Chapter 21
The Road Ahead

Marcus Runefors, Ragnar Andersson, Mattias Delin, and Thomas Gell

Abstract This chapter sums up some major findings and draws conclusions on desirable future directions for fire safety practices and research. Like in parallel fields of safety where human life is at stake, there is a need for a broadened systems-oriented approach, and towards preventing adverse consequences rather than preventing their preceding events. Due to demographic transitions, the residential fire safety problem is increasingly to be seen as a matter of human vulnerability, thus raising new challenges for all actors involved in designing and providing living environments.

A **resident** is anyone from zero to hundred years or more. Regardless of age, abilities and health, everyone deserves safe housing conditions. This matter is a shared responsibility across sectors. Relevant **actors** need to be identified and ascribed roles in a more systematized multi-sectoral fire safety work. Fire safety **technology** already offers significant protection if fully employed. Yet, new challenges appear ahead in the wake of ageing populations, shifting lifestyles and household structures and changing housing policies for residents with special needs.

A major concern relates to the **governance** of fire safety at local, national and international levels with regard to leadership, monitoring, accountability, implementation, learning and sharing in order to ensure continuous improvements.

Keywords Risk governance · Actors · Global perspective · Innovation · Strategy · Fire prevention

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M. Runefors et al. (eds.), *Residential Fire Safety*, The Society of Fire Protection Engineers Series, https://doi.org/10.1007/978-3-031-06325-1_21

1 Introduction

Like other adverse events, fires do not occur randomly, even if it sometimes may seem so. They always result from latent conditions (technical, social and organizational), allowing them to happen and influencing their likelihood and severity. Moreover, frequent adverse events like fires tend to appear with strong regularity. They tend to reoccur with similar frequency and patterns year by year, implying a resembling continuation in the future as long as nothing is done to really alter the situation.

These regularities and environmental latencies constitute the rationale for applying a holistic systems approach when addressing human risk problems. Human risks and their adverse manifestations reflect design features of human environments for housing, working life, transportation, etc., which are usually man-shaped and thus also usually modifiable. Historically, accidents and other adverse events were often blamed on the individual or seen as acts of God. Today, we know better and realize that it is by designing our human environments we also determine our human risks, and that it is a societal responsibility to continuously strive for safer environments.

Residential fire is a type of adverse event occurring in the home environment. The home as a system, or rather the "housing system" to include its users as well, constitutes in its inner core of the physical home plus its occupants and visitors. This core is surrounded by a spectrum of actors who, in various ways and to various degrees, influence the design of our housing system in its broadest sense: Who lives where and under which socio-technical conditions? What do we do, and what do we store in our homes? etc. The housing system is also located in a broader context in the form of built environments, business activities, infrastructure, climate and so on, bringing further actors into the scene.

In this final chapter, we wish to reflect on some major challenges and related potentials, based on the aggregate knowledge as presented in previous chapters of this book. These challenges and potentials are structured according to the above-mentioned system components, plus one overarching perspective intended to meet the need of continuous improvements (Fig. 21.1).

The remaining of this chapter is structured around the components in the figure above.

2 The Resident(s)

"Resident" includes human beings in ages from zero to a hundred years or even more. Over a long age span, human capabilities and associated needs of support and environmental adaption vary within wide frames. In periods of life, such as in early childhood, we are helpless and fully dependent on others, and in periods we might be well functioning and supposed to care for both ourselves and others in need. At

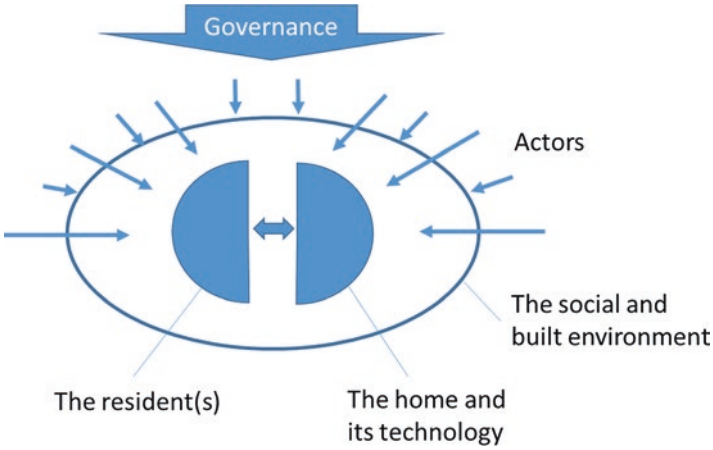

Fig. 21.1 The components of the housing system

older age, many of our capabilities often diminish, making us once again dependent on the care of others. The way this collective responsibility is organized varies between societies and over time; historically within family structures and more recently through institutionalized welfare systems. Modern societies tend to move towards larger proportions of single households with older residents, often with multiple health impairments and less resilient to injuries caused by fire (Chap. 4). This makes way for excessive vulnerabilities with regard to a number of residential hazards, not least fire (Chap. 5). There are also younger groups, typically without impairments, that have a high risk since addiction to alcohol and drugs limits their abilities to respond in case of fire.

As clearly shown in several chapters in Part I, human life and health in case of fire are increasingly related to vulnerability characteristics. This fundamental observation implies important needs for further developments in fire safety:

Even though the risk groups of fires have been rather well known for quite some time (see Chap. 2), further efforts are needed to deepen our understanding of why certain groups are at elevated risk. The literature, which is almost exclusively from western countries, clearly points at the elderly as the main group of concern. However, "the elderly" constitutes a very heterogeneous group with regard to capacities, vulnerabilities and lifestyles, calling for more detailed studies on this matter in the future. Smoking and alcohol are well-known risk factors, but in addition prescribed drug consumption combined with functional and medical impairments may play increasing roles. In other parts of the world, children still stand out as a group of major concern from a fire safety perspective (see Chap. 1). Why is that, and which developments in richer countries contributed to the significant reduction of fire fatalities in this group over time? In yet other parts of the world, women in younger adulthood represent the most exposed group in terms of fire-related mortality. This phenomenon still remains largely unexplained, although handful studies exist suggesting a spectrum of causes including dressing style, cooking habits and

various types of family violence. Further analysis and clarification are very much needed.

Expected future developments of fire-related mortality need to be better modelled and projected, as input for elaborated and more realistic strategic planning at national and international levels. Such projections presuppose accuracy in historical data, both with regard to fire-related mortality and demography. Major determinants of fire-related mortality, as identified through research, such as health and disability status among residents, proportion of single households, prescribed drug consumption, smoking and alcohol habits and so on, need to be taken into account as well. Parallel political trends in housing policy for frail and service-demanding elderly are other factors of concern.

Strategical conclusions must be reached in each country separately, based on national conditions, but some generic implications can be outlined. These include:

- Ageing populations and deinstitutionalization in health and social care raise new challenges for the fire safety community. A growing share of frail residents, often living in single households, with considerable health and functional impairments and often under incapacitating medication, tends to remain living in their original homes without continuous assistance and surveillance. The challenges include installation (and sometimes development) of new technology to compensate the reduced abilities, e.g. new alarms for the hard of hearing and extinguishing systems for those unable to evacuate themselves in case of fire.
- Groups at risk in case of fire are characterized by elevated risks in many other respects, such as falls, suffocation, poisoning, suicide and cardiovascular issues. Fire safety professionals should seek collaboration with health and social sectors to provide broader safety solutions, taking all these problems into account. Addressing each risk one by one implies serious suboptimization of public resources and substandard solutions for those in need.

3 The Technology

Even though future technological innovation provides large opportunities to reduce the risk from fires, there is also a lot of currently available technology that should not be overseen. The most prominent example is the smoke alarm described in Chap. 8. This device has been instrumental in reducing the number of fatalities from fires and has received a wide adoption. Regulatory requirements on smoke alarms in many building codes have been vital to achieve this level of adoption, but also widespread give-away programmes, which have shown to often be cost-effective (Chap. 13).

Other available technologies, such as sprinklers and stove guards (see Chap. 11), have not yet received the wide implementation of the smoke alarm. There are a few countries that mandate sprinkler in certain residential structures, but there is often a conflict with the interest to not increase the cost of new housing. The time span

needed for wide implementation is also substantial given that the lifetime of a buildings is many decades. Also, since the risk of fire for the general public is relatively low, it is not obvious that the investment in sprinklers can be motivated from a cost-benefit perspective (Chap. 13).

Stove guard is a newer innovation, tailored to handle cooking top fires, which is one of the leading causes of fire injuries in many countries. Despite this, the adoption rate is quite low, which might be due to the rather high price and, possibly, reliability issues related to early products. However, given the rapid development of new sensors, it is not difficult to foresee that the stoves of the future will have the inherent ability to detect and prevent the ignition of materials on the stove.

A well-known fire problem, especially pronounced after the transition to petroleum-based materials, is upholstered furniture. In many countries, a large proportion of the fire victims die before the fire has spread from the furniture first ignited. This requires measures to be implemented that influence the fire very early in the development. The most common way to address this is by fire-retardant treatment of the materials (Chap. 10) which has been implemented in several codes in the US and in the UK some decades ago. However, environmental concerns about the substances being used have led to a partial roll-back of the requirements. This is despite the more environmentally friendly alternatives that have been lately developed [e.g. 1]. In parallel, there has been an effort to modify the most prominent ignition source in these fires, the cigarette, through the implementation of the RIP-cigarettes in many countries in the last decade. Unfortunately, this has been found not to be effective in reducing the risk of ignition (Chap. 10).

Other available sophisticated fire protection systems such as the detector-activated sprinkler system can hardly be motivated for all housing, but is very cost-effective for the high-risk groups previously described. This clearly illustrates the necessary link between the understanding of the resident and the specific technology.

Except for incremental improvements of available technologies, such as interconnected and/or multi-sensor smoke detectors or smoke detectors that are less sensitive to user errors, it is difficult to foresee where new innovations that reduce the risk of residential fires will emerge. It can, however, be speculated that the surge of new technologies in the area known as Internet-of-Things (IoT) will provide huge opportunities as well as the increased installation of home surveillance cameras. What is clear, however, is that effective innovations will only be possible when the innovators have deep knowledge about the actual problem as presented in this anthology. Almand [2] has asked 14 global leaders in fire safety about where innovation is most needed, and they primarily named cooking and upholstered furniture as key areas of concern.

Turning to generally technological development in society, this can provide both opportunities and challenges from a fire safety perspective. Exploiting potential synergies between fire safety and more generic developments can be both faster and cheaper than the development of stand-alone fire safety technologies. Several such synergies can be identified. One example is the reduced energy consumption in many consumer products, which decreases heat development both in the product and in potential bad connections in the fixed wiring system. Also, the introduction

of induction stoves, which results in both lower temperatures and that only metallic materials will heat up, is likely to reduce the risk of stove-related fires.

Although much of the technological development in the electrical system is likely to be positive from a fire safety perspective, there is also reason to closely monitor other developments such as charging of electric cars, solar panels, DC-circuits as well as energy storage in batteries or hydrogen. Although neither of those has so far proved themselves as major hazards in this respect, the development needs to be thoroughly investigated [3, 4].

Other developments in the building sector, such as increased use of wood as building material in large structures as well as the use of flammable claddings, cannot be expected to have a large influence of the general mortality rates since the victims typically die early in the fire development. However, they do introduce the risk of large catastrophic fires such as the Grenfell tower fire. Another pronounced development in the building sector is low energy housing which requires very airtight buildings, which might cause very large pressures in case of fires, potentially hindering evacuation (Chap. 9).

4 The Actors

By tradition, fire safety in dwellings has been regarded as mainly the responsibility of the resident. In the days when people built their own houses/furniture and mainly depended on their family for support when in need, this was a natural view. But today, our houses are designed by architects, built by building companies, and we buy our furniture and household appliances from resourceful multinational companies. In case of unemployment or illness, we depend on others such as the society to provide support. It seems rational to put forward the idea that all those organizations, having a profound influence on the preconditions for a safe system, also take on the responsibility to make it safer beyond minimum standards.

The National Fire Protection Association in the United States has formulated the notion of the "Fire & Life Safety Eco-System" [5] presented in Fig. 21.2. This idea of an ecosystem with a plethora of actors having a significant impact in different phases of a process aiming at creating fire safety is quite useful and underlines to a large extent the same idea of the importance of the responsibility of the "system designers" as put forward in the Vision Zero philosophy (see Chap. 15).

The Vision Zero target statement can, at least initially, be difficult to grasp as it seems to have an air of unrealistic or wishful thinking. However, behind the ethically motivated statement itself, as described in Chap. 15, there is a consistent underlying systemic safety philosophy that is truly goal-oriented and pinpoints responsibilities and driving forces necessary to create a safer system.

The mobilization of the entire system of actors, striving in the same direction, would benefit from better structures of incentives. Today, it is not rare that the saving of one actor becomes another actor's cost, or a resident's fatality. The national

Fig. 21.2 The NFPA Fire & Life Safety Eco-System. (Source: Reproduced with permission from the National Fire Protection Association, Copyright© 2020, NFPA, Quincy, MA. All rights reserved. For a more information on the referenced subject, please go to www.nfpa.org)

strategies presented in Chap. 20 invite and encourage all actors to participate based on existing frameworks of legislation, altruism and own decisions, e.g. responsibility in line with Agenda 2030, but better incentives, e.g. economic, are needed in the future, and we need to monitor a broader spectrum of values of a resilient residence and correlate incentives to that.

Much of the programmatic activities and campaigns that have been directed towards the residential fire problem have been performed by local fire services, often with support from the national level. Some of the efforts have been very successful, such as the campaigns to increase the share of households with working smoke alarms. However, in most cases, campaigns and other interventions within the fire safety area are poorly measured and evaluated, making it difficult to judge their effectiveness. As suggested in Chap. 16, partnering with academic institutions can be an effective way to acquire a capacity for the design of measurable programmes and can also develop institutional capacity to sustain such programmes.

The community of involved actors, however, stretch far beyond "the usual suspects" – i.e. the organizations that we normally understand as the Fire safety professionals; the fires services, the fire appliance industry, fire engineering consultants, the building inspectors, etc. As described in, e.g. Chap. 2, the population most at risk for not surviving a residential fire is a very selected group of people, whose vulnerabilities render them unable to manage even a trivial fire situation. In this respect, caregivers and domestic help providers might be the key actors for identifying at-risk individuals and as well as for providing additional safety measures. The establishment of broad efforts, involving fire, social, health and other experts, is therefore a natural way forward. Such programmes and initiatives exist, but as pointed out in Chap. 17, preventing fire for vulnerable groups can in part be seen as a 'wicked problem', as there are challenges that transcend sectoral boundaries; and span several public agencies, thereby involving different areas of policy across several political-administrative levels. A major obstacle is, in many cases, regulations on data protection and privacy, making it difficult to share information as needed for cross-sector cooperation to be meaningful and effective.

Another aspect of stretching beyond the actors mainly present today is the use of volunteers and semi-professionals to gain time for the first response to a residential fire, perhaps a neighbour intervening in case of fire, as described in Chap. 19. This is still a novel strategy, but is probably a safety measure worth to expand and develop further to save lives. Perhaps it can be optimized in combination with the rescue service with the use of the model in Chap. 12.

One systemic problem when it comes to housing is that the building industry in general hardly works according to industrial principles and also has a very low level of standardization. Even in cases where the production is partly industrialized, as in the case of buildings constructed of prefabricated modules, the assembly of these modules into complete buildings might fail due to lack of quality control and an educated workforce. Further, the non-uniform and 'bushy' nature of the building industry are also making it difficult to get it to take on its responsibility as a key actor in the fire safety ecosystem. Fire safety, albeit included in material standards, in building codes and normally subject to some type of inspection, is seldom regarded as a true value in the finished building. It is rather seen as a burden or costly add-on, generally leading to migration towards minimum legislative requirements.

A relevant question is thus: how can fire safety become a core value in residential buildings – for the building industry as well as for the residents? One role-model is undoubtedly the automotive industry, where safety has become a key characteristic, valued by the car-buyers and something the car manufacturers must relate to if they want to stay in business. A way forward could possibly be to try to make the fire safety characteristics an inherent value in the rating systems that already exist for "green" or "sustainable" buildings.

5 Governance: Leading, Learning and Sharing

As presented in Chap. 2, much is known about the characteristics of victims of fatal fires and the risk factors associated. The chapter also clearly demonstrates the striking similarities among those factors across the investigated countries, which is instrumental for cooperation. It should, however, be noted that the studies are almost exclusively performed in Western countries and, given the differences in age- and sex patterns for some countries found in Chap. 1, more variation on a global scale can be expected compared to what is apparent in the published literature.

There are also still some issues on data collection with the lack of consistent global data on fire fatalities, which causes difficulties in comparing countries and injury patterns. Some efforts are underway to develop joint criteria in the European Union [6], and a new ISO-standard has also recently been released [7]. However, there is still a long way until a coherent definition and coding of fire fatalities have been implemented globally.

Systematic safety work relies to a large extent on access to data. Data on the adverse events themselves – the fires – is normally collected by the fire and rescue services as outlined in Chap. 6. But such data also must be supplemented by data from other sources for the purpose of deeper analysis and contextual understanding. In the case of fire injuries or fatalities, information from databases in the health and forensic sectors, police, etc. (see Chap. 1) are needed. When evaluating fire safety interventions, such as fire safety education campaigns (Chap. 16) or cost-benefit analysis of "hard" fire safety measures (Chap. 13), the activities themselves have to be measured and data, including cost data, made available for analysis. In these latter areas, there is room for much improvement, as the evidence-based tradition within the fire safety community has been rather weak. GIS-based and geostatistical analysis, Chap. 18, where geo-coded fire data and census data are included in the models, is a powerful tool for investigating and visualizing the spatial and social distribution of fires, as well as for planning and prioritizing optimal areas for local fire safety activities.

Even if characteristics and risk factors are of vital importance for prevention, more is needed to develop a sound and evidence-based strategy for prevention. This need to be based on much richer data than the register data typically used in research today. The investigation of fatal fires needs to account for the full social and organizational environment around the victims to identify how the outcome could have been prevented. This requires additional scientific disciplines to be involved in the investigation, such as sociologists, political scientists, geriatrics, etc.

The investigation should probably also include non-scientific actors more familiar with the system, such as authorities at different levels and possibly companies in the field. To retain the interest of those actors, the generation of generalized scientific knowledge should be in tandem with local knowledge on actual events. One example of such process is the OLA-process regularly performed in the road sector in Sweden, where selected traffic accidents are reviewed by a group of selected

actors, which has the capacity to implement measures to reduce the risk of similar accidents in the future.

Such a process is believed to result in the implementation of actual preventive measures in society in tandem with the long-term development of general scientific knowledge that may benefit actors outside the local context.

As previously mentioned, there is an enormous gap in knowledge regarding the fire risk of the great majority of people living outside the western countries. As described in Chap. 1, the most common source of residential death and injury data for many low-income countries is burn data, which often doesn't include the source of those burns (i.e. fire or another source). However, there is ample reason to assume that the bulk of fire fatalities in those countries also occurs in residential settings. Primitive stoves are a major cause of fires and burns in most developing countries, with women and children at particular risk.

In contrast to high-income countries, where an ageing population [8] will create challenges for residential fire safety, the situation in low-income countries is different, but probably even more problematic. On a global scale, more than one billion people live in informal settlements with little or no built-in fire safety. The urbanization is rapid; by 2050, two thirds of the world's total population will live in urban areas, and 1 billion dwellings will have to be built in such areas to accommodate this increase [9].

The fast population growth in, e.g., sub-Saharan Africa will create megacities with little means of providing its citizens with proper infrastructure or housing. One such example is Lagos, Nigeria, where the population in 2021 is estimated to be close to 15 million, a number that is expected to double by 2050 – making it the third largest city in the world [10]. It is evident that this development will create residential environments with serious possibilities of aggravating the burden of residential fire injuries and fatalities. Whether the residences will be in the shape of makeshift dwellings or substandard high-rise "slum" buildings, the risk for mass-causality catastrophic fires can be expected to be high.

It is not realistic to expect countries or cities under such a rapid expansion and lack of national education or capacity in fire safety engineering to be able to apply our western type of fire safety standards. There is a strong need now to begin fire safety "capacity building", including [11]:

- Enhanced fire loss data capture and analysis.
- Build-up of fire safety education and research capacity.
- Transfer of adapted technology and knowledge.
- Contextually appropriate adaptations of western codes and standards.

Fortunately, lessons learned in the western world can accelerate this capacity building – calling for a wide partnership with different stakeholders/resources.

In the ongoing work with the 2030 Agenda for sustainable development [12], fire is a topic, but most attention regarding fire in general seems directed towards wildfires coupled with climate change. However devasting those fires are, the potential for large-scale fire disasters involving mass casualities is probably higher in urban areas. There are, therefore, good reasons for emphasizing the risk for both small and

large-scale fires in residential areas in the developing megacities. Such an emerging risk falls naturally, e.g. under the UN Sustainable Development Goal no 11.1 – "By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slum.".

The International Association of Fire Safety Science (IAFSS) highlights the need for the fire safety community to be part of the solution to what can be called "Grand societal challenges" [13]. Two such challenges where fire safety has an important role to play were identified as (i) climate change, resiliency and sustainability, and (ii) population growth, urbanization, globalization and changing demography. In that context, it is evident that residential fire safety is a core fire issue in the 2030 Agenda.

6 Conclusions

This book provides a comprehensive overview of various aspects relating to fatal fires and their victims. Based on this, and the discussion above, several conclusions can be drawn including the ones mentioned below.

There is an increasing **need to focus on high-risk groups**, especially older adults and socio-economically marginalized groups, and this requires additional disciplines to be involved in fire prevention. It is not enough to have a focus on preventing the fire, instead fire safety promotion of tomorrow should also address the capabilities and limitations of the victims as well as the social and organizational context surrounding the individual. This has implications for the organization of fire safety practices, where it is hard to imagine successful fire prevention efforts without the involvement of social services as well as NGOs who are regularly in contact with the groups. It also has implications for the level of fire prevention in homes; given the limited amount of resources in society and the comparably low risk of fatal fires for the general public, it can hardly be motivated to invest in sophisticated fire protection technologies, such as detector-activated sprinklers, for all citizens. Rather, there is a need to improve our abilities to tailor the fire protection depending on the needs of the individuals. Finally, it has implications on fire investigation where not only cause and origin of the fire should be sought but also how different latent conditions contributed to the final outcome.

Most of the western countries have come a long way in reducing the number of fire fatalities, while the rates in many poorer countries are significantly higher. This calls for an increased **global perspective** on fire safety, e.g. in the spirit of 2030 Agenda goal 17 "Partnerships for the goals". This includes both research to understand the differences in the fire problems in these countries compared to the countries where most of the research has been performed. However, it also includes global cooperation and capacity building in countries with a high risk to not only understand, but also to reduce the risk.

For general fire safety in society, there is a need to **promote innovation**, and this can, at least partly, be addressed by appropriate incitement structures and an attempt

to promote fire safety as an inherent quality of buildings and products. This can also help to address the limited adoption rate of available technologies beyond the smoke alarm, such as stove guards and residential sprinkler systems. A problem related to innovation for residential fires safety is the lack of resources and driving forces for a dedicated common effort; the system and its actors are simply too disparate and scattered compared to, for example, fire safety of underground structures. Most of the research and development within the area is founded by governmental agencies, with minimal contributions from the other system designers/actors.

There is also clearly a need for **increased knowledge** in several areas, not least about the situation in non-western countries with regard to fire safety. There is also a need for more knowledge about factors that promote and hinder effective prevention efforts and also the cost-benefit of available means for reduction of fire risk, both in general and for specific groups.

However, no change will occur without **political leadership**. Political goals should be set, strategies redesigned to meet these goals, and a sustainable governing system put in place to ensure their systematic implementation. The Vision Zero approach may serve as a model of inspiration. In addition to these national challenges, there is a need for strengthening global leadership as well, to reach improved international support, coordination, benchmarking and learning across nations. The residential fire problem can be seen as a core fire safety issue in relation to major challenges such as climate change, resiliency, sustainability, changing demographics and urbanization. Therefore, there are strong factual and strategic reasons to integrate the ongoing and future work on residential fire safety into major political initiatives such as the 2030 Agenda.

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