

MEAN ANNUAL PROBABILITY OF HAVING A RESIDENTIAL FIRE EXPERIENCE THROUGHOUT A LIFETIME: DEVELOPMENT AND APPLICATION OF A METHODOLOGY

M. Barnett, D. Bruck and A. Jago

Centre for Environmental Safety and Risk Engineering and School of Psychology
Victoria University, Melbourne, Australia

ABSTRACT

The frequency of all residential fires attended by the Melbourne Metropolitan Fire Brigade is routinely recorded and hence well known. However, the frequency of residential fires which are not attended by the Fire Brigade, including instances where the occupant of a dwelling or some other person has extinguished the fire or the fire has self-extinguished, has previously remained unknown. This paper has two aspects; (i) it describes a newly developed questionnaire for collecting relevant data on an unattended or attended residential fire experience throughout an individual's lifetime, and (ii) it reports a probability finding based on 473 adults sampled from the western region of Melbourne, Australia. Findings from the Fire Safety Awareness and Experience Questionnaire show the mean annual probability of having a fire experience (either attended and unattended) while an adult (aged over 18 years) was .012, meaning that, within this sample, the adults had on average one fire experience every 83.3 adult years.

INTRODUCTION

In Australia preventable house fires occur in and around the home every day¹. Residential fires can lead to injury, loss of life, loss of valuable property, and the loss of personal irreplaceable belongings². Fires occurring within private dwellings make up the largest proportion of all accidental fire-related deaths in Australia³. In the year 2000, there were more than 10,000 residential fires which caused over 1,500 injuries and 70 deaths, in a population of 19,153,000⁴. Despite fire safety campaigns within the community the incidence of attended fires within residential dwellings increased by 25.8% during 1991 to 2000⁵.

Residential fires begin from a variety of causes, most of which are preventable⁶. With the use of fire statistics, ongoing research has identified groups within society who are the most vulnerable to injury and death in home fires; and hence such groups have been targeted with preventative interventions. However, statistical analysis is generally limited to fires attended by fire services only, and these tend to be the most serious fires⁷. In tackling the fire problem investigating reported fires only may not be sufficient. The Home Office in the UK, for example, estimates that of all residential fires, approximately 90% never come to the attention of the fire service⁸. This large statistic indicates that the majority of home fires either self-extinguish or are being extinguished by the occupant of that dwelling. Due to the enormity of information being omitted, a thorough assessment of residential fires, in any given area, is not possible.

In an effort to gain a clearer understanding of the residential fire problem research has been carried out in the U.S. and U.K. investigating the incidence and features of unreported fire events. In the U.S. the first study was conducted in 1974 by the Consumer Product Safety Commission⁹. Surveys were used to collect information on structural fires (fires within a dwelling) and non-structural fires (those in the surrounding yard space). Results from this survey showed a higher than expected number of serious, unreported fires, in which injuries were sustained.

In 1981 the U.S Consumer Product Safety Commission (1985) conducted another investigation into un-reported residential fires in order to update the 1974 database. The objective of the project was to obtain a valid estimate of all residential fires occurring in the U.S. in a 12 month period. Telephone

interviews were used to collect data from 32,000 households, from December 1983 to November 1984. Detailed information was gathered on all attended (reported) and unattended (non-reported) residential fires occurring within a three-month retrospective reporting period. Fires that occurred within and immediately around a residential structure were included as well as fires in personnel motor vehicles. From these households 1819 residential fires were reported, with 85 being attended fires and 1734 unattended fires.

The overall estimation of fires occurring in the U.S. during the survey period was derived from the total number of residential fires reported in each monthly cohort being projected to the U.S. population of households. The estimate revealed that there were approximately 25,197,000 residential fires in the continental US during the 12 month period, an equivalent to 3 out of every 10 households. Approximately 4% (925,000) of these fires were attended and the majority, 96% (24,250,000), were unattended. In comparing these estimates to those made in the 1974 survey (in which there was an estimated 13 million residential fires) the number of fires in the U.S. had since doubled. The Commission attributed this increase to a number of factors including; an increased number of households in the U.S, increased early detection of fires due to smoke detectors allowing household residence to extinguish the fire themselves, and increased rigor of the survey methodology compared to that of 1974 survey.

In contrast to the finding that the overall fire incidence appears to be on the increase in the U.S., results from a British survey found a decrease in domestic fire rates over an 8 year period. The British Crime Survey (BCS) was developed to provide a fuller measure of the number of domestic fires in England and Wales in 2001/2 by gathering data on unattended fires as well as attended fires¹⁰. Previously the survey had been conducted in 1999 (2000 BCS sweep), 1995 (1996 sweep), and 1993 (1994 sweep). Additional to acquiring incident statistics, the BCS was designed to collect an extensive range of social demographic information in order to identify those groups within society more likely to experience an unattended fire. In the 2001/2 sweep over 30,000 respondents were asked if they had experienced a domestic fire in the previous 12 months, and if so how many fires had occurred during that period. If the person had experienced more than one fire they were asked to report on the most recent. The unattended fires measured by the BCS were those that resulted in little or no damage and hence were not officially recorded by fire services.

Prevalence rates were determined by calculating the percentage of households who reported having had a domestic fire experience in the specified 12 month period. Results revealed that 1.5% of survey respondents had a domestic fire in 2001/2. This figure represented a large fall in prevalence rates compared with previous years, in which the rate was 3.1% in 1999, 3.4% in 1995, and 3.9% in 1993. However, it was noted that prevalence rates in previous survey sweeps had been based on an average recall period of approximately 14 months, therefore some of this reduction may have be due to the shorter recall period in the 2001/2 survey. In order to make an estimate of the total number of domestic fires in the U.K. within the 12 month period the incident rate was multiplied by the estimated 21,968,600 domestic properties in England and Wales in 2001. This calculation resulted in 383,300 domestic fires. Because this estimate was derived from a sample of the population the BCS calculated the range within which the true value is likely to fall. Using a 95% confidence interval, the BCS found the true value to lie between 346,000 and 421,000 domestic fires.

Results also indicated that in 2001/2 only 12% of respondents reported experiencing more than one fire, which compared to 11% in 1999. In addition, findings showed that in 2001/2 22% of households stated that the fire service was called to the last reported fire. This indicated a rise in attended fires compared to the previous sweep (1999 findings) in which 14% of households had an attended fire. The conclusion drawn from the 2001/2 BCS was that although there appeared to be an increase in attended fires, overall the long-term downward trend in domestic fires appeared to be continuing, possibly even accelerating.

In addition to the use of surveys as a method to collect the missing unattended fire data, attempts have been made to gather such data from alternative information sources (e.g. hospital and fire records).

The Home Accident Surveillance System (HASS) is a database in the U.K. that contains records of non-fatal accidents that take place in the home or at leisure, which cause a serious enough injury to necessitate a visit to hospital¹¹. Marriot (1993) aimed to evaluate the suitability of HASS as potential source of information that could possibly be used in a large scale study to examine unattended fires through casualties that had occurred. Findings indicated that fire services were called to 41% of fires in the survey, substantially higher than the British Crime Survey would have predicted at that time (8% to 12%). In addition, the author found that many HASS records were not complete enough to conduct a meaningful investigation of the fire events listed and in chasing up cases for further detail only 10% of persons from the database were willing to be interviewed. It was therefore concluded that using HASS data alone was not an effective method of recruiting participants for this type of investigation. It is possible that attended fires were over represented due to the database containing cases in which the person was injured seriously enough to seek medical attention, indicating the fires were likely to be more serious. The problem still remained that records did not include smaller fire incidents in which no injuries occurred.

Because of the large proportion of unattended fires being reported in previous research studies it is clear that in order to gain a clearer understanding of the fire problem within Australia it is necessary to investigate not only attended fires, but those unattended also. Although injury record data is another alternative information source to fire service records, it may not be sufficient to assess the full extent of the problem, as most fires in which serious injuries occur are being attended by the fire services. The use of surveys can be an effective method of collecting missing fire data. In addition, there is a need for overall detailed database which includes information on attended and non attended fires in which injuries may or may not have been sustained. In Australia, the incidence of unattended fires is currently unknown. Determination of incident rates for unattended fires is important as it will help gain an understanding of the overall extent of the fire problem in Australia. This paper details the development of a survey and database to collect information on attended and unattended residential and recreational fire experiences in Australia.

Additionally, this paper has two aspects; (i) it describes a newly developed methodology that can be used to calculate the mean annual probability of having an unattended or attended residential fire experience throughout an individual's lifetime, and (ii) it reports a probability finding based on 484 adults from the western region of Melbourne, Australia.

DEVELOPMENT OF THE QUESTIONNAIRE

The Fire Safety Awareness and Experience Interview Schedule was developed to collect information on all residential, recreational, and workplace fire experiences, including attended and non-attended fires, since the age 18. The schedule was retrospective in nature and collected information including demographic factors, occupant characteristics, situational variables, and the number of fires experienced by each participant.

Selection of Interview Schedule Items

Questions to be included in the Interview Schedule were selected using previous literature as a guide to determine the type of information that should be collected. An inventory of variables to be included was constructed, and from this list a draft questionnaire was initially developed. Questionnaire items were included if they were deemed to be important in eliciting information that might lead to uncovering possible risk factors. The questions selected to collect data on non-attended fires were based on existing measures within the literature for fires in which death or injuries have occurred and included: age, sex, socioeconomic status (education and occupation), type of residence, fire origin, and composition of household (family structure/ people present).

Use of Focus Groups in Survey Development

Focus groups were selected as a method of identifying and pre-testing interview schedule items. Three focus groups comprising of 5-8 individuals per group was used to aid in the construction of the survey. Focus group 1 was carried out with a group of professional fire-fighters. The fire-fighters were included in the early stages of the questionnaires development due to their direct involvement in the extinguishment of home fires on a regular basis. Firefighters have the experience and knowledge in regards to the area under investigation, thus aiding the questionnaire's validity.

In addition to giving feedback on the existing survey items, members of the Metropolitan Fire Brigade provided 7 questions to be included in the questionnaire. The questions asked participants whether they had a fire alarm in their home, how many they have, how often they change the battery, whether they clean the alarm and how often, whether they test the alarm and the method used, and whether their alarms were Standalone (battery operated) or Hardwired (electrically connected to a power supply). The questions were general in nature so that people who had not experienced a fire would still complete a questionnaire. This was important as to avoid bias sampling (including participants with fire experiences only).

Focus group 2 consisted of participants from a fire safety engineering center. Participants had a great deal of knowledge in regards to the topic and also contributed feedback regarding the structure of the survey. Focus group 3 consisted of a group of university students who partook in a pilot test of the questionnaire and were required to give feedback regarding the questionnaire's structure, wording, clarity and ease of completion.

The Finalized Survey

The Fire Safety Awareness and Experience Questionnaire consists of four separate interview schedules. The first schedule was the Demographic Interview Schedule and was the standard survey which all participants completed whether they had experienced a fire or not. This survey collected information on whether the person had experienced a fire and their demographics. Information on the presence of smoke alarms in current residential dwellings (which are compulsory in Victoria, Australia) and respondent's knowledge on correct maintenance procedures and behaviour in carrying out these procedures in the home was collected as part of this schedule.

The remaining three interview schedules were tailored to collect information on residential fires, recreational fires, and workplace fires. These three schedules were similar in structure and items were alike, but differed slightly to adapt to the different fire types that participants had experienced. The Residential Fire Interview Schedule was a ten page survey, which participants completed only if they had experienced a domestic fire. Each survey collected information on one fire experience only, so if a participant had experienced multiple residential fires they would be required to complete an additional survey for each fire.

A 'fire experience' was defined as a situation in which the participant was personally involved in the ignition and/ or extinction of the fire, or was an immediate observer of the event. Fire experiences were recorded if there was a naked flame or the presence of smoke, singeing, or smoldering. In addition, there had to have been some degree of property damage. Fires that occurred inside the home and fires which occurred in the space surrounding the home were included. To determine the mean annual probability of having a residential fire experience a formula was applied using two variables; current age and total number of fires experienced.

Survey Amendments during the Data Collection Phase

The survey underwent minor changes through the data collection phase, as survey improvements were identified during its use. Changes involved making the survey easier for the researcher to use so as to decrease time taken to complete each interview. For example, due to the commonality of answers

given to some question items during the testing phase, a number of questions were given tick box responses so as to save researchers time in writing a full response.

APPLICATION OF THE QUESTIONNAIRE

Data collection

The second phase of the project was the consent, recruitment, and data collection phase. Prior to recruitment and data collection, two factors were considered: the sample size required, and the method of recruitment to reach the sample size goal and to be a representative sample.

Sample Size & Statistical Power

For this study a calculation of statistical power was inappropriate because the research does not aim to detect an effect, so no estimation of effect size can be made. Instead the sample size was based on considerations that the number of unattended fires reported in the sample would be sufficient to allow some key trends to emerge. It was determined that a total sample of some 60 -80 fires would be sufficient to see some key trends emerge. When more resources permitted such trends could be further tested on a larger sample using the developed questionnaire. A sample size of 500 participants was determined as shown in the box below:

The population of Australia (20 million) experiences 10,000 attended residential fires per year:
20,000,000 people = 10,000 attended fires per year
500 people = 0.25 attended fires per year
Retrospectively across 30 adult years for 500 people:
500 X 30 = 0.25 X 30 attended fires across 30 years
= 7.5 attended fires across 30 years for 500 people
UK home office estimates for every 1 attended home fire, 9 unattended home fires occur:
= 7.5 X 9
= 67.5 unattended fires across 30 years for 500 people

Recruitment Method

Face-to-face interviews were selected as the data collection method to allow for probing and follow up questions to be asked during the survey's completion. This was particularly important because the collection of data was relying on retrospective memory, hence prompts may be needed to aid in the recall. In order to conduct face-to-face interviews direct access to the population was required. It was determined that the most effective way to gain access to a large variety of people was to collect data in shopping complexes. The advantages of using shopping centers for data collection is that there is generally a high traffic flow of people and flexible opening hours would give access to a wide variety of age groups within Melbourne.

In order to conduct data collection on the premises of any shopping complex approval from management was required. Consent to set up a research stall was requested from the marketing managers of 12 shopping complexes in Melbourne. Out of the 12 shopping complexes approached, 4 gave permission to carry out the research project on their premises. Three shopping complexes were located in the North-West region of Melbourne, one in North-East Melbourne.

A small stall was set up by the researchers in each shopping complex during the data collection periods. Individuals or groups of shoppers who were walking past the research stand or who were located within the vicinity of the research area were randomly approached by the researcher. Approached shoppers were asked if they were interested in completing The Fire Safety Awareness and Experience Questionnaire. If a participant agreed to participate they were invited to take a seat at the stall.

The Demographic Interview Schedule was usually completed first, following a Fire Interview Schedule if necessary. Following completion of the Demographic Interview Schedule the participant was asked if they had experienced a fire since the age of 18 and the number of experiences. If the participant had experienced a fire of interest the relevant survey was produced and completed (either residential or recreational).

If a participant initially stated that they had not experienced a fire since the age of 18, some examples were presented to the person (e.g. cooking fires) in order to elicit any memories that might not have been recalled immediately.

On completion of the questionnaire participants received either a pen with a fire safety message on it or a fire safety flashing bike clip. These rewards assisted in public safety aims of the MFB.

Data Analysis & Results

Table 1 shows the number of occupants who reported having had a fire experience since the age of 18, and the total number of fires experienced. The majority of fire experiences were domestic (94%), and were unattended (75.2%). Also shown is the current age of the occupant at the time the fire experience survey was completed presented in decades.

TABLE 1. Fires within the sample

Variable	n	%
Fire Experience		
No	397	79.7
Yes	101	20.3
No. Fires Experienced by Each Participant		
1 fire	92	91.0
2 fires	6	5.9
3 fires	3	2.9
Fire Type		
Residential	95	94.0
Permanent	94	
Holiday house	1	
Recreational (Parkland)	6	5.9
Camping	5	
Child Play	1	
Fire Recorded		
Attended	25	24.7
Unattended	76	75.2
Current Age of Person Reporting Fire in Survey		
1 fire		
18-40	33	---
41-60	41	---
61+	15	---
2 fires		
18-40	0	---
41-60	3	---
61+	1	---
3 fires		
18-40	0	---
41-60	2	---
61+	1	---

To determine the mean annual probability of having a fire experience a formula was applied using two variables; current age and total number of fires experienced. Probability was determined by the Number of Years Lived (current age) minus 18 years (fires since the age of 18 were investigated only), which calculates the Adult Years Lived (N). Subsequently the Total Number of Fire Experiences (F) was divided by the Adult Years Lived (N) giving us the Annual Probability of a Fire (P) for each individual case. Using this methodology it was then possible to determine the mean annual probability of experiencing a residential fire across all participants and all fires, as well as for all un-attended fires and attended fires.

Out of a sample of 500 the mean annual probability was calculated for 473 participants. Two cases were excluded due to overlapping with another household (only 1 person per household was to be interviewed). For the remaining 25 persons the annual probability could not be determined as they refused to give interviewers their current age. Four of these cases had experienced one residential fire; one case had experienced two fires.

This probability rate calculated above is inclusive of recreational fires, in which there were 5 camping fires and one experience in which a child started a fire in the bush land behind the occupant's home. Also included in this calculation was one fire experience that occurred in a holiday house. The mean annual fire experience probability rate can also be calculated.

The mean annual probability of having a fire experience whilst an adult was .0125. This means that within this sample adults had on average one fire experience every 83.3 adult years. The mean fire probability for all attended fire types was also calculated, indicating that adults have .195 chance of experiencing an attended fire per 50 Adult Years. The mean fire probability for all unattended fires was calculated indicating that adults have .425 chance of experiencing an attended fire per 50 Adult Years. Other probability rates are shown in Table 2.

TABLE 2. Mean fire experience probability: Residential & recreational fires, N = 473

Variable	Mean	Probability
All fires	.0125	1.2 fires per 100 adult years 0.6 fires per 50 adult years
Attended fires	.0039	0.39 fires per 100 adult years 0.195 fires per 50 adult years
Unattended fires	.0085	0.85 fires per 100 adult years 0.425 fires per 50 adult years

DISCUSSION & CONCLUSION

The use of a survey was an effective means of gathering detailed information on attended and unattended residential fires. The survey methodology allowed for the statistical analysis of all fire types, rather than being constricted to using medical records of those injured, or fire brigade records alone. The developed survey is not limited to collecting data on domestic fires only, and can be utilized to investigate recreational fires, (e.g. camping) or workplace fires.

Incident rates help form the beginning of understanding into whether a problem exists that society is unaware of, and the magnitude of the problem. Similar to findings of the U.S. and U.K. the majority of fire experiences (75%) were unattended. In fact results were extremely similar to those findings in the U.K. in which 22% of fires recorded by the BCS survey were attended, 78% unattended; the present study 24.7% and 75.2%. This finding highlights the fact that a substantial number of unattended fires

are occurring in Australian homes and hence, there is need for further investigation of their details to help develop preventative programs.

Like findings from the British Crime Survey, results from this study showed that the majority of participants who had experienced a fire experienced 1 fire only (see Table 1). However it should be noted that younger participants had less adult years to report on; hence may have reported less fire events merely because they have had less time to experience more than one fire compared to older participants. As seen in the results section, those experiencing multiple fires were all over the age of 40.

In comparison to previous studies which have collected fire data for specific time periods (for example, 3 months and 12 months) this study collected fire experiences spanning over a participant's adult years. Collecting such data allowed for a new calculation method to be applied in order to determine the mean annual probability of having a fire experience (either attended or unattended) within the study sample.

The data collected in the present study can be used as a basis to build up a larger database which would have a number of beneficial future uses. Not only can the database be used to determine a mean probability of having a fire experience, but could also be used to collect data for specific time frames. This would allow for further estimates to be made regarding incident rates for unattended fires in Australia for such periods. With regular data collection the fire rate can be monitored to determine whether preventative measures are having an effect.

In addition to the gathering of incident data, the Fire Safety Awareness and Experience Questionnaire collected information including demographic factors, occupant characteristics, and situational variables relating to the fire event. Hence, the database can also be used to investigate the possible risk factors of unattended fires (looking at factors such as age, gender, and socioeconomic status). From the collection of such information it is also possible to determine whether risk factors for unattended fires are similar or different to the risk factors of attended fires in which there are deaths and injuries. This is beyond the scope of the present paper, however, it will be the basis of future investigations.

There were a number of limitations in the use of The Fire Safety Awareness and Experience Questionnaire. The survey was quite long to complete for those participants who had a fire experience, particularly if they had more than one fire. In some cases participants were happy to answer the demographic questions, and to state they had had a fire experience, but were not willing to spend more time discussing the experience. In other cases some details were not given or missed during the interview if a participant was in a rush. In addition, because participants were asked to report any fire experiences since the age of 18, older participants were required to think back over an extensive period of time. Memory decay problems might have led to the under reporting of some fires, particularly minor events.

The validity of the conclusions of this study would be improved with a larger sample size. However, it is important to note that this project is a starting point to collecting data that currently does not exist in Australia, and the developed questionnaire could be used internationally to enable cross-cultural comparisons to be made.

In conclusion, the findings from this study indicate a large proportion of fires occurring within Australian homes are unattended. Without the use of surveys this valuable information would otherwise remain unknown. More research on unattended fires is needed to gain a better understanding of the overall nature of fire risk.

REFERENCES

1. Busselton Fire & Rescue, "Fire safety in the home", Retrieved October 27, 2004, from <http://www.busseltonfrs.com>, 2003.
2. Committee on Injury and Poison Prevention, "Reducing the number of deaths and injuries from residential fires", *Pediatrics*, 105:6, 1355-1357, 2000.
3. Department of Emergency Services, "Fire fatalities: Who's at risk?", Retrieved October 27, 2004, from <http://www.emergency.qld.gov.au>, 1998.
4. Australian Bureau of Statistics, "Australian social trends 2000. Housing- Housing stock: Home fire safety", Retrieved September 26, 2004, from <http://www.abs.gov.au>, 2000.
5. Taylor, R. and Pepperdine, S., "The MFB's human behaviour research project", *Proceedings of the 3rd International Symposium on Human Behaviour in Fire*, 67-77, 2004.
6. Miller, I., "Human behaviour contributing to unintentional residential fire deaths 1997-2003", New Zealand Fire Service Commission, Research Report 47, 2005.
7. Lilley, J.M., Arie, T. and Chilvers, C.E., "Accidents involving older people: A review of the literature", *Age and Aging*, 24, 346-365, 1995.
8. Marriott, "Causes and consequences of domestic fires", Retrieved October 27, 2004, from <http://www.odpm.gov.uk>, 1993.
9. U.S. Consumer Product Safety Commission, "1984 National sample survey of unreported, residential fires", Final Technical Report, Contract No C-83-1239, Audits and Surveys Inc., Princeton, 1985.
10. British Crime Survey, "Fires in the home: findings from the 2001/02 British Crime Survey", Retrieved October 27, 2004, from <http://www.odpm.gov.uk>, 2001.
11. The National Archives, "Home and leisure accident surveillance systems", Retrieved January 07, 2007, from <http://www.ndad.nationalarchives.gov.uk>, 2005.