. For these people the toxic gases, including carbon monoxide, which will be released during combustion, are the greatest danger. The smoke spreads faster and further through the house than flames do, and thus the impact area of smoke is larger than the actual fire area. Consequently people in the near surrounding of the fire area may become intoxicated by the smoke or become disorientated and therefore cannot escape anymore. If these persons cannot be rescued from this dangerous situation, the probability of death is high.

To gain insight into the number, nature and circumstances in residential building fires with people inside two types of incident investigations are conducted by the Fire Service Academy and the Netherlands Fire Service. The first investigation focusses on fatal residential building fires and is conducted from January 2008 to present. In this study a fatal residential building fire is defined as a fire involving civil fatalities due to fire, which took place in a building with a residential function or another 'housing related' object and is not caused intentionally.
The second investigation focusses on nonfatal residential building fires where people were rescued by the fire brigade. A fire rescue is defined as an evacuation by the fire brigade of a person who cannot, or does not want to, escape independently, and wherein the person would end up in a worse condition if the fire brigade does not intervene. This worse condition can for example be caused by fire (heat), smoke or (threat of) jumping. The criterion for a worse condition is that the situation (fire or the consequences of fire, such as smoke) must be life threatening to the victim. The study on nonfatal residential building fire rescues is an explorative study and is conducted from January 2014 to present.
The results of both studies [4, 5, 6] of incidents in 2014 and 2015 are presented in this paper.

METHODOLOGY

Study on fatal residential building fires

The main goal of the study on fatal residential building fires is to obtain a representative view of the critical factors in fatal fires in order to identify possible policy improvements for reducing the number of fatalities in residential building fires. To achieve this objective, the causes, circumstances and development of the fatal fires are investigated annually. The incidents are mainly collected based on news items on the Internet and on messages on social media. In addition fire investigators of the Netherlands Fire Service are asked to alert the Fire Service Academy when a fatal residential building fire took place in their region. The criteria to include a fatal residential building fire in the study are the following:

- The fatal fire took place in the period from January 1, 2014 to December 31, 2015 in the Netherlands;
- The fatality is a direct result of an unintentional fire. Deliberately caused fires with fatal outcome, such as fires caused by arson by sanely adults, murder or suicide, are excluded from the study. Also fatalities caused by a natural death, with no connection to the fire are excluded;
- The victim is a resident or visitor of a residential function or another housing related object that is hit by (the effects of) fire. This means that there must be question of more or less permanent residence and familiarity of the victim with the environment. Fatal fires in nursing homes are therefore included in the study, but fatal fires in (for example) hospitals are excluded. Fatal house fires in mobile homes and barns (if belonging to a residential property) are also included in the study.

If the incident meets the research criteria the corresponding fire investigator and/or fire commander is asked to fill in a digital questionnaire. In the questionnaire information is inquired about general characteristics, such as the time of the fire and the region in which it took place, about building characteristics, such as the type of residential building and the presence and operation of smoke detectors, about fire characteristics, such as the cause of the fire and the extent of smoke spread, and about human characteristics, such as gender and extent of awareness and mobility.

Study on nonfatal residential building fire rescues

The main goal of the explorative study on nonfatal residential building fire rescues is to obtain insight in the extent and circumstances of rescues done by fire brigades. Up to now there is no clear picture if victims of residential building fires, in particular those in a room on fire, can be rescued at all, knowing that residential building fires can develop rapidly and it takes time for the fire brigades to arrive at the

fire scene. The methodology of the study is basically the same as of the study on fatal residential building fires. It differences in the design of the questionnaire, as it is less extensive than in the study on fatal fires, and in the criteria to include the incident in the study. The criteria to include residential building fire rescues in the study are the following:

- The rescue took place in the period from January 1, 2014 to December 31, 2015 in the Netherlands;
- It is a rescue in a nonfatal fire from a building with a residential function or another housing related object;
- The situation is life threatening to the victim because of (effects of) fire or subsequent actions of the victim. The fire does not necessarily have to rage at the residence of the victim;
- The rescue was carried out by the fire brigade.

Items that are analysed are, amongst others, the time course of the firefighting actions and the rescue, the degree of fire and smoke development at the time of the rescue in comparison to the conditions in the final situation of the fire, the location of the rescued person, and the reason for the need of rescue by the fire brigade.

RESULTS

Response and number of incidents and victims

The response rate in the study on fatal residential building fires in both years is 100%. In the study on nonfatal residential building fire rescues the response rate is 87% in both years. Table 1 summarizes the number of incidents and victims that are analysed in the two studies.

Table 1. Number of incidents and victims in analysis

	Fatal fires		**Nonfatal fire rescues**	
	Incidents	Fatal victims	Incidents	Rescued victims
2014	30	30	76	186
2015	27	31	76	157
Total	**57**	**61**	**152**	**343**

Fire characteristics in general

The fatal fires occurred predominantly in the months of January (11%), February (21%), September (11%) and November (14%). The incidents with nonfatal fire rescues mainly took place in the months of January (13%), April (13%) and May (11%).

Most of the fatal fires occur around the weekends, namely on Fridays (19%), Saturdays (21%) and Mondays (19%). The same is the case for incidents with nonfatal fire rescues, as they occurred predominantly on Thursdays (16%), Fridays (19%) and Sundays (17%).

The largest amount of fatal fires are reported to the alarm receive centre between 19:00 and 01:00 hours (32%) and between 07:00 and 13:00 hours (28%). The incidents with nonfatal fire rescues are mainly reported between 01:00 and 07:00 hours (32%) and between 19:00 and 01:00 hours (20%). This indicates that the possibility of being hit by a fatal fire or nonfatal fire rescue is greater at times when people are commonly sleeping. In the study on fatal fires additional information about the circumstances of the victims is asked. The data confirms that at the time of the fire, many people were asleep, namely a little more than half of the victims (n=32; 53%). The other half was awake, though most of them had a reduced mobility or were immobile (n=19; 31%).

Attendance time for the first fire engine

The average attendance time for the first fire engine was for the fatal fires 7.1 minutes (sd=2.6) and for the nonfatal fire rescues 6.1 minutes (sd=2.0), both based on attendance times that are rounded on minutes. In both types of residential building fires the maximum attendance time was between 13 and 14 minutes. In the fatal fires the first fire engine arrived in 19% of the cases within 5 minutes and in 66% of the cases within 8 minutes. In the nonfatal fire rescues the first fire engine arrived in 35% of the cases within 5 minutes and in 88% of the cases within 8 minutes. This might suggest that the firefighters attend at a later time in the fatal fires than in the nonfatal fire rescues. Though, for the probability of the survival of fire not only the attendance time is of importance, but rather the combination of the attendance time and the time prior to the report of the fire to the fire department. This means that insight in the time between the start and detection, and between detection and reporting, is probably more important than the attendance time.
Additional information is asked about the time of death, the time of the start of the fire and the time of detection of the fire is only asked in the fatal fire study. About half of the victims (n=28; 46%) had already passed away before the fire was noticed. These victims could not be rescued by the firefighters at all, regardless of a short report and attendance time. The two major problems for these victims is possibly a reduced mobility (n=9; 32% of 28) and the delay in the detection of fire because of the state of awareness of the victims as about three-quarters of the other victims (n=14; 74% of 19) were asleep during the fire. For these victims a smoke detector seems an appropriate measure to shorten the detection time and to prevent casualties. Nevertheless, in the study on fatal fires it is found that in a quarter of all cases (n=15; 25%) a smoke detector was present and operational. This is also true for a quarter (n=7; 25% of 28) of the victims who had already passed away before the fire was noticed. This indicates that a smoke detector cannot prevent fatality in all cases. Possibly it is the location of the smoke detector, usually installed in the hallway and/or landing, that made it ineffective [3], as most victims were in the room of fire origin.
A few victims (n=9; 15%) deceased in the period after the report and before the arrival of firefighters. The maximum attendance time was 14 minutes, though in two-thirds of the cases (n=6) the first fire engine arrived within 8 minutes. In these cases the fatalities are possibly due to the relative late notification of the fire, however it cannot be excluded that they could be rescued if the firefighters arrive even faster.
The other victims (n=18; 30%) deceased after the arrival of the first fire engine. In some cases (n=7) the fire started more than 30 minutes before the report, making a fast report and a relative short attendance time irrelevant. In four cases the fire was reported very quickly, namely within 5 minutes after it started, and in one case even within 1 minute. In all of these cases the first fire engine also arrived very quickly, as it arrived within 8 minutes. Other circumstances made that the victims did not survive. The mentioned circumstances are a reduced mobility, the victims' clothes that caught fire and dense smoke.

Type of residential building

The nonfatal fires in residential buildings with rescues have occurred mostly in apartment buildings (69%) and predominantly in portico flats (41%), but also a considerable part occurred in single-family houses (28%), especially in row houses (18%).
The fatal fires are more evenly distributed on apartment buildings (47%) and single-family houses (44%). The fatal fires in apartment buildings occur mainly in buildings with apartments that are connected to a hallway (21%) and in nursing homes or senior housing (18%), instead of in portico flats. The fatal fires in single-family houses take predominantly place in row houses (32%), just as it is the case with nonfatal fire rescues.
The distribution of fatal fires and nonfatal fire rescues among the various types of residential buildings shows that the type of dwelling is irrelevant as about a half of the incidents took place in apartment buildings and the other half in single-family houses. Further on in the paper it will be discussed that by

fatal residential building fires the human factors are predominantly relevant for the fatalities. For nonfatal fire rescues, on the other hand, the type of residential building is very relevant, as eight out of ten victims needed to be rescued from an apartment building. In this type of residential buildings several apartments are connected to the same hallway or stairwell. When the occupant of the burning apartment leaves the door open, the only escape route from the other apartments, namely the hallway or stairway connected to the burning apartment that is also connected to their apartments, will quickly fill with smoke. Consequently the neighbours will be trapped by the fire and smoke, and need to be rescued when dense smoke blocks their only way out. This also explains why comparatively many victims (80%) in apartment buildings need to be rescued in case of fire.

Table 2 presents the distribution of fatal fires and nonfatal fire rescues among the various types of residential buildings.

Table 2. Type of residential buildings

	Fatal fires		**Nonfatal fire rescues**	
	Incidents	Victims	Incidents	Victims
Apartment	**47%**	**49%**	**69%**	**80%**
Portico flat	*7%*	*7%*	*41%*	*56%*
Apartment building	*21%*	*25%*	*13%*	*10%*
Apartment above company or store	*0%*	*0%*	*6%*	*8%*
Nursing home/senior housing	*18%*	*16%*	*3%*	*3%*
Single-family house	**44%**	**43%**	**28%**	**19%**
Row house	*32%*	*30%*	*18%*	*12%*
Semi-detached house	*4%*	*3%*	*3%*	*2%*
Detached house	*9%*	*10%*	*5%*	*3%*
Holiday cottage	**5%**	**5%**	**1%**	**0%**
Other	**4%**	**3%**	**2%**	**1%**
Unknown	**0%**	**0%**	**1%**	**0%**
Total	**100%**	**100%**	**100%**	**100%**

All the victims of the fatal fires (n=61) were, at the time that they were found or initially rescued, inside the residential building. This is also true for about two-thirds of the nonfatal fire rescue victims (n=216; 63%). The other third of the victims is rescued from a balcony, roof or roof terrace. This means that about one in five of all analysed residential fires with persons still in the building at the time of the arrival of the fire brigade has a fatal outcome. Such incidents have a significant impact on the firefighters concerned. **Only the fatal and nonfatal cases with victims inside the residential building are further analysed hereafter.**

Location of the victims

Most victims of fatal residential building fires are in the room of fire origin (n=36; 59%) compared to a small part of the nonfatal fire rescue victims (n=28; 13%). Nevertheless, the absolute numbers of victims in the room of fire origin is comparable. This is noteworthy as the generally held assumption is that probability of rescue from a room of fire origin is minimal, while the absolute numbers show that indeed persons can be rescued alive from the room of fire origin and survive the fire.
In both the fatal fires and the nonfatal fire rescues the victims are located in the living (n=21; 34% and n=68; 31%) or in a bedroom (n=14; 23% and n=84; 39%). Relatively more victims of fatal fires are located in the kitchen (n=8; 13%) compared to the nonfatal fire rescue victims (n=5; 2%). On the contrary, relatively more victims of nonfatal fire rescues are located in the hallway or landing (n=18; 8%) compared to the fatal fire victims (n=2; 3%).

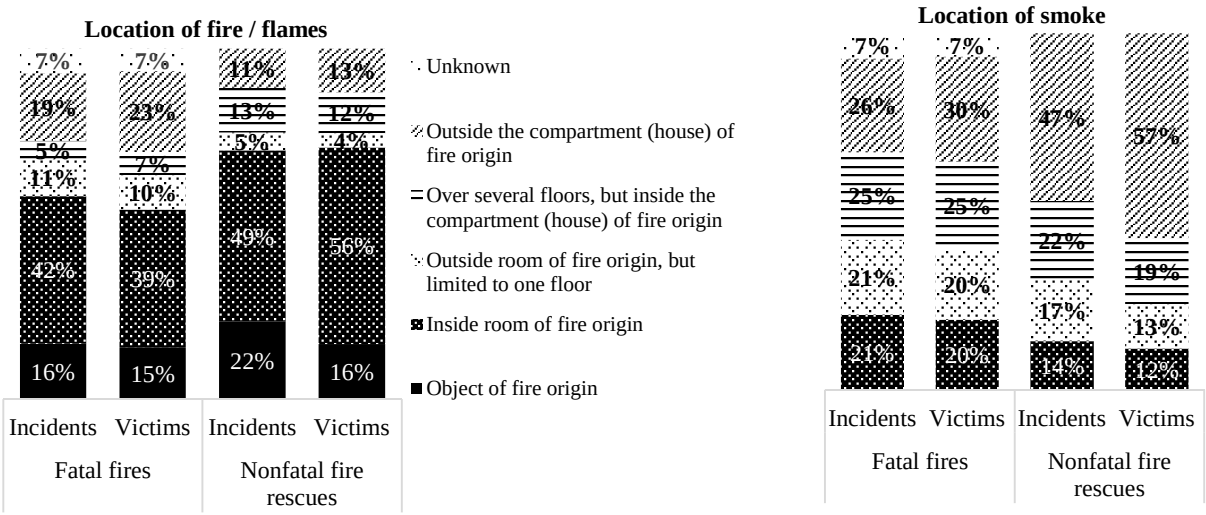
Characteristics of the victims

The age is known for 90% of the victims of fatal residential building fires and for 73% of the nonfatal fire rescue victims. Relatively more victims of fatal residential building fires are 80 years old or older (n=21; 38%) compared to the nonfatal fire rescue victims (n=5; 2%). The victims of nonfatal fire rescues are more often in the age of 20 to 40 years old (n=59; 38%) than the fatal fire victims (n=4; 7%). Although the absolute numbers are low, they are also more often younger than 20 years old (n=19; 12% and n=1; 2%). For the other age groups the distribution is comparable as almost three out of ten victims is between 40 and 60 years old (n=16; 29% for fatalities and n=42; 27% for non-fatalities) and about a fifth is between 60 and 80 years old (n=13; 24% for fatalities and n=29; 18% for non-fatalities).
The gender is known for all the victims of fatal residential building fires and for 74% of the nonfatal fire rescue victims. In both studies about three-fifths is male (n=36; 59% and n=93; 58%) and two-fifths is female (n=25; 41% and n=67; 42%).
The degree of mobility is only asked in the study on fatal residential building fires and is known for 77% of the victims. A third is mobile (n=20; 33%) and has no other impairments that impede them to escape without help. Of 18 mobile victims it is known if they were in the room of fire origin or not, and most of them were (n=14; 23%), frequently asleep (n=8; 13%) but sometimes awake (n=6; 10%). Only few victims were outside the room of fire origin (n=4; 7%) and only one was awake, but slept just before and was under the influence of narcotics. Of the victims who were in the room of fire origin and awake, two were awakened too late, two victims got their cloths on fire, and of two no further information is given. Of the victims who are reduced or immobile or have other impairments that impede them to escape independently (n=27; 44%) about a half was in the room of fire origin (n=15; 25%) and the large majority of them was awake (n=11; 18%). Also most of the impaired victims outside the room of fire origin was awake (n=8; 13%). This indicates that for the mobile victims first the location is determining, as most of them were in the room of fire origin. Secondly the state of awareness is of importance for survival, as most of the victims outside the room of fire origin were asleep. For the impaired victims just the fact that they cannot escape by themselves fast enough is the most determining factor, as there is no big difference in the number of victims that were in- or outside the room of fire origin and almost three-quarter of the impaired victims were awake.

Situation at the time of arrival of the fire brigade

The location of the fire or flames and the degree of the smoke spread is known in 93% of the fatal residential building fires. For the nonfatal fire rescues the location of the fire or flames and the degree of the smoke spread is known in all cases. In both the fatal fire incidents and the nonfatal fire rescue incidents the fires are relatively small. In most of the incidents it is limited to the room of fire origin (n=33; 58% and n=83; 71%) or even to the object of fire origin (n=9; 16% and n=26; 22%). Nevertheless, the victims had to be rescued or did not survive the fire. As the figure indicates, it is not strongly related to the fire size but it is rather related to the degree of smoke spread. In most of the incidents the smoke is spread outside the room of fire origin (n=29; 51% and n=75; 64%) or even spread over several floors or further (n=41; 72% and n=107; 91%). This confirms the general view that smoke is more dangerous for the victim than the flames or heat of fire.
In Figure 1 the situation at the time of the arrival of the fire brigade is presented.

Figure 1. Situation at the time of arrival of the fire brigade



Need for rescue

The fatal fires and nonfatal fire rescues with a similar pattern and a similar combination of features are grouped into ‘types of rescues’. The classification of types of rescues is based on the process of escape. After all, the starting point for fire safety is that in case of fire the participants are able to escape independently. The process of escape consists of the following phases:

1. The detection of the fire;
2. Decision making based on an assessment of the situation;
3. Escaping.

In the various stages of the process the possibility to escape independently can be obstructed, so that a rescue becomes necessary. The obstructions may have been caused by the conditions of the victims, the fire situation or by the building characteristics. The combination of the three phases of the process and the three types of obstruction causes have led to the six types of rescues, which are described in Table 3. For the distribution of cases on the rescue types additional use is made of the flow chart as shown in Figure 2.

Following the flowchart one can see that there is a hierarchy in the reasons for rescue. The most important reason is an obstructed escape route (because, even if a person is able to flee, an obstructed escape route will prevent that). So, a case can be classified as a type 3 rescue (escape route is blocked), while the victim is reduced mobile and also seriously injured by fire. This is because a blocked escape route is considered to outweighs the grounds of obstructions caused by a serious injury or a reduced mobility. First, to escape independently it is important that the escape route is available. When it is blocked, victims are trapped and rescue will be the only option to survive. Second, a (mobile) impairment caused by serious injury weighs heavier than an already existing mobile impairment. In case of a severe injury there is a probability of loss of consciousness (also a form of serious injury) where after there is usually no possibility to escape. In case of an existing mobile impairment the victim can possibly still escape, but it takes more time and effort making a rescue necessary.

Table 3. Description of the types of rescues

Type	Description	Escape process and cause of obstruction
1	The victim has not yet detected the fire until the moment of rescue.	During the phase of fire detection an obstruction occurs, for example, because the victim is sleeping.
2	The victim decides not to escape, while it is physically possible.	During the phase of decision-making an obstruction occurs, for example, because the victim is confused or does not want to leave the building for another reason.
3	The victim cannot escape (any longer) because of a blocked escape route.	During the phase of escaping an obstruction occurs that is caused by building characteristics.
4	The victim cannot escape (any longer) because of serious injury by fire or smoke.	During the phase of escaping an obstruction occurs that is caused by the fire situation.
5	The victim cannot escape (any longer) because of an already present mobility impairment.	During the phase of escaping an obstruction occurs that is caused by the conditions of the victim.
(6)	The victim cannot escape (any longer) because of another reason of obstruction.	During the phase of escaping an obstruction occurs that is caused by building characteristics, the fire situation and/or the conditions of the victim.

In this particular study a type 6 rescue did not occur.

Figure 2. Flow chart for the distribution of rescue types

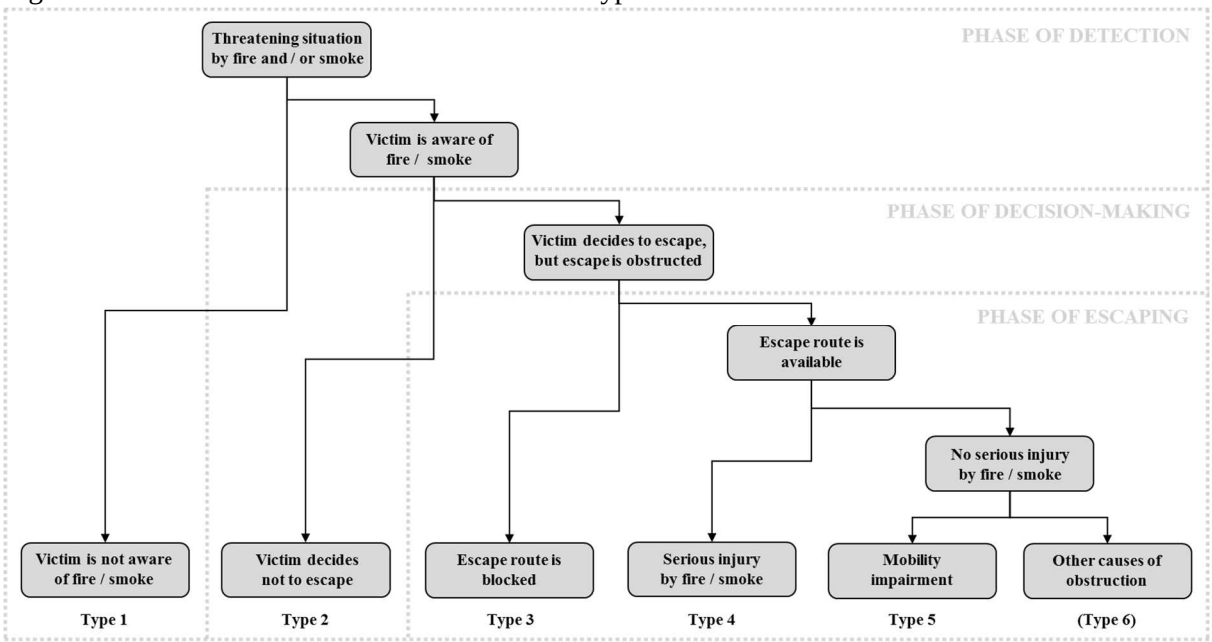


Table 4 shows the distribution on the various types of rescues for the victims of fatal fires and nonfatal fire rescues.

Table 4. Types of rescues

Type	Fatal fire victims		Nonfatal fire rescue victims	
	Number	**Percentage**	**Number**	**Percentage**
1. Victim did not notice the fire	24	39%	45	21%
2. Victim decides not to escape	0	0%	25	12%
3. Escape route was blocked	16	26%	127	59%
4. Victim was seriously injured by the fire	11	18%	14	6%
5. Victim could not escape because of reduced mobility	10	16%	5	2%
Total	**61**	**100%**	**216**	**100%**

As the table shows, most victims of fatal fires did not notice the fire (n=24; 39%), while most of the victims of nonfatal fire rescues could not escape because of a blocked escape route (n=127; 59%). For the five types of rescues the relevant building features are analysed, as well as the relevant fire and human characteristics, and the relevant characteristics of the firefighting interventions. The features associated with the respective types give indications for effective measures to prevent situations that make a rescue necessary.

Stage of life threat of victims in fatal and nonfatal fire rescues

For the degree of threat to life of the victims the following three situations are distinguished.

- In a rescue with immediate threat to life the victim is rescued from the room of fire origin, or an area (inside or outside the building) where there is dense smoke.
- In a rescue with a milder form of acute threat to life the victim is rescued from another area from the fire area (inside or outside the building) where there are no flames and where there is no or light smoke nearby the victim. Nevertheless there is a situation of acute threat to the life of the victim, but for other reasons. One example is a situation of fast fire and/or smoke spread and the smoke pours from the stairwell of the portico flat into the apartment, leaving the only option for the victim to escape to the balcony and wait for a rescue or to consider to jump.
- In an evacuation as a precaution the victim is rescued from an environment where there is (barely) no or light smoke, but without interventions the victim cannot escape safely. This is the case if, for example, the stairwell of the portico flat (the only escape route) is filled with smoke and the smoke not yet pours into the apartment of the victim, so the victim has not yet discovered the fire.

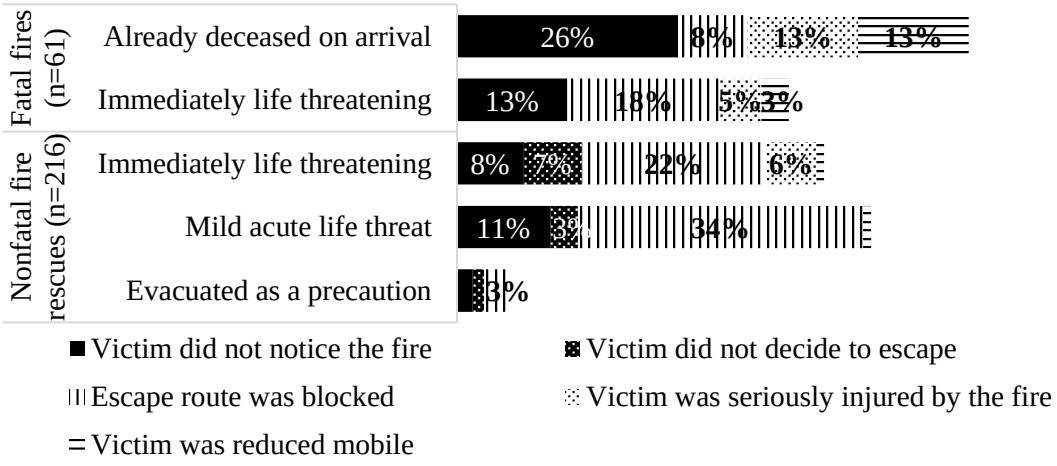
The different stages of life threat are applicable to both the fatal fires as the nonfatal fire rescues. In fatal fires there is also a fourth situation wherein the victim already has deceased before the arrival of the fire brigade.

Among nonfatal fatal rescues about two-fifths of the victims (n=94; 44%) is rescued from direct threat to life: about three out of ten of these victims is rescued from the room of fire origin (n=28; 13% of all nonfatal fire rescues from inside) and the other victims are rescued from another room where there is heavy smoke (n=66; 31% of all nonfatal fire rescues from inside). Half of the victims (n=107; 50%) has been rescued from a milder form of acute threat. The other victims (n=15; 7%) have been evacuated as a precaution because they are trapped by the fire and/or smoke and therefore could not escape independently (but there is no immediate threat to life).
In the fatal fires most of the victims (n=37; 61%) were already deceased when the fire brigade arrived and as a consequence rescue was impossible. Of these victims, two thirds (n=25; 41% of all fatalities) were found in the room of fire origin. About four out of ten victims of fatal fires (n=24; 39%) were in a situation of immediate life threat. Initially they have been rescued, but later they are deceased from their injuries. Of these victims, about a half (n=11; 18% of all fatalities) is rescued from the room of fire

origin. In total, six out of ten victims of fatal fires are present in the room of fire origin at the time the fire brigade tries to rescue the victim. This is the case for 8% of the rescued victims of nonfatal fires. Figure 3 presents the distribution of rescue types per stage of life threat for the fatal fires and the nonfatal fire rescues.

Figure 3. Distribution of rescue types per stage of life threat

(labels only visible if ≥ 3%)



Almost half of the victims who did not notice the fire was already deceased before the first fire engine arrived, or even before the fire was reported to the fire brigade. This indicates that if the victim does not notice the fire, the probability of survival is limited. Conversely, it confirms that an early detection of fire increases the probability of survival. Also rescues as a consequence of an obstructed escape caused by a reduced mobility are closely related to cases were the victim was already deceased on the arrival of the first fire engine, namely in about three-quarters of all rescues because of a reduced mobility. This is also true for rescues with victims who were seriously injured by the fire, however to a lesser extent since it is related to only about half of all rescues because of serious injuries. In cases wherein the escape route was blocked (type 3) the probability of being rescued and to survive the fire is better than cases with other determining obstructions of an independent escape, such as an delayed detection (type 1) or a reduced mobility (type 5).

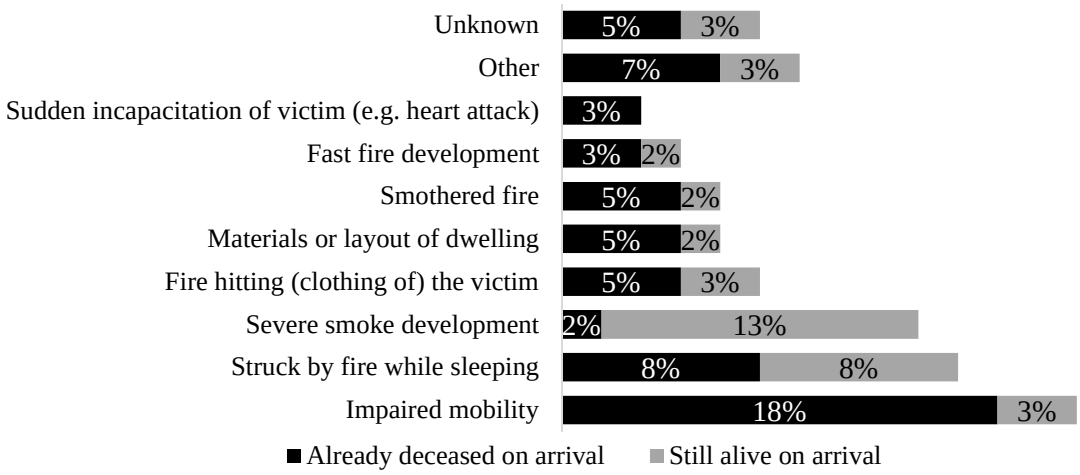
Method of rescue

In the study on nonfatal fire rescues information is gathered about the method in which the victims have been rescued. In the situations of immediate life threat most of the victims are dragged out by the firefighters (n=40; 19%). Others are rescued by means of a ladder truck / rescue vehicle (n=18; 8%), by supported walking without (n=16; 7%) or with rescue mask (n=15; 7%), or by means of a hand ladder (n=5; 2%). The chosen method of supported walking without rescue mask sounds not suitable for the circumstances of dense smoke, however most of these victims were rescued in a split second and the time needed for affixing the mask would take too long. When little more time is available, for example in the situations of mild acute life threat, we see that the firefighters will take the time to affix the rescue mask and support the victims while walking them outside (n=33; 15%). Others in the situation of mild acute life threat are rescued by means of a ladder truck / rescue vehicle (n=28; 13%), by supported walking without rescue mask (n=22; 10%), by means of a hand ladder (n=15; 7%), or they are dragged out by the firefighters (n=9; 4%). Only few victims are evacuated as a precaution. Almost half of them are rescued by means of a ladder truck / rescue vehicle (n=6; 3%) or by supported walking without rescue mask (n=6; 3%), and some are rescued by wearing a rescue mask (n= 2; 1%) or in another way (n=1; 0.4%).

Major factors of fatality

In the study on fatal fires information is gathered about the most decisive factor that led to the decease of the victim. The distribution on the most mentioned major factors of fatality are visualised in Figure 4.

Figure 4. Major factors of fatality for victims in fatal fires (n=61)



In one out of ten fatal fires the factor of fatality is not known. In a fifth of the cases the reduced mobility of the victim is mentioned as the major factor of fatality (n=13; 21%). Often the victim was already deceased on the arrival of the first fire engine, subsequently they could not be rescued. Also a major factor for many victims is the fact that they were struck by the fire while they were sleeping (n=10; 16%) or that there was a severe smoke development (n=9; 15%). The severe smoke development is also the most mentioned factor for the victims that were still alive on the arrival of the first fire engine, namely for a third of all victims that were initially rescued.

LIMITATIONS

The results of both studies should be interpreted with caution. The fatal fires only include the victims that deceased from a unintended fire in a building with a residential function or another 'housing related' object. The cases wherein there was a proven or strongly suspected case of murder or suicide are not included in the study. In 2014 and 2015 in total about twenty-seven victims of fatal dwelling fires were caused by murder or suicide and were excluded from the study. That is about a third (31%) of the victims of intended and unintended fatal residential building fires together.

Also the study on nonfatal fire rescues has some limitations. First of all the data collection is based on news items wherein a rescue by the fire brigade is mentioned. Also the data collection of fatal fires is initially based on news items, however, in contrast of fatal fires not all fire rescues become a news item. Secondly, the study is an explorative study and therefore new for the fire service. Therefore the incidents with fire rescues are rarely reported to the Institute for Safety. Another limitation is the lower response rate (87%) of the nonfatal fire rescue study compared to the fatal fire study (100%). Also in the nonfatal fire study the quality of the response was limited, as in some cases many victims were rescued and not all data of the victims was gathered. Those cases, representing at least twenty-three victims in total, were excluded from the study. Also nonfatal fire rescues of other persons (e.g. inmates or neighbours) in fatal residential fires were excluded from the study in order to not disrupt the collection of data for the study on fatal residential fires. Consequently the data of eighteen incidents with at least one hundred and eighty victims in total is not collected. To overcome this problem of missing data the questionnaires of both studies are integrated for the incidents with fatalities and rescued victims as well. To improve the quality

of the response of the study on nonfatal residential fire rescues some questions are reformulated. Finally, to improve the depth of the hitherto explorative study and to align it with the study on fatal residential fires the questionnaire of the study of nonfatal fire rescues is extended. Because of these adjustments it is in the following years possible to compare more data and thereby gain a better understanding of the difference between fatal residential fires and nonfatal residential fire rescues.

CONCLUSION

The analysis of the difference between fatal and nonfatal casualties in residential building fire rescues presented in this paper is a first step in gaining a better understanding of the determining factor for fatality and survival in case of a residential fire. The results show that in absolute numbers relatively many victims are rescued from the room of fire origin (n=28), compared to the victims in the room of fire origin that did not survive the fire (n=36). This indicates that even if residential fires tend to develop rapidly and for the first fire engine it takes some minutes to attend, there is still a reasonable probability to rescue victims out of a room of fire origin. However, if the fire is not noticed by the victims or the victims are reduced mobile or have another impairment that impede them to escape without help then the probability of survival is limited. When an independent escape is obstructed by a blocked escape route, for example, if the shared hallway of an apartment building is full of dense smoke, there is a reasonable possibility to rescue the trapped victims. This finding, and the finding that fire rescues more frequently took place in apartment buildings, indicates that the building features are of importance for the need of rescue in case of a fire. Especially the circumstance of several apartments that are connected to the same hallway or stairwell, that is the only way out and in case of a fire can quickly be filled with smoke, makes that many neighbours will be trapped by the fire and/or smoke and need to be rescued. In fatal residential fires there are many victims with a reduced mobility, who could not escape (fast enough) without help. The mobile victims that did not survive the fire where frequently in the room of fire origin and did not notice the fire (fast enough) as many of them were asleep. Some victims were outside the room of fire origin, but asleep or under the influence of narcotics and therefore did not notice the fire (fast enough). This indicates that a reduced mobility and a reduced awareness of mobile persons decreases the possibility to survive a fire strongly. In other words, the human features are of great importance in fatal fires. Since many victims were already deceased before the first fire engine arrived, or even before the fire was reported to the fire brigade there is need for measures (by policy or education) to shorten the time of detection and report of fires. The finding also reduces the importance of attendance times, which are already quite short.

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