Residential Fires in Surrey, B.C. 1988 – 2007

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This report was inspired by the belief of Chief Len Garis of the Surrey Fire Department regarding the need for development of evidence-based intervention and prevention fire safety campaigns to better protect his community from the risk for, and consequences of, residential fires.

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Executive Summary

Over 50,000 fires occurred in Canada in 2002, accounting for $1,489,012,263 in property losses; nearly half of these fires (41 per cent) occurred in residential structures (Council of Canadian Fire Marshals, 2002). Furthermore, approximately three-quarters of Canadians who died in a fire in 2007 died in a residential fire. Given these statistics, it is important for residents to develop knowledge and adopt fire safety prevention behaviours.

Previous research has identified that the primary sources of residential fires commonly include cooking, smoking cigarettes, heating equipment, or electrical malfunction (e.g. Ahrens, 2007; Diekman, Ballesteros, Berger, Caraballo, & Kegler, 2008; Duncanson, 2001; Hall, 2008; Leistikow, Martin, & Milano, 2000; Miller, 2005). The majority of these fires can be attributed to accidental causes that result from human error or negligence.

In many cases, the risk of injury or death resulting from a residential fire can be lowered through adoption of fire safety prevention behaviours, such as installation and maintenance of a smoke alarm. However, research suggests that many residents do not maintain the functioning of their smoke alarm, which puts them at increased risk of injury or death. Furthermore, several sub-groups within the population, including young children and older adults, are at greater risk of injury or death from residential fire due to the fact they are less likely to be alerted by a smoke alarm, and less likely to be able to successfully respond to it (Bruck, 2001; Marshall, Runyan, Bangdiwala, Linzer, Sacks, & Butts, 1998; Miller, 2005; Newton, 1998). Other risk factors increasing the likelihood of death include impairment, being asleep, or having a disability (Duncanson, 2001; Lin, 2004; Marshall et al., 2008; Miller, 2005; Newton, 2003).

The current study conducted an analysis of 4,758 structure fires that occurred between 1988 and 2007 in the City of Surrey, British Columbia. Over these two decades, the rate of fires steadily increased, up to approximately 80 to 88 fires per year per 100,000 people. Overwhelmingly, the most common property class involved in a structure fire was residential (75.5 per cent). The remainder of this report focused only on these 3,594 fires.

The majority of residential fires occurred in a year round use single-family dwelling (87.5 per cent). Most of these single-family homes were privately owned and lived in (71.2 per cent), whereas slightly more than one-quarter (27.4 per cent) were rented.

The relative rate of fires was compared over the six communities within the City of Surrey. Communities with the highest frequency of fires included Newton (30.6 per cent) and Whalley (26.2 per cent). The smallest proportion of fires was found in Cloverdale (7.8 per cent), followed by Fleetwood (11.1 per cent), South Surrey (11.8 per cent), and Guildford (12.5 per cent).

The most common source of ignition identified was overwhelmingly cooking; this accounted for more than one-third of all residential fires (39.9 per cent), whereas

match/open flame accounted for approximately one-fifth (17 per cent). In addition, over the past five years, smokers' material has been resurging as a source of residential fire, increasing to 13.4% in 2007 from 9.8% in 2003.

Source of ignition was compared to community of residence. The results indicated that cooking equipment was significantly more likely to be a source of fire in Newton (50.5 per cent) or Fleetwood (49.6 per cent), compared to communities like South Surrey (24.6 per cent) or Cloverdale (30.9 per cent). In contrast, South Surrey and Cloverdale were significantly more likely to experience residential fires from matches or open flame (25.4 per cent and 21.5 per cent respectively). These two communities were also significantly more likely to experience fire from electrical sources (25.4 per cent and 21.5 per cent respectively). Heating fires were also significantly more likely to occur in South Surrey (15.1 per cent) or Guildford (10.2 per cent). Fires resulting from exposure (e.g. spreading apartment fires) were significantly more likely to occur in Guildford (7.7 per cent).

The literature indicates that smoke alarms are a primary prevention of fire related casualties. Although the data revealed an increasing trend in the proportion of residences installing smoke alarms, more than one-third (36.0 per cent) of residences involved in a fire did not have a smoke alarm installed. In addition, of those 1,554 residences that did have a smoke alarm installed, in approximately half (49.5 per cent) of those cases the alarm was not activated. In fact, the data showed a declining trend in functioning smoke alarm presence, to the point where less than one-third of residences had a functioning smoke alarm in place.

Certain communities were more likely to have smoke alarms present and functioning. Guildford residents (78.1 per cent) were significantly more likely than the other communities to have a smoke alarm present; in contrast, Whalley was the least likely (56.5 per cent). Fleetwood was the least likely community to have functioning smoke alarms installed. Smoke alarm status was significantly affected by ownership status, as renters were less likely to have a smoke alarm (functioning or not) installed than those who owned their house.

These statistics are important, because the data indicated that a functioning smoke alarm effectively reduced the associated cost of fire. With a functioning smoke alarm in place, residents or neighbours would be alerted more quickly to the presence of fire, preventing the fire from spreading and causing excessive damage. Further, the research indicates a functioning smoke alarm should reduce the risk of injury or death occurring in a residential fire. However, functioning smoke alarms were significantly predictive of injury from a fire; this association is possibly due to inability on the part of the victim to respond, however it needs to be explored in more depth in further research.

In addition, the results of this current analysis indicated that death was not affected by the presence of functioning smoke alarms; this is likely a function of the small data size (n = 24) regarding residential fire related deaths. However, death was significantly more likely to occur if the fire began from smokers' related materials.

The data analyzed in this report revealed some important trends in fire safety that will help the fire department in carrying out information and distribution campaigns relative to fire safety. Given that the rate of fires in Surrey continues to increase, it appears as though there is a need to promote the knowledge of Surrey residents regarding safe fire practices.

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Introduction

Fires are a threat to public safety in terms of potential death, injury, and financial costs. In Canada, in 2002, 53,589 fires occurred, accounting for $1,489,012,263 in property losses; most commonly (41 per cent), these fires involved residential properties (Council of Canadian Fire Marshals, 2002). The frequency of residential fires is concerning as residential fires are the most common source of fire-related death (Miller, 2005) Specifically, in 2002 82% of Canadians (n = 304) who died in a fire died in a residential fire. (Council of Canadian Fire Marshals, 2002). Similarly, 80% of Americans who died in a fire in 2006 died in a residence (Karter, 2007). In the early 1990s, residential fires caused the deaths of between 4,000 to 5,000 Americans and injured an additional 20,000 each year (Baker and Adams, 1993). Given this, it is imperative that citizens adopt behaviours that minimize the risk of both fire and fire-related fatalities.

Of primary importance to preventing death from residential fires is the use of a smoke alarm that notifies residents of the presence of smoke and fire, potentially providing them with sufficient time to exit the residence (DiGuiseppi, Slater, Roberts, Adams, Sculpher, Wade, & McCarthy 1999). However, research has indicated that many households do not have functioning smoke alarms (Douglas, Mallonee, & Istre, 1999). Despite the fact that the largest proportion of fire related fatalities occur in residential locations, residential buildings are often not officially regulated in terms of fire safety (Jennings, 1996). As such, the presence of fire prevention methods, such as smoke alarms, is not required for residential locations, with the exception of mass-residential locations, such as apartments and hotels.

As will be discussed in the review of the literature, the likelihood of death occurring is also mediated by other factors, including the source of the fire, victim characteristics, and when the fire occurs. Likewise, these and other risk factors also effect the likelihood of injury occurring and the amount of property lost. This report will review the risk factors associated with residential fires, including cause of the fire, outcome of the fire, and methods of preventing residential fire or reducing the risk of negative outcomes. In addition, the current report provides an analysis of fire data collected from Surrey, British Columbia between 1988 and 2007. The intention of this exploratory report is to provide the Surrey Fire Department with the risk factors associated with fire incidence and outcomes across the City of Surrey.

Residential Fire Description

The following section will review the nature of residential fires. Specifically, the causes, location, and timing of residential fires will be discussed.

Causes of Residential Fires

In the early 1990s, heating-related residential fires were responsible for nearly one-third (31 per cent) of all American residential fires (Baker and Adams, 1993). However, more recent statistics identified that approximately one-fifth (19 per cent) of residential fires resulted from heating-related sources (Ahrens, 2007). Heating-related sources include stoves (wood, gas, or electric), kerosene heaters, space heaters, fireplaces, hot water heaters, and chimneys (Baker and Adams, 1993; Ahrens, 2007). Fires resulting from heating equipment involved either malfunction or flammable materials, such as clothing or falling on the equipment while residents were sleeping (Department of Emergency Services, 1998). In the early 1990s, these sources were the most common sources, second only to cigarettes, for accidental residential fires resulting in multiple fatalities (Baker and Adams, 1993). More recent statistics identified heating equipment, along with smoking, as the primary sources of fire-related deaths, accounting for nearly one-quarter (24 per cent) each (Ahrens, 2007; Diekman, Ballesteros, Berger, Caraballo, & Kegler, 2008). In contrast, in recent years, cooking-related fires have resulted in the greatest proportion of fire-related injuries (Ahrens, 2007).

Smoking

Diekman and colleagues (2008) recently estimated that a 1% reduction in the prevalence of current smokers would result in a 7% decrease in fire-related fatalities from smoking. However, despite the fact that fewer people smoke today than in the past, smoking continues to be identified as the fourth leading cause of unintentional residential fires (Diekman et al., 2008) and was the leading cause of fire fatalities in the United States and United Kingdom (Leistikow, Martin, & Milano, 2000), as well as in Denmark (Leth, Gregersen, & Sabroe, 1998). Smoking-related fires are commonly caused by human error; for example, many fires are started when a smoker falls asleep with a lit cigarette which ignites a flammable material, such as a mattress or pillow (Miller, 2005; Holleyhead, 1999). Given this, it was not uncommon to find that fires ignited from smoking materials tended to occur in the bedroom or living room (Diekman et al., 2008).

Research has indicated that the presence of a physical disability or substance impairment were important risk factors for residential fire related fatalities due to smoking, particularly given that the fire often originated near the victim (Duncanson, 2001; Leth, Gregersen, & Sabroe, 1998). In effect, disabled persons were frequently exposed to fire as a result of dropping the cigarette on their clothing and being unable to remove the clothing or otherwise escape a growing fire.

Given the potential fire hazard that smoking materials pose, fire-safe cigarettes have been developed that self-extinguish when not being used (Diekman et al., 2008). These cigarettes are wrapped in paper that contains “speed bumps”, or bands of paper which are less porous. If the smoker does not draw on the cigarette when the paper has burned to the speed bump, the cigarette will be put out due to lack of oxygen (Nicholson, 2004). These cigarettes have the potential to reduce risk of fire and fire-related fatalities, as previous research reported that if cigarettes are put out within 10 minutes, the risk of fire was significantly reduced (Little, 1974). Use of self-extinguishing cigarettes has since been legislated across Canada and in approximately half (52 per cent) of all American states (Diekman et al., 2008). However, to date, their effectiveness does not appear to have been independently evaluated.

Cooking

In the early 1990s, cooking was identified as the source of nearly one-fifth (15 per cent) of fires (Baker and Adams, 1993; Duncanson, 2001). However, more recent statistics identified cooking as the leading source of residential fires, responsible for over one-third (38 per cent) of residential fires, compared to one-fifth (19 per cent) of fires caused by heating equipment (Ahrens, 2007). However, cooking-related fires were less likely to result in death (15 per cent) than were heating equipment-related fires (24 per cent), presumably given that the residents would be awake during the cooking process, but not necessarily when using heating equipment (Ahrens, 2007). Despite this, Duncanson (2001) and Miller (2005) concluded that cooking-related fire fatalities in New Zealand were frequently associated with a person who had consumed alcohol and come home to cook food, but who then fell asleep with the food on the stove.

Cooking-related fires have also been responsible for many fire-related injuries. A common situation identified by Hall (2008) involved a fire starting on the stove when food was left unattended, and the victim trying to fight the fire and becoming injured in the process. Unattended cooking equipment was responsible for nearly half (46 per cent) of injuries suffered (Hall, 2008).

Cooking resulted in fire either through unattended food on the stove or through flammable clothing that caught on fire when placed in close proximity to the stove. Ahrens (2007) identified that food or other cooking materials were the most common item to be initially ignited, accounting for slightly more than one-third (34 per cent) of residential fires. Duncanson (2001) similarly noted that oil or fat appeared to be present in nearly half (40 per cent) of the twenty cooking related fire fatalities examined. This finding was supported by Hall (2008), who reported that frying, which is often done with hot oil, was the method of cooking that posed the greatest risk of fire.

Electrical

Compared to heating equipment and cooking, electrical sources have accounted for a relatively low proportion (6 per cent) of residential fires (Ahrens, 2007). Electrical sources include fires that originate from lighting equipment, overused power supply or outlets, meters, power switch gear or current overload protection devices, or malfunctioning cords or plugs (Ahrens, 2007; Patel, 2005). These fires accounted for slightly more than one-tenth (11 per cent) of American residential fire fatalities (Ahrens, 2007). According to Patel's (2005) research, residential electrical-fires more commonly involved a heat-related source; two-thirds of these fires were attributed to heat-related factors, such as improper installation or maintenance of electrical equipment, while one-third were attributed to an electrical arc (commonly the result of worn or otherwise damaged cables).

Duncanson, Woodward, and Reid (2002) speculated that electrical fires were more common in areas of lower socioeconomic status due to the older nature of the homes and their deteriorating electrical supply. Similarly, Patel (2005) identified that homes built in the 1940s and 1950s in New Zealand were at a higher risk for electrical fires, because the electrical supply was not sufficient to meet current demands and safety standards had improved since the electrical wiring was originally installed.

Additional Sources

Relatively few fires were identified as caused by candles (4 per cent), clothes dryer or washer (4 per cent), trash fires (4 per cent), exposure to other fire (3 per cent), or children playing with heat or fire (2 per cent) (Ahrens, 2007). Together, these fire sources accounted for 13% of residential fire fatalities in the United States (Ahrens, 2007).

Human Error

Many residential fires are the result of carelessness (Jennings, 1996). According to Ahrens (2007), nearly three-quarters (73 per cent) of residential fire fatalities were the result of human error. This included playing with fire or a heat source, misuse of products, leaving equipment turned on and/or unattended, and failing to clean equipment. Moreover, Duncanson (2001) found that in over half (60 per cent) of the cooking-related fire fatalities that involved food igniting on or in the stove, alcohol use was identified as a contributing factor.

Alcohol consumption has frequently been identified as a contributing factor for both risk for residential fire and fire-related fatalities (Miller, 2005; Bruck, 2001; Kashaninia, 2000; Holleyhead, 1999; Department of Emergency Services, 1998). Alcohol intoxication increases the risk of fire originating from a dropped cigarette (Holleyhead, 1999), food left cooking on the stove (Duncanson, 2001), or failure to awaken to a smoke alarm (Bruck, 2001) and successfully execute an escape plan from the residence (Department of Emergency Services, 1998; Miller, 2005). In addition, Miller (2005) identified that alcohol intoxication was related to irrational behaviours, such as moving towards the fire and attempting to fight the fire. Alcohol impairment and fire fatality primarily appears to involve males in their early twenties, and males between 40 and 50 years of age (Bruck, 2001).

Suspicious Fires

Baker and Adams estimated that one in ten fires originated from a suspicious incendiary source (10 per cent) (Baker and Adams, 1993). A decade later, this number had dropped to 5% of residential fires (Ahrens, 2007). However, one-tenth of intentionally set residential fires resulted in death (Ahrens, 2007).

Previous research has identified that many arsonists are mentally disordered; a small proportion of these may have suffered from pyromania, which involves the pathological setting of fires (Bohnert, Ropohl, & Pollak, 1999). Other motives for arson have included financial need, disguising other criminal activity, vandalism, or jealousy (Bohnert, Ropohl, & Pollak, 1999).

Risk for Residential Fire Fatality

Residential fires have accounted for the vast majority of fire related fatalities. According to Chien and Wu (2008), three-quarters of fire related fatalities in the United States and 78% of fire related fatalities in London were the result of a residential fire.

Residential fire fatalities primarily result from smoke inhalation or carbon monoxide poisoning (Miller, 2005). It is relatively rare for victims to die solely from burning (Newton, 1998). Often, residents of the household are overwhelmed by smoke-related fumes before they can successfully exit the residence. Furthermore, research indicated that many residential fire victims died by the time the fire service was notified of the fire (Newton, 1998).

Research has consistently reported that young children and older persons are the most likely to be killed in a residential fire (Miller, 2005; Bruck, 2001; Newton, 1998; Marshall, Runyan, Bangdiwala, Linzer, Sacks, & Butts, 1998). As will be discussed in a subsequent section of this report, much of this risk is the result of an inability to hear and respond to an alert from a smoke alarm. For similar reasons, persons with a disability and those incapacitated by alcohol or drugs have also been identified as at a higher risk for a fire related fatality (Miller, 2005; Lin, 2004; Newton, 2003; Duncanson, 2001; Marshall et al., 1998). Marshall and colleagues (1998) identified a ‘highly vulnerable’ group, characterized by risk factors including being very young (under five) or old (over 64), being impaired by alcohol or drugs, or having a physical or cognitive disability. The presence of even one of these risk factors was sufficient to raise the likelihood of death from a residential fire from 31% to 54% (Marshall et al., 1998). Furthermore, highly vulnerable persons were four times more likely to be killed as a result of a fire than less vulnerable individuals. This risk was mitigated somewhat by the presence of a functioning smoke alarm.

Older adults are not only less likely to hear and respond to a smoke alarm, but cognitive and physical disabilities associated with aging increases the challenge of successfully escaping. Furthermore, an additional reason why older persons are at a greater risk for residential fire fatality is that their age renders them less capable of recovering from injuries (such as skin burns or smoke inhalation) than younger persons (Miller and Davey, 2007).

Young children have also been at higher risk for death from a residential fire due to risky activities, such as playing with fire starting materials (Miller, 2005; Istre, McCoy, Carlin, & McClain, 2002; Newton, 1998). Istre and colleagues (2002) identified that fire play by children between zero and four years of age accounted for 60% of 40 fire-related injuries and deaths between 1991 and 1998 in Texas. Miller (2005) attributed such outcomes to the fact that these young children had not yet developed an appreciation for the potential harm that fire can cause and, when a fire started, many hid somewhere in the house and subsequently died.

Scholer, Hickson, Mitchel, and Ray (1998) found that children were at greater risk of dying from a residential fire when their mother was poorly educated and/or was a young mother. Moreover, when the mother had more than two other children, the risk of a young child dying in a fire increased more than six times, compared to mothers without any other children. Children whose mothers met all three of these high risk conditions were identified as being 150 times more likely to die in a residential fire compared to children whose mothers did not meet any of these conditions (Scholer et al., 1998). These statistics suggested that young mothers were a population who would benefit strongly from fire education.

Previous studies have found that males were at a greater risk of dying in a fire than females (Miller, 2005; Duncanson, 2001; Marshall et al., 1998). This outcome was likely the result of males attempting to fight the fire and being overwhelmed by smoke-related fumes (Miller, 2005).

Socioeconomic status has also been associated with risk for fire related fatalities with those living in socioeconomic deprivation more likely to die (Miller, 2005; Duncanson, Woodward, & Reid, 2002). In contrast, Lizhong, Heng, Yong, and Tingyong (2005) found the opposite result in China; residential fires were more likely to occur in areas characterized by high levels of development where there were higher income levels and better educated residents. It is important to note that research identified a variety of factors related to poor socioeconomic status that mediated the relationship with residential fires, including an increased likelihood of living in cheap housing structures, an increased risk of smoking and/or drinking alcohol, a decreased likelihood of having installed and maintained a smoke alarm, and lower rates of education (Duncanson, Woodward, & Reid, 2002).

Location of Fires within the Residence

According to American data collected in the early 1990s on residential fire-related fatalities, residential fires most commonly originated in the living room (83 per cent)

(Baker and Adams, 1993). Another one-fifth originated in the bedroom (20.8 per cent), followed by slightly more than one-tenth in the kitchen (11.7 per cent), and less than one-tenth in exit-ways (7.6 per cent), structural areas (5.1 per cent), or heating equipment areas (1.5 per cent) (Baker and Adams, 1993). However, more recent statistics indicated that nearly half of all residential fires originated from the kitchen (40 per cent) (Ahrens, 2007). With respect to residential fire fatalities, fire most commonly originated in the bedroom (24 per cent) or living room (24 per cent) (Ahrens, 2007).

Interestingly, Ahrens (2007) identified that less than one-quarter (23 per cent) of residential fires extended beyond the original room of origin. However, when the fire did spread beyond the original room, it accounted for over three-quarters (77 per cent) of deaths. This was likely the result of the residents failing to observe the initial flame, thereby resulting in the fire getting out of control before an alarm was activated or escape plans could be enforced.

Time of Residential Fires

American research identified that two-thirds (65.8 per cent) of residential fires occurred between 8 am and 8 pm (Bruck, 2001). According to Ahrens (2007), many of these fires occurred during the dinner hours; specifically, between 5 pm and 8 pm. This result is not surprising, given that, as stated above, nearly half of all residential fires originated in the kitchen, presumably during cooking.

However, research has indicated that the vast majority (81 per cent) of residential fires resulting in death occurred overnight, specifically between the hours of 8 pm and 8 am (Bruck, 2001). This statistic was primarily attributed to the fact that residents were asleep and not aware of the fire (Baker and Adams, 1993). Presumably, this statistic has decreased, given the increased prevalence of smoke alarms. However, as will be discussed in a later section, certain members of the population, including children and youth, are less likely to be awakened by a fire alarm (Bruck, 1999).

American research suggested that fires and fire related fatalities most commonly occurred during January and December (Ahrens, 2007). This finding was not surprising given that these months are among the coldest; therefore, there is an increased tendency for residents to employ heating equipment that may malfunction or ignite surrounding materials (Department of Emergency Services, 1998; Newton, 2003).

Type of Structure

Recent statistics indicated that the majority of residential fires occurred in single or dual family dwellings (72 per cent) as compared to apartments or townhouses (28 per cent) (Ahrens, 2007). To put this conclusion in perspective, similar proportions of the population within the City of Surrey in 2001 resided in these locations. In other words, this result was consistent with the proportion of individuals who were projected to reside in single or dual family dwellings in the City of Surrey in 2001 (70.1 per cent) as compared to apartments or townhouses (29.9 per cent) (City of Surrey, 1996). Similarly, single or dual family dwellings accounted for the vast majority of residential fire related deaths (85 per cent) and injuries (72 per cent) (Ahrens, 2007). Australian research indicated that a large proportion of residential fires resulting in death occurred in rental properties (Department of Emergency Services, 1998).

The cheap nature of residential structures found in neighbourhoods with low levels of socioeconomic status were often associated with a disproportionate risk for fire (Duncanson, Woodward, & Reid, 2002; Miller, 2005). This relationship was likely mediated by the lower levels of income and education found in areas of low socioeconomic status, in addition to the higher rates of smoking generally found in these areas (Duncanson, Woodward, & Reid, 2002).

Ahrens (2007) identified that the causes of single or dual family dwelling fires tended to differ from the causes of apartment fires. Specifically, the use of heating or electrical equipment was responsible for many more fires in single or dual family dwellings (29 per cent) than in apartments (12 per cent) given that in apartments these processes tended to be centrally operated and maintained. However, cooking related fires continued to be very prevalent in both locations, accounting for nearly one-third (30 per cent) of fires in residential dwellings, and two times as many (60 per cent) apartment fires (Ahrens, 2007).

Preventing Death from Residential Fires

There are several ways that residential fire fatalities can be prevented, including use of smoke alarms and improving public awareness regarding fire prevention and fire safety.

Smoke alarms

Smoke alarms work by sensing smoke and sounding an alarm to notify residents (Baker and Adams, 1993). To detect smoke, smoke alarms use either an ionization process, whereby the flow of an electrical current contained within the smoke alarm is reduced in the presence of smoke, or a photoelectric process, which relies on the use of reflected light in the presence of smoke to set the alarm off (Baker and Adams, 1993). Baker and Adams (1993) recommended the use of both forms of smoke alarms given that the ion detector is superior in recognizing a fire with flames, but a photoelectric detector is more efficient at detecting a smouldering fire (Baker and Adams, 1993) and responds more quickly to a fire than an ionization detector (Warda and Ballesteros, 2007). Smoke alarms that combine these processes are also available (Warda and Ballesteros, 2007).

Smoke alarms are generally either operated by battery or are hard-wired into the electrical system of the home. While hard-wired detectors are becoming increasingly popular, in the early 1990s, the majority (72 per cent) of residential smoke alarms were battery powered (Warda and Ballesteros, 2007). Smoke alarms should be replaced at least every 10 years, while battery-operated alarms should have new batteries installed annually (Warda and Ballesteros, 2007). Moreover, smoke alarms should be tested on a monthly basis (Baker and Adams, 1993).

It is important that residents install and maintain smoke alarms, as they will allow a faster response to fire, thereby reducing the risk of fire-related fatalities and injuries (Ontario Fire Service Messenger, 2004). Experts have recommended that smoke alarms should be located outside of each bedroom in the residence, as well as on each floor (Baker and Adams, 1993; Warda and Ballesteros, 2007). In effect, the fire alarm should be able to inform residents at any time of the possible presence of fire.

Limitations of Smoke Alarms

Although smoke alarms can reduce the likelihood of fire-related injuries or deaths, there are some limitations to relying on them. Research has indicated that certain sub-groups of the population are less likely to respond to a smoke alarm. Bruck's (1999) research with 20 children and youth identified that the majority (85 per cent) of the 6 to 17 year old participants were not awakened by the sound of a smoke alarm on both of the nights the alarm was activated, whereas all adults did. Those youth who did wake up on both nights tended to be older, around 16 to 17 years of age. These results were attributed to the fact that children and teenagers require greater amounts of deep sleep than adults, which correspondingly makes it more difficult to rouse them from sleep. Therefore, young children appear to be at the greatest risk of residential fire-related fatalities. Bruck (1999) suggested that families consider using interconnected smoke alarms that will set off an alarm in or near the parents' bedroom should a fire occur near the child's room.

As previously discussed, young children were also more likely to die or be injured in a residential fire that was caused by their playing with fire. Istre and colleagues (2002) found that the presence of a smoke alarm had no effect on preventing the injuries or deaths of these children, presumably because they were too young to comprehend the potential damage the fire could cause and to understand what to do when the fire began. Many young children who were injured or died in a fire were engaging in fire play while unmonitored by an adult (Miller, 2005). Furthermore, when a fire begins, the child may respond by hiding, thus increasing the potential danger to them (Miller, 2005). As such, the presence of a functioning smoke alarm may increase the potential survival of these children by notifying a nearby adult of the danger the child is in.

Older persons, often over the age of 65 years old (Department of Emergency Services, 1998), are also at greater risk of dying or being injured in a residential fire (DiGuiseppi, Edwards, Godward, Roberts, & Wade, 2000; Miller, 2005; Newton, 2003). Bruck (2001) noted that many not only suffered from hearing impairments due to older age, but were also more likely to use sleeping medication, thus ensuring that they experienced a deep sleep. However, the time at risk for older persons was reduced because they tend to require shorter periods of deep sleep (Bruck, 2001).

Bruck (2001) has also identified that individuals who were impaired, whether by age-related hearing loss, medication or other drug use, or use of alcohol were similarly less likely to be successfully awakened by a smoke alarm. In fact, research suggested that alcohol impairment was the primary risk factor for a fire-related fatality as it changes sleep patterns so that deep sleep occurs during the hours when a fire is most likely to occur (approximately one am to four am) (Bruck, 2001). Moreover, as previously discussed, alcohol-impaired individuals may be unable to successfully execute an escape plan (Ballard, Koepsell, & Rivara, 1992; Department of Emergency Services, 1998). In addition, individuals who were sleep deprived were also harder to rouse by a smoke alarm (Bruck, 2001; Bruck and Horasan, 1995). According to Bruck (2001), these findings indicated that the volume of smoke alarms should be raised to the maximum tolerable by the human ear (90 decibals).

As previously mentioned, it is important to consistently check and replace batteries to ensure functionality of smoke alarms. However, previous research indicated that in approximately one-quarter of residential fires, smoke alarms were not functioning (Warda and Ballesteros, 2007). Further, in approximately two-thirds of residential fire fatalities, there was either no smoke alarm present or it did not function (Ahrens, 2007; Miller, 2005). Sources of non-functioning commonly included dead batteries, alarm malfunction, absence of batteries, or the alarm being disconnected because of previous false alarms, typically a result of activities such as cooking (Warda and Ballesteros, 2007; Miller, 2005). Alarms also malfunctioned due to improper installation and location (Warda and Ballesteros, 2007; Miller, 2005). Therefore, it is essential that residents not only install smoke alarms following the guidelines provided by the manufacturer, but also check the alarm on a regular basis to ensure that they are functioning appropriately.

Sprinklers

Sprinklers in residential structures are a relatively recent phenomenon as the installation cost was historically generally prohibitive to the public (Marshall et al., 1998). According to Ahrens (2007), approximately 1% of fires uncontained in single and dual family dwellings had a sprinkler present, compared to nearly one-tenth (8 per cent) of uncontained apartment fires. Although the data is limited by the small proportion of structures containing sprinklers, the successful operation rate of sprinklers appeared to be much higher than smoke alarms. In nearly all apartment fires where sprinklers were present (97 per cent), they successfully activated (Ahrens, 2007).

Public Education

Given that many fire related fatalities are the result of poor decision making on the part of the occupants, some fire prevention research has focused on the ability to modify behaviours. Others have attempted to simply raise awareness among members of the population regarding their relative risk and what they can do to better protect themselves from harm.

Public education campaigns can be directed towards all members of the population or can be more specifically targeted towards sub-groups who exhibit greatest risk for negative outcomes. With respect to fire, public education campaigns are often directed towards those sub-groups at highest risk of injury or death from residential fires (Warda, Tenenbein, & Moffatt, 1999a).

According to the Centres for Disease Control and Prevention (CDC), those most at risk of dying or being injured in a residential fire are also the least likely to have a smoke alarm installed (no date). As previously discussed, this sub-population includes older adults, typically those who are 65 years of age and older. To reduce their risk of fire-related injury and death, the CDC introduced several education campaigns to ensure that older adults living at home on their own were aware of the importance of installing and maintaining functioning smoke alarms. For instance, the Meals on Wheels program staff have regular contact with older adults when they deliver their meals to their homes. Using this contact, the local fire department works with staff to install smoke alarms and educate older adults about how to prevent fires and what to do if one occurs (CDC, no date).

Public education campaigns have had varying rates of success. Many programs resulted in initial short-term improvements in awareness regarding fire safety, but their effectiveness over the long-term has not necessarily been demonstrated (Warda, Tenenbein, & Moffatt, 1999b). It is possible that this lack of long-term benefit was the result of targeting education towards an entire population, rather than those with specific risk factors associated with a lack of fire safety. For instance, while Warda and colleagues (1999b) questioned the long-term effectiveness of educating elementary school children in fire safety, given the lack of long-term research, they identified that targeted education campaigns towards those in housing projects in the United States were successful in improving fire safety among this high risk population. For instance, McConnell, Dwyer, and Leeming (1996) used visual stimuli (i.e. a video involving a child being rescued by a firefighter) together with fire safety information to educate new housing project tenants about the importance of fire safety. Following the presentation, the recipients of this program committed to working towards at least three fire safety behaviours and were given a card that reviewed essential fire safety behaviours. Follow up research 15 months following the demonstration indicated that program recipients were five times less likely to have experienced fire than those who did not receive the program (McConnell, Dwyer, & Leeming, 1996).

Distribution Campaigns

Given that previous research has substantiated the association between use of a smoke alarm and reduced risk of injury or death from residential fire, fire departments may at times engage in distribution campaigns in which they provide and, at times, install smoke alarms to those without them. However, it is important to emphasize that fire departments should, whenever possible, install the alarm for the resident, given that the distribution of smoke alarms does not always result in the use of smoke alarms. For instance, DiGuiseppi and colleagues (2002) found that the distribution of smoke alarms had no effect on reducing risk of injury or death from residential fire; a primary reason for this result was that the majority of the 20,050 distributed alarms had not been installed.

With respect to neighbourhoods that would benefit most from this initiative, research has demonstrated that residential fires are more common in neighbourhoods with lower socioeconomic status, partly as a result of lower rates of smoke alarm installation and maintenance (Duncanson, Woodward, & Reid, 2002). As such, areas characterized by low socioeconomic status may benefit from campaigns that seek to raise public awareness regarding the utility of smoke alarms in the home and which pair that education with the distribution of smoke alarms (Duncanson, Woodward, & Reid, 2002).

Research has demonstrated that smoke alarm distribution campaigns have been successfully carried out in high risk areas. Several studies have reported a reduced rate of injury following the distribution of smoke alarms (Warda et al., 1999b). Furthermore, several distribution campaigns in the United States have resulted in not only installation, but also maintenance of smoke alarms over time (Warda et al., 1999b). This is extremely important, as research has previously suggested that simply installing a smoke alarm does not necessarily reduce risk for injury or death. Instead, their role in lowering risk for injury or death is related to their maintenance over time, as a non-functioning smoke alarm cannot alert residences to the presence of smoke or fire.

The success of distribution campaigns likely results from the combination of education regarding fire safety with an immediate ability to act on that information. In other words, fire safety education might result in an increased awareness regarding the danger of fire, but that increased awareness does not necessarily translate to actual behaviour. However, if the person receiving education is simultaneously provided with the ability to act on that education by installing a smoke alarm, the awareness is more likely to result in behaviour consistent with that awareness. Therefore, if residents can simultaneously receive not only information regarding fire safety, but a way to act on that information, in terms of having a smoke alarm be provided and installed, the education campaign is much more likely to be successful in reducing risk of injury or death from fire (McConnell, Dwyer, & Leeming, 1996).

Residential Property Fire Safety Inspections

In order to promote residential fire safety, many fire departments are now conducting fire safety inspections within their communities. As part of this service, the fire department sends representatives to the homes of residents within their community to conduct a fire-safety inspection. The results of the inspection provide the resident with information on how they can improve the safety of their home, such as by developing a family escape plan, and installing and maintaining smoke alarms in appropriate areas. Home inspections can also be paired with smoke alarm distribution if the residence does not have one installed.

Research on the effectiveness of these residential fire safety home inspections is lacking; however, the efficacy of similar inspections has been evaluated with respect to home visits for prevention of injury to children. For instance, a study published in 1993 identified that home visits involving inspection for hazards in which the resident was provided with information regarding the specific hazards in their home and general education regarding injury prevention resulted in a significant increase in home safety behaviours 12 months later. These safety behaviours included a significant increase in the presence of functioning smoke alarms, and the reduction of electrical hazards that could result in fire (Schwarz, Grisso, Miles, Holmes, & Sutton, 1993). Other studies have found similar moderate levels of improvement in fire safety behaviours (e.g. Bablouzian, Freedman, Wolski, & Fried, 1997; and Schmeer, Stern, & Monafo, 1988).

More recently, a Canadian study published in 2005 identified successful long-term effects in terms of knowledge, beliefs, and behaviours at home. The home visits were conducted with a random sample of 1,172 families with children under the age of eight years old who had attended one of five pediatric hospitals in Canada for injuries such as burning, scalding, and falls (King, LeBlanc, Barrowman, Klassen, Bernard-Bonnin, Robitaille, Tenenbein, & Pless, 2005). The home visits consisted of an assessment for hazards (such as lack of smoke alarm and access to matches) and administration of an injury-related questionnaire (King et al., 2005). Half of the families were placed in the intervention group; this group was given a home injury prevention package and the hazard assessment findings, while families in the non-intervention group received only a general home safety pamphlet.

The families were surveyed again at 12 months (King, Klassen, LeBlanc, Bernard-Bonnin, Robitaille, Pham, Coyle, Tenenbein, & Pless, 2001) and 36 months (King et al., 2005) following their initial participation in the study. At both follow-up interviews, those families who had received the hazard findings and the specific home injury prevention package reported significantly fewer injury-related visits to the doctor as compared to families with the general safety information pamphlet. However, the effectiveness of the home visit did appear to wear off closer towards the 36 months as opposed to the first year after delivery. Therefore, in order to maximize the positive effects of home visits, it appears necessary to repeat the home visit every few years.

Another important finding relating to home care visits was identified in a recent study in the United Kingdom. Together with the Fire and Rescue Services, the Department for Communities and Local Government (2008) undertook a study on attitudes and behaviours of residents with respect to fire safety. Among the many conclusions of this report, they identified the "importance of accurately identifying the fire safety issues specific to certain groups, and developing authoritative communications materials and tactics for specific audiences" (Wassall, 2009: 38). In other words, to deliver the most effective fire safety education, the fire service should first collect information on the nature of the specific risks and needs of each community it visits. Communities may differ with respect to their perceived and actual fire safety (e.g. recognition of the fire-related dangers of smoking, use of an escape plan, maintenance of a fire alarm) and may also experience different causes of fires (e.g. fires that result from exposure through proximity, such as in apartment blocks, fires that result from cooking). Therefore, the report suggested that not only should fire education be undertaken with a regular frequency, but also that it should speak specifically to the causes of fire as related to the behaviours of the group receiving the education (Wassall, 2009).

Current Study

The Surrey Fire Department is attempting to increase awareness regarding fire safety and promote the use of smoke alarms to reduce risk of injury and death associated with fire in all communities of Surrey, B.C. However, prior to engaging in a public education and distribution campaign promoting the use of smoke alarms, the Surrey Fire Department wanted to review the residential fires that occurred in Surrey over the previous 20 years to identify trends that may affect the nature of their education campaign. For instance, the Department wanted to identify which factors affected the likelihood that a residential fire would result in injury or death, the factors related to the cost of residential fires, and the effect of a functioning smoke alarm with respect to residential fire outcomes.

Methodology

The current analysis reviewed 4,758 structure fire incidents that occurred in the City of Surrey between 1988 and 2007. According to Jennings, "treating fires as individual unconnected occurrences obscures lessons that could be learned from analysis on a neighborhood scale" (1996: 6). In other words, by analyzing the incidence of fires occurring within particular communities, it is possible to identify common factors present within communities that can be targeted by fire safety education and awareness campaigns. Given this, much of the subsequent analysis will involve cross-community comparisons to determine whether there are fire safety and fire hazard patterns at the community level.

Description of Surrey

The city of Surrey has a growing population, with an estimated 437,686 residents in 2006. The city can be divided into six communities/burrows: Whalley; Guildford; Fleetwood; Newton; Cloverdale; and South Surrey (Figure 1).

Figure 1: Communities of Surrey

The most populated community in Surrey is Whalley with approximately 92,000 residents (Table 1). Whalley contains the city centre, which has approximately 21,602 residents. Each of the communities is composed of approximately one-third residential structures, with the remaining structures non-residential, including education, hospital, and retail structures.

Table 1: Population Breakdown of Surrey Communities

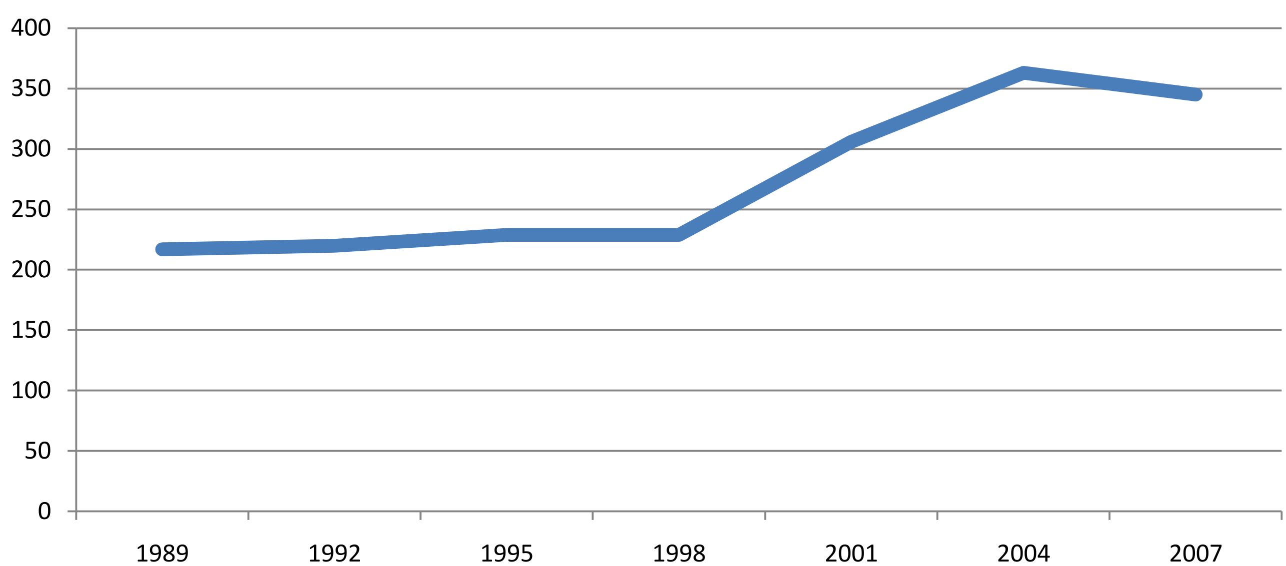
Community	Population Estimate 2006
Newton	117,020
Whalley	92,069
South Surrey	66,455
Guildford	58,545
Fleetwood	58,268
Cloverdale	45,329
Total	**437,686**

Results

Description of Incidents

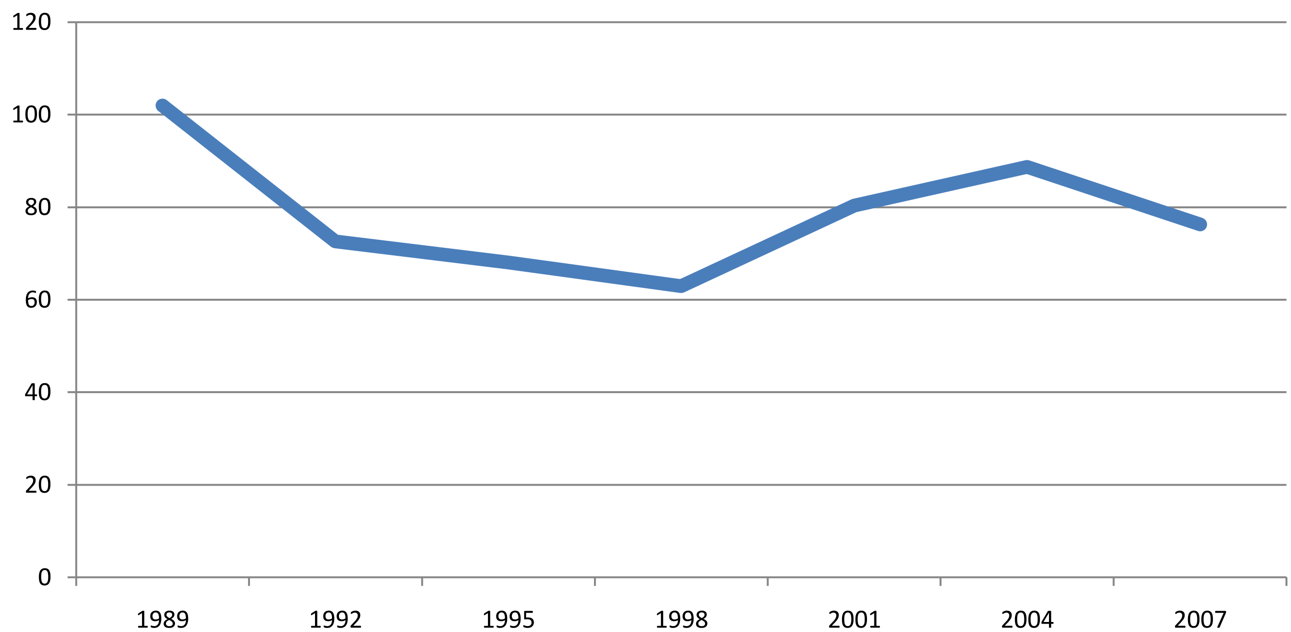
Between 1988 and 2007, there were 4,758 structure fire incidents in Surrey, British Columbia. The data indicated that the proportion of fires responded to by the fire department generally increased over these years (Figure 2).

Figure 2: Structure Fire Incidents 1989-2007 (3 year intervals)



A potential cause for the increase in residential fires per year is population growth in Surrey. The population of Surrey was estimated at 287,000 in 1991, growing to 452,396 in 2007 (City of Surrey Website). Therefore, to determine whether the proportion of fires relative to the population size increased over the years, fire incident rates were computed and graphed. The rate of fires per year was computed by dividing the fires per year by the estimated size of the population and multiplying by the standard value of 100,000 (Appendix A). The results are graphically displayed in Figure 3. These results indicated that the rate of fire has been fairly turbulent over the years, most recently showing a decrease to approximately 76 fires per 100,000 people.

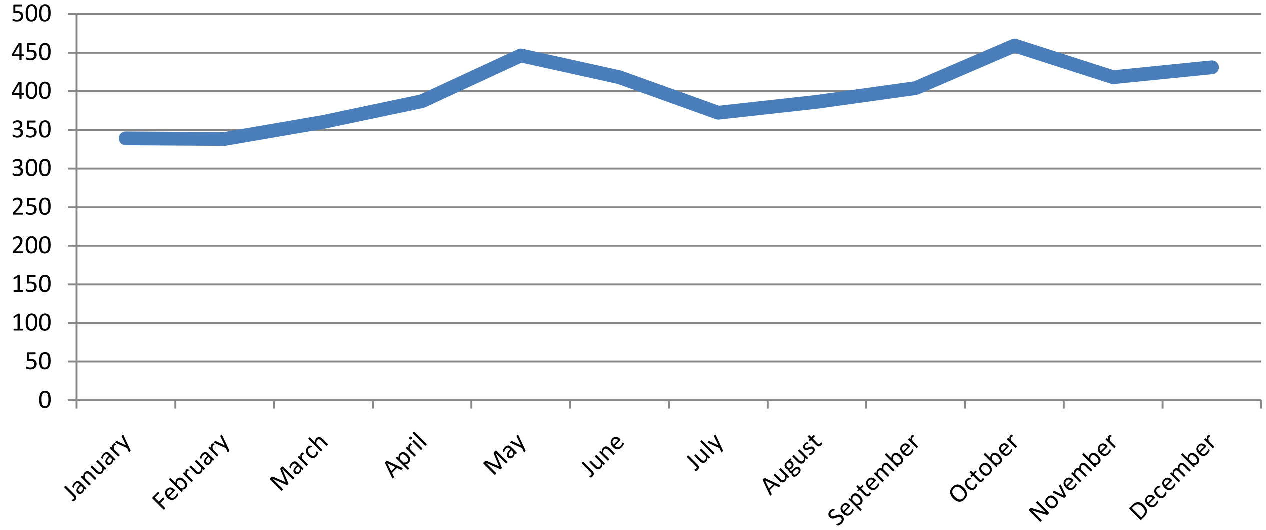
Figure 3: Rate of Structure Fires per 100,000 Residents 1989 – 2007 (3 year intervals)



In comparison to the literature reviewed from other countries, there was no particular pattern evident in the distribution of structure fires over the 12 months of the year (Figure 4). While in other countries, the colder months of the year have resulted in more fires, this pattern did not appear in Surrey; this is not surprising given that temperatures rarely fluctuate substantially (City of Surrey website).[1] Generally, the proportion of fires were fairly flat over the 12 months of the year, with the slight exception of a peak in May (9.4 per cent) and October (9.6 per cent).

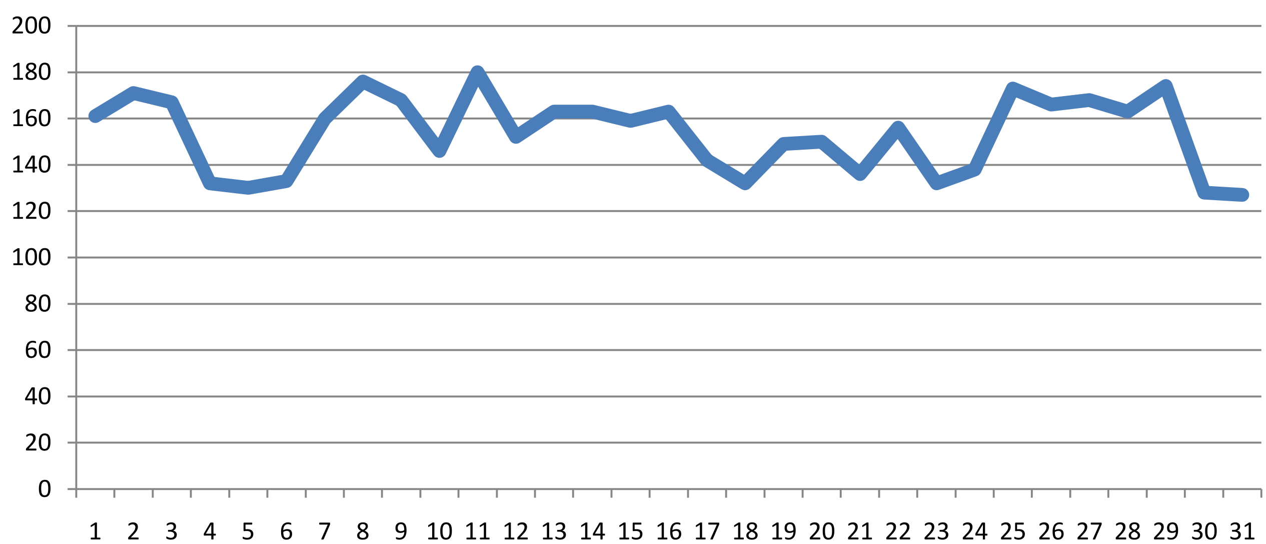
[1] On average, fluctuating between 3°C to 21.5°C throughout the year (City of Surrey website)

Figure 4: Proportion of Fires over the 12 Months of the Year



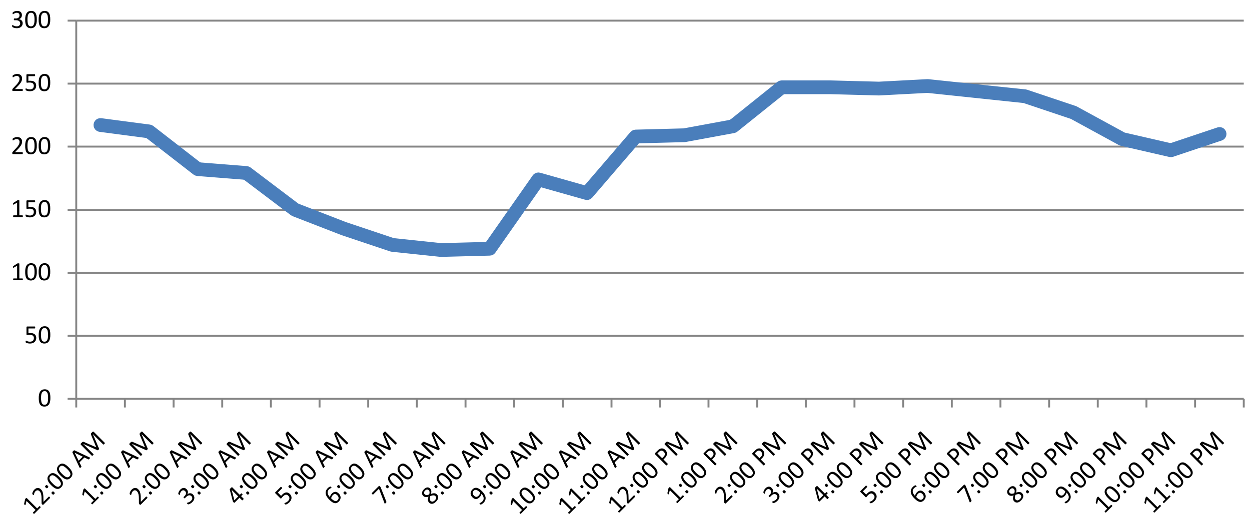
Similarly, the proportion of fires occurring on different days of the month were also fairly evenly distributed (Figure 5).

Figure 5: Structure Fires over Days of the Month



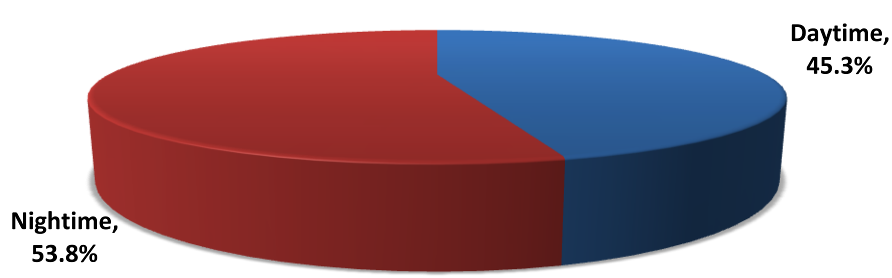
In terms of the typical hour that fire occurs, previous research identified that two-thirds of structure fires occurred during the day, between 8 am and 8 pm (Bruck, 2001). As shown in Figure 6, this general trend was reflected in the current analysis, as the number of fires increased steadily between 8 am and 8 pm. In the current analysis, the lowest proportion of fires occurred between the hours of approximately 6 am (2.6 per cent) and 8 am (2.5 per cent).

Figure 6: Proportion of Structure Fires Occurring Over 24 Hour Day



This data was recoded into the two categories of 8 am through 7 pm (day) and 8 pm through 7 a.m (night). Although the proportion of fires occurring overnight (54.3 per cent) was slightly higher than the proportion of fires occurring during the day (45.7 per cent), these proportions were nearly equal (Figure 7). These proportions were consistent across the six communities within Surrey.

Figure 7: Proportion of Fires Occurring During Day and Night



Nearly half (43.9 per cent) of the structure fires for which gross footage could be determined (n = 3,845) were between 101 and 500 square metres in size. Nearly another one-third (31.9 per cent) were between one and 100 square metres. The remaining fires occurred in spaces that were 500 square metres or larger.

The vast majority of structure fires (83.5 per cent) occurred with between zero and ten occupants present. Less than one in ten occurred with between 11 and 60 occupants (7.2 per cent), between 61 and 100 (3.5 per cent), between 101 and 300 (4.0 per cent), or more occupants (1.8 per cent).

Property Information

Property type refers to the type of property the residential fire occurred in, such as residential, assembly, institutional, business, or storage. Of the 4,758 structure fire incidents, the most common property class denominated was residential, accounting for three-quarters of fires (n = 3,594[2]; Table 2). The remainder of fires in Surrey were composed of: assembly (such as theatre, church, education, other recreation); mercantile (such as textiles, furniture, and hardware); miscellaneous (such as labs, quarrying, and farm facilities); industrial manufacturing (such as chemical, paint, wood, and paper); storage properties (such as for agricultural or paper products); special property and transportation (such as outdoor property); business (such as office or personal space); and institutional (including penitentiaries, medical facilities, and daycares).

Table 2: Property Type Categories (n = 4,758)

Property Type	Per cent
Residential	75.5%
Assembly	5.3%
Mercantile	4.0%
Miscellaneous	3.8%
Industrial Manufacturing	3.7%
Storage Properties	3.1%
Special Property and Transportation	2.5%
Business	1.5%
Institutional	0.5%

[2] There were another 285 Residential Fires between 1989 and 1992 that were previously unaccounted for in the structure fire incidents. These additional 285 fires lacked sufficient information to be included in any of the subsequent analyses; therefore, the remainder of this report consists of the 3,594 fires with complete or near complete information available.

Given that the focus of this report was on residential properties, the remaining analysis will consist of the 3,594 residential structure fires in Surrey. Of these 3,594 fires, the majority (87.5 per cent) occurred in a year round use single-family dwelling, of which the majority were lived in by the owner (71.2 per cent), and only slightly more than one-quarter (27.4 per cent) were rented. Of the remaining residential fires, slightly more than one in ten (12.0 per cent) occurred in a year round use two-family dwelling (i.e. duplex). Less than 1% (0.5 per cent) occurred in a single-family seasonal dwelling. Nearly two-thirds (61.6 per cent) of residences involved in a fire were privately owned and occupied, whereas another one-third (34.4 per cent) were privately owned and leased to others (i.e. rented). Very few residences were associated with government (2.8 per cent) or under construction (1.2 per cent). The majority of residential buildings that had information on building height (n = 3,535) were two stories tall (84.5 per cent). Another 14.0% were three to six stories tall, while 1.5% were over 10 stories.

Residential Fires in Six Communities of Surrey

The community of Newton accounted for slightly less than one-third of all residential fires (30.6 per cent) in which address was recorded (see Table 3).[3] This was followed by slightly more than one-quarter of all residential fires in Whalley (26.2 per cent). Residential fires were least common in Cloverdale (7.8 per cent). When looking specifically at the past five years in which fire data was collected, the statistics were essentially identical, with a slight increase in the proportion of fires occurring in Guildford and Cloverdale. Overall, 296 fires occurred within the city centre in Whalley, 159 of which occurred in the most recent five years.

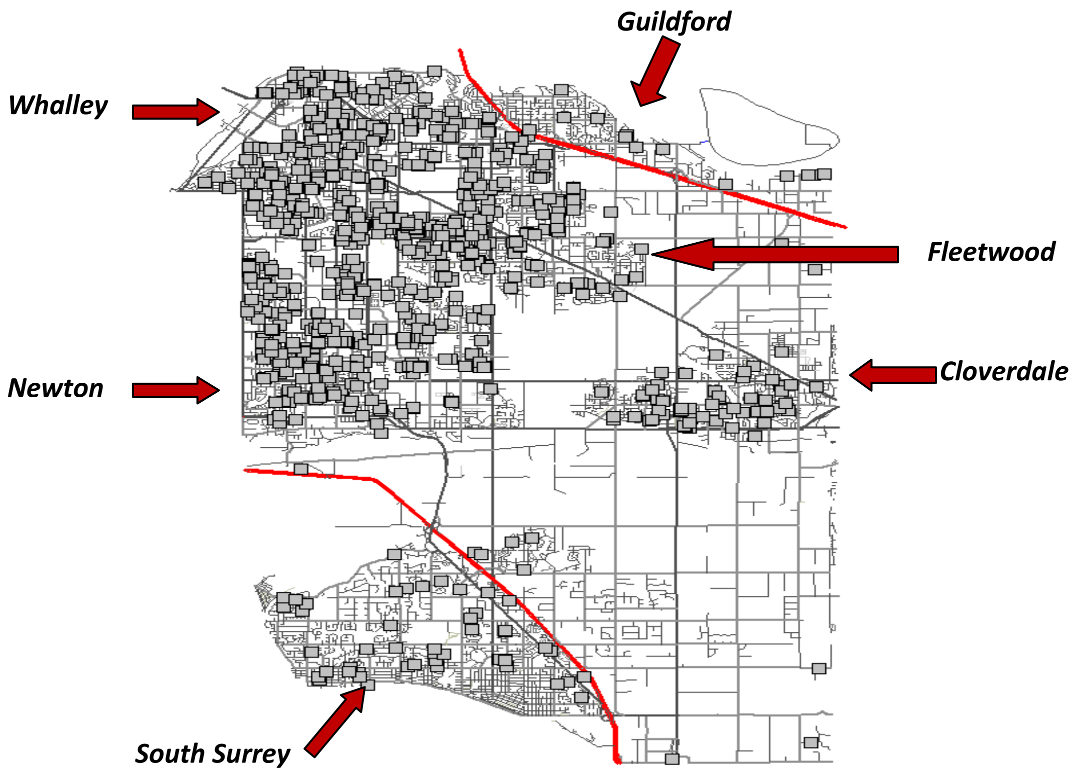
Table 3: Communities and Residential Fires over All Years of Data and the Past Five Years

Community	Residential Fires 1998 – 2007 (n = 2,656)	Residential Fires 2003 – 2007 (n = 1,579)
Newton	30.6%	30.6%
Whalley	26.2%	25.5%
Guildford	12.5%	13.5%
South Surrey	11.8%	11.7%
Fleetwood	11.1%	10.1%
Cloverdale	7.8%	8.5%

[3] Address was recorded for 2,656 of the 3,594 incidents (73.9%)

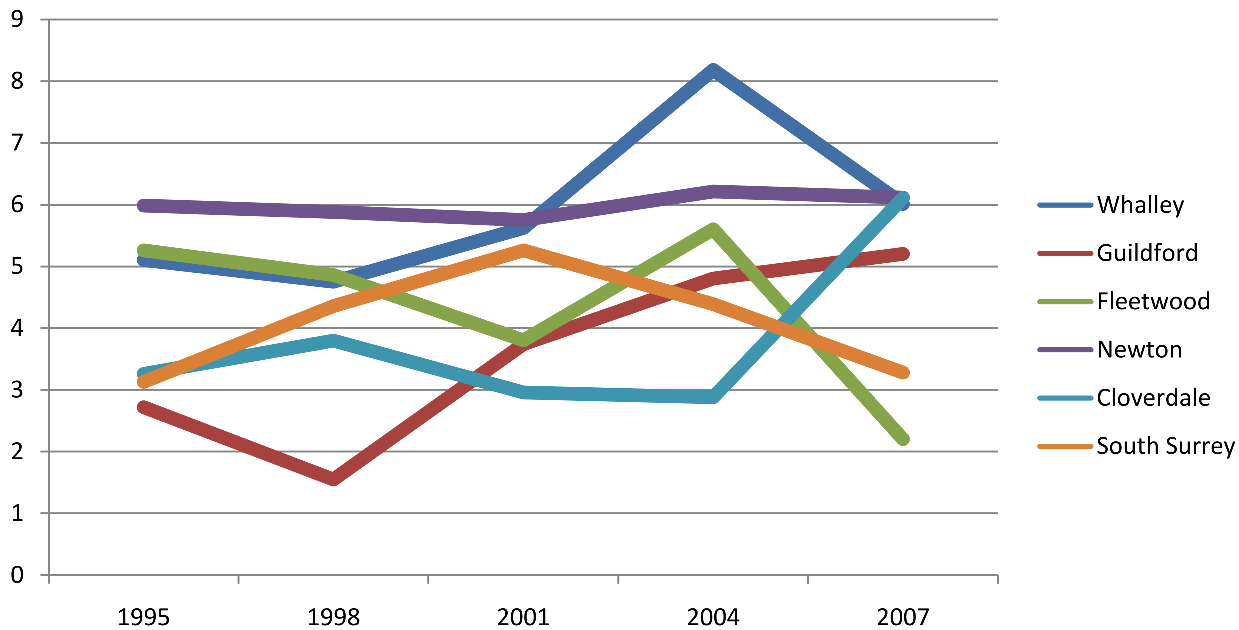
This data is graphically represented in the following map. As seen in Figure 8, fires were primarily concentrated in Whalley and Newton and, to some extent, in Cloverdale. Fire incidents were generally more spread out in Guildford, Fleetwood, and South Surrey.

Figure 8: Mapped Distribution of Fires across Surrey



The fact that the majority of fires were found in Newton and Whalley and the lowest proportion in Cloverdale was not surprising considering the relative population of these communities (Appendix B). However, when comparing the rate at which fires occurred per 10,000 people, Newton and Whalley continued to experience the greatest proportion of fires, along with Guildford (Appendices C through G). Over the most recent five years of data available, the lowest rate of fires per 10,000 people was found in Fleetwood and South Surrey, while the rate of fires occurring in Cloverdale steadily increased. The rates of fires in all six communities are compared in Figure 9.

Figure 9: Rates of Fires per Community per 10,000 Residents



Ownership

Homes were significantly more likely to be owned by the resident in Fleetwood (79.1 per cent), South Surrey (71.5 per cent), and Cloverdale (71.2 per cent).[4] In contrast, they were significantly more likely to be rented by the resident in Guildford (48.5 per cent) and Whalley (39.3 per cent).[5]

Response to Fire

"Action taken" refers to the action taken by the fire department or other responder in reaction to the identified fire. Of the 3,594 fires over 1988 to 2007, the action taken was undetermined for 120 cases (3.3 per cent), and unclassified for 51 (1.4 per cent) (Table 4). Once these 171 cases were removed, the data indicated that the majority of the residential fires were extinguished by the Fire Department (75.1 per cent). Fires extinguished by the fire department were primarily extinguished using one line of a 38mm hose (47.6 per cent), two or more lines of a 38 mm hose (26.0 per cent), or a combination of 38mm, 65mm, 77mm or larger hoses (10.9 per cent). The remaining fires were primarily extinguished by the occupant (13.6 per cent), either by smothering the fire (18.9 per cent), using a garden hose (17.7 per cent), using a small water container (14.5 per cent), or using a dry chemical (13.3 per cent).

[4] x^2 (5) = 63.03, p < .001
[5] x^2 (5) = 70.61, p < .001

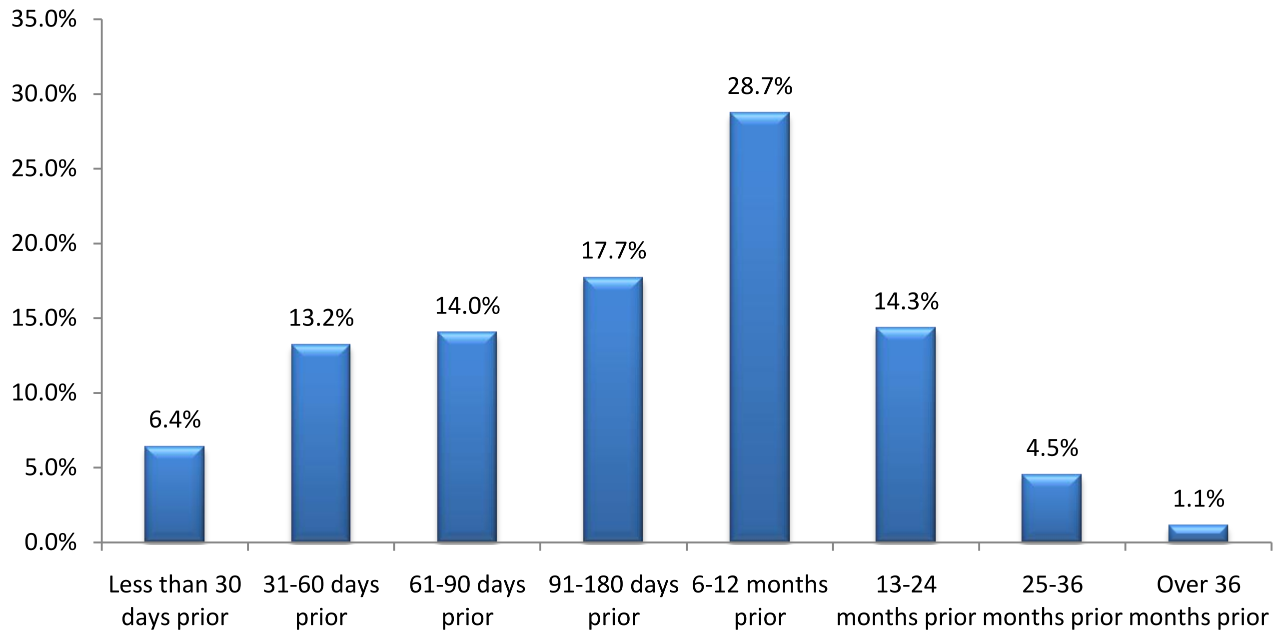
Table 4: Action Taken in Response to Fire (n = 3,423)

Action Taken	
Extinguished by fire department	75.1%
Extinguished by occupant	13.6%
Extinguished other than fire department	6.0%
Burned out	2.2%
Extinguished by automatic system	1.3%
Minor fire – no action	0.6%
Hazard removed	0.7%
Shut off gas/oil/electricity	0.4%
Investigation	0.1%

Past Inspections

Inspections by fire officials are commonplace for residential locations with a larger number of occupants, such as apartments and hotels. From 1988 to 2003, the time since the last inspection occurred was recorded. After 2003, this information was no longer available. Between 1988 and 2003, there were 2,471 residential fires; of these, information was available on past inspections for 265 cases (10.7 per cent). For the 265 cases in which data was available, over one-quarter (28.7 per cent) of inspections had taken place between six and 12 months prior to the residential fire (Figure 10). This was more characteristic of buildings that were either one to two stories (27.4 per cent) or three to six stories (30.2 per cent) tall as compared to those over 10 stories (15.4 per cent), which is likely a function of apartments being inspected on a more regular basis than residential homes.

Figure 10: Length of Time between Last Inspection and Residential Fire (1988-2003; n = 265)



An analysis was conducted to determine whether the last inspection date was associated with the likelihood of injury or death occurring. The data revealed no significant relationships between the length of time since last inspection and the likelihood of either death or injury occurring. Presence or absence of an inspection was also not significantly associated with the severity of the fire.

Sprinklers

The vast majority (89.0 per cent) of residences that experienced fires between 1988 and 2007 did not have sprinklers installed. Of the 202 residences that did have a sprinkler installed, nearly half (41.1 per cent) had a complete and supervised sprinkler set (Table 5). Slightly less than one-quarter (23.3 per cent) had a partial speaker that was unsupervised. Approximately 13% had a complete sprinkler set that notified the fire department. Between 1988 and 2007, the use of complete and supervised sprinklers became more common, increasing to over half (59.4 per cent) of residences.

Table 5: Presence of Sprinklers

Type of Sprinkler	Sprinklers Present 1988-2007 (n = 202)	Sprinklers Present 2003-2007 (n = 96)
Complete, supervised	41.1%	59.4%
Partial, unsupervised	23.3%	11.5%
Complete, alarm to Fire Department	12.9%	13.5%
Partial, supervised	9.9%	8.3%
Complete, unsupervised	8.4%	2.1%
Partial, alarm to Fire Department	4.5%	5.2%

The presence of particular sprinkler sets was significantly associated with the six communities. Residences in Guildford were significantly more likely to have any form of sprinkler present (Table 6).[6].

Table 6: Presence of Sprinklers by Community

Community	Sprinklers Present 1988-2007 (n = 2,545)
Whalley	1.2%
Fleetwood	2.7%
Cloverdale	3.4%
Newton	3.9%
South Surrey	5.4%
Guildford	14.7%

[6] x^2 (5) = 98.81, p < .001

Source of Ignition

As discussed in the literature section of this report, residential fires result from a number of causes, including smoking materials, cooking equipment, and electrical malfunctions. In the current study, the source of ignition for nearly one-quarter (23.2 per cent) of residential fires could not be determined[7]. Once these incidents were removed from the analysis, the main source of ignition for residential fires was identified as cooking equipment, accounting for more than one-third of all residential fires (Table 7). Nearly another one-fifth of fires (17.0 per cent) were the result of matches and open flames, such as candles. Slightly less than one in ten residential fires resulted from either miscellaneous sources, including fireworks and explosions, or heating equipment, such as fireplaces and central heating units. Compared to the previous literature, electrical fires were relatively rare, accounting for approximately 14% of all fires when combining the categories of electrical fires due to appliances, distribution equipment, and other sources. Similarly, the proportion of fires that resulted from smoker's material was very uncommon, accounting for less than one-tenth of all residential fires.

Table 7: Source of Ignition of Residential Fires (n = 3,425)

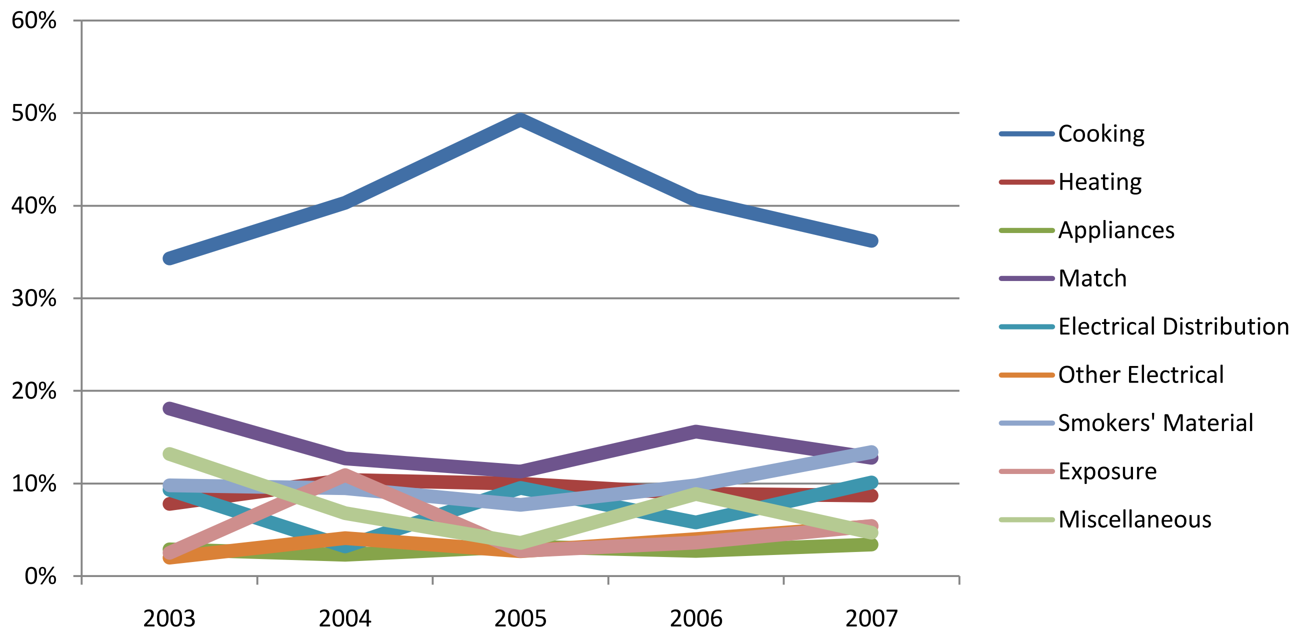
Source of Ignition	Per Cent
Cooking Equipment	39.9%
Match (non-smoking) / Open Flame	17.0%
Heating Equipment	9.5%
Smokers' Materials	8.6%
Miscellaneous	7.4%
Electrical Distribution Equipment	7.1%
Other Electrical	7.1%
Exposure	4.0%
Appliances / Electrical Equipment	3.4%

The source of ignition was analyzed specifically for the previous five years in order to determine the most recent trends in residential fires. As seen in Figure 11, cooking

[7] This analysis includes the additional 285 cases from 1998 to 1992.

equipment was overwhelmingly the most common source of residential fire. Although far less common as a source of ignition, a match or open flame was nearly consistently the second most common source of residential fire.

Figure 11: Most Recent Five Year Trends in Residential Fire Ignition



As indicated in Table 8, cooking equipment accounted for between one-third and half of all residential fires each year. However, the most recent year of data (2007) indicated that cooking equipment, as a primary source of residential fire, while still the most common source, dropped to slightly more than one-third of fires (36.2 per cent). In this most recent year, residential fires resulting from an electrical disturbance or from smoker's material accounted for slightly higher proportions of fires than in previous years. The inclining trend in smoker's material as a source of residential fire was unexpected as it contrasted the generally declining trend in the proportion of the population who smoked cigarettes.

Table 8: Source of Ignition over Previous Five Years (2003 to 2007)

Source of Fire	2003 (204)	2004 (221)	2005 (221)	2006 (224)	2007 (149)
Cooking Equipment	34.3%	40.3%	49.3%	40.6%	36.2%
Heating Equipment	7.8%	10.4%	10.0%	8.9%	8.7%
Appliances / Electrical Equipment	2.9%	2.3%	3.2%	2.7%	3.4%
Match or open flame	18.1%	12.7%	11.3%	15.6%	12.8%
Electrical Distribution Equipment	9.3%	3.2%	9.5%	5.8%	10.1%
Other Electrical	2.0%	4.1%	2.7%	4.0%	5.4%
Smokers' Material	9.8%	9.5%	7.7%	9.8%	13.4%
Exposure	2.5%	10.9%	2.7%	3.6%	5.4%
Miscellaneous	13.2%	6.8%	3.6%	8.9%	4.7%

Source of Ignition by City

To detect potential trends in city location and source of ignition, the source of ignition was cross-referenced against the six city communities (Table 9). For nearly all communities, cooking equipment was the primary source of fire. This was especially true of Fleetwood and Newton, where cooking equipment contributed towards nearly half of all fires. Cloverdale and South Surrey were exceptions, as a match or other open flame was the most common source of fire, accounting for approximately one-quarter of all fires. However, for both communities, cooking equipment was the second most common source.

Table 9: Source of Ignition within the Six Surrey Communities (n = 1,988)

Source of Ignition	Cloverdale (n = 149)	Newton (n = 609)	Whalley (n = 524)	Guildford (n = 246)	S. Surrey (n = 232)	Fleetwood (n = 228)
Cooking Equipment	30.9%	50.4%	38.2%	38.6%	24.6%	49.6%
Heating Equipment	9.4%	8.0%	8.2%	10.2%	15.1%	7.9%
Appliances / Electrical Equipment	2.7%	3.1%	2.9%	2.8%	5.6%	2.6%
Match or Open Flame	21.5%	12.2%	17.6%	15.9%	25.4%	14.9%
Electrical Distribution Equipment	12.1%	6.6%	7.8%	7.3%	4.3%	6.6%
Other Electrical	3.4%	2.0%	3.1%	3.7%	5.6%	5.3%
Smokers Material	10.1%	7.1%	7.4%	9.8%	8.2%	7.5%
Exposure	1.3%	3.1%	4.4%	7.7%	1.3%	3.5%
Miscellaneous	8.7%	7.6%	10.5%	4.1%	9.9%	2.2%

This information was also analyzed for the previous five years of fire data. The data generally followed similar trends as cooking equipment was nearly consistently the most common source of fire (see Table 10). The exception to this was in Cloverdale where match or open flame accounted for slightly more fires than did cooking equipment. In addition, in contrast to the previous finding that residential fires in South Surrey were primarily caused by match or open flame, the proportion of residential fires that were caused by cooking equipment increased to become the most common source of fire in South Surrey over the most recent five years.

Table 10: Source of Ignition within the Six Surrey Communities for the Previous Five Years (n = 909)

	Cloverdale (n = 78)	Newton (n = 278)	Whalley (n = 230)	Guildford (n = 116)	S. Surrey (n = 107)	Fleetwood (n = 100)
Cooking Equipment	25.6%	53.6%	36.5%	43.1%	30.8%	44.0%
Heating Equipment	7.7%	9.7%	8.7%	9.5%	15.9%	8.0%
Appliances / Electrical Equipment	3.8%	2.2%	2.2%	3.4%	4.7%	2.0%
Match or Open Flame	26.9%	9.7%	15.2%	8.6%	15.9%	17.0%
Electrical Distribution Equipment	15.4%	7.2%	7.0%	6.0%	2.8%	9.0%
Other Electrical	3.8%	1.8%	3.5%	4.3%	5.6%	6.0%
Smokers Material	9.0%	7.2%	8.7%	12.9%	12.1%	9.0%
Exposure	0.0%	1.8%	6.5%	7.8%	0.9%	3.0%
Miscellaneous	7.7%	6.8%	11.7%	4.3%	11.2%	2.0%

For fire prevention and education purposes, it is important to know whether specific sources of residential fire are particularly common in certain areas of the city. As such, the six communities were compared to the sources of ignition. Given the fact that many more fires occurred in Newton and Whalley than in other areas of the city, it was not surprising to find that these two communities were overrepresented in nearly all categories of ignition source. However, this was particularly true with respect to cooking equipment, as the results indicated that residential fires caused by cooking equipment overwhelmingly occurred in Newton (37.5 per cent), followed by Whalley (24.4 per cent) (Table 11).

Table 11: Source of Ignition Compared over Six Surrey Communities

Source of Ignition	Cloverdale	Newton	Whalley	Guildford	S. Surrey	Fleetwood
Cooking Equipment (n = 818)	5.6%	37.5%	24.4%	11.6%	7.0%	13.8%
Heating Equipment (n = 184)	7.6%	26.6%	23.4%	13.6%	19.0%	9.8%
Appliances / Electrical Equipment (n = 64)	6.3%	29.7%	23.4%	10.9%	20.3%	9.4%
Match or Open Flame (n = 330)	9.7%	22.4%	27.9%	11.8%	17.9%	10.3%
Electrical Distribution Equipment (n = 142)	12.7%	28.2%	28.9%	12.7%	7.0%	10.6%
Other Electrical (n = 67)	7.5%	17.9%	23.9%	13.4%	19.4%	17.9%
Smokers Material (n = 157)	9.6%	27.4%	24.8%	15.3%	12.1%	10.8%
Exposure (n = 74)	2.7%	25.7%	31.1%	25.7%	4.1%	10.8%
Miscellaneous (n = 152)	8.6%	30.3%	36.2%	6.6%	15.1%	3.3%

This analysis was repeated for the previous five years of fire data. The results were similar in that Newton and Whalley continued to be overrepresented in terms of different sources of ignition (Table 12).

Table 12: Source of Ignition Compared over Six Surrey Communities over Previous Five Years

Source of Ignition	Cloverdale	Newton	Whalley	Guildford	S. Surrey	Fleetwood
Cooking Equipment (n = 380)	5.3%	39.2%	22.1%	13.2%	8.7%	11.6%
Heating Equipment (n = 89)	6.7%	30.3%	22.5%	12.4%	19.1%	9.0%
Appliances / Electrical Equipment (n = 25)	12.0%	24.0%	20.0%	16.0%	20.0%	8.0%
Match or Open Flame (n = 127)	16.5%	21.3%	27.6%	7.9%	13.4%	13.4%
Electrical Distribution Equipment (n = 67)	17.9%	29.9%	23.9%	10.4%	4.5%	13.4%
Other Electrical (n = 33)	9.1%	15.2%	24.2%	15.2%	18.2%	18.2%
Smokers Material (n = 84)	8.3%	23.8%	23.8%	17.9%	15.5%	10.7%
Exposure (n = 33)	0.0%	15.2%	45.5%	27.3%	3.0%	9.1%
Miscellaneous (n = 71)	8.5%	26.8%	38.0%	7.0%	16.9%	2.8%

A final analysis regarding the source of ignition of residential fires was performed to determine whether there were any significant relationships between the community and the source of fire. The data indicated that cooking equipment was significantly more likely to be a source of fire in Newton (50.5 per cent) or Fleetwood (49.6 per cent), and significantly less likely to be a source of fire in South Surrey (24.6 per cent) or Cloverdale (30.9 per cent).[8] However, residential fires resulting from a match or candle were

[8] x^2 (5) = 63.64, p < .001

significantly more likely to occur in South Surrey (25.4 per cent) or Cloverdale (21.5 per cent), and significantly less likely to occur in Newton (12.2 per cent) or Fleetwood (14.9 per cent).[9]

There was also a significant association between communities and heating as a source of residential fires. Specifically, heating equipment was significantly more likely to result in a fire in South Surrey (15.1 per cent) or Guildford (10.2 per cent) than in any of the other four communities of Fleetwood (7.9 per cent), Newton (8.0 per cent), Whalley (8.2 per cent), or Cloverdale (9.4 per cent).[10] Similarly, electrical distribution equipment as a source of residential fire was significantly more likely to occur in South Surrey (25.4 per cent) or Cloverdale (21.5 per cent), and significantly less likely to occur in Newton (12.2 per cent) or Fleetwood (14.9 per cent).[11] In contrast, fires resulting from exposure were significantly more likely to occur in Guildford (7.7 per cent) than in any other community, and were significantly less likely to occur in South Surrey or Cloverdale (1.3 per cent each).[12] Lastly, fires resulting from miscellaneous sources were significantly more likely to occur in Whalley (10.5 per cent) or South Surrey (9.9 per cent), and significantly less likely to occur in Fleetwood (2.2 per cent) or Guildford (4.1 per cent).[13]

There were no significant associations between community and smokers' material, appliances or electrical equipment, or other electrical equipment, as sources of fire, indicating that these sources of fire were not significantly more or less likely to occur in any of the six communities in Surrey.

In summary, fires in Newton and Fleetwood tended to be associated with cooking equipment, while fires in South Surrey and Cloverdale tended to be associated with use of a match or candle, heating equipment, or electrical distribution equipment; residential fires in Guildford tended to result from exposure, and residential fires in Whalley tended to result from miscellaneous sources. These results have important implications for public education initiatives as they suggest that some communities in Surrey are significantly more likely to experience specific sources of residential fire causes than other communities.

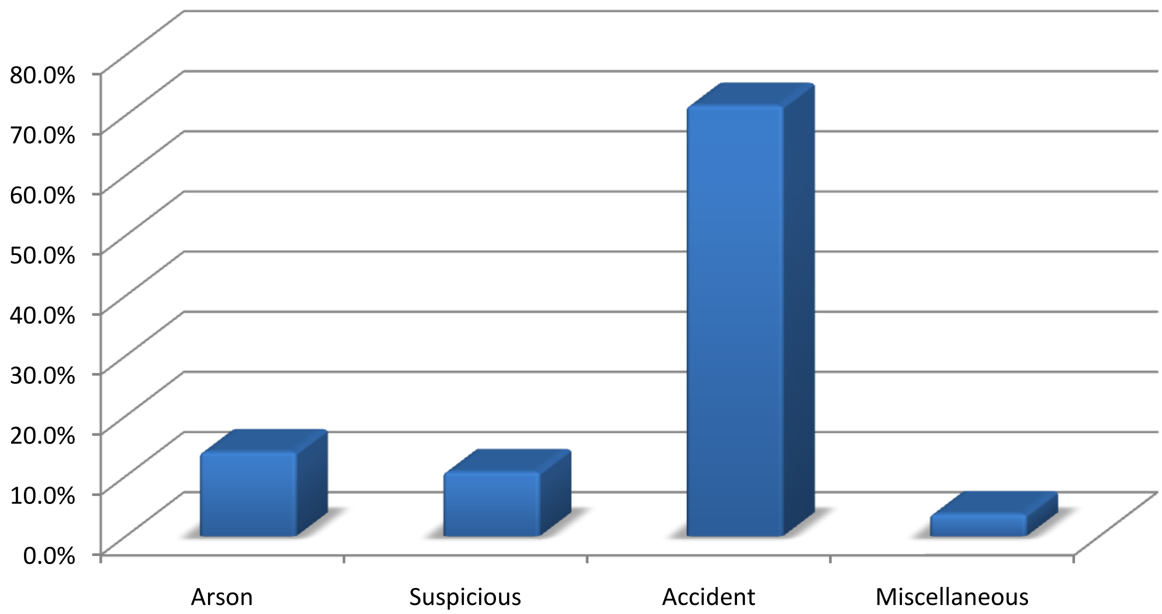
Cause of Residential Fires

The specific cause of fire can be attributed to an accident, an intentional fire, or a miscellaneous source. Of the 3,594 fires, the specific cause could not be identified for 531

[9] x^2 (5) = 25.25, p < .001
[10] x^2 (5) = 11.89, p < .05
[11] x^2 (5) = 25.25, p < .001
[12] x^2 (5) = 18.46, p < .01
[13] x^2 (5) = 22.04, p < .01

fires (14.8 per cent). When these fires were removed, the most commonly identified cause was overwhelmingly an accident (71.6 per cent). The most common cause of accidental fire was identified as "ignorance of hazard" (28.3 per cent). Another one-fifth of accidental fires (21.8 per cent) were attributed to distraction. Figure 12 displays the general cause categories for these residential fires; overwhelmingly, they are accidentally caused.

Figure 12: Intentional and Unintentional Causes of Fires (n = 3,063)

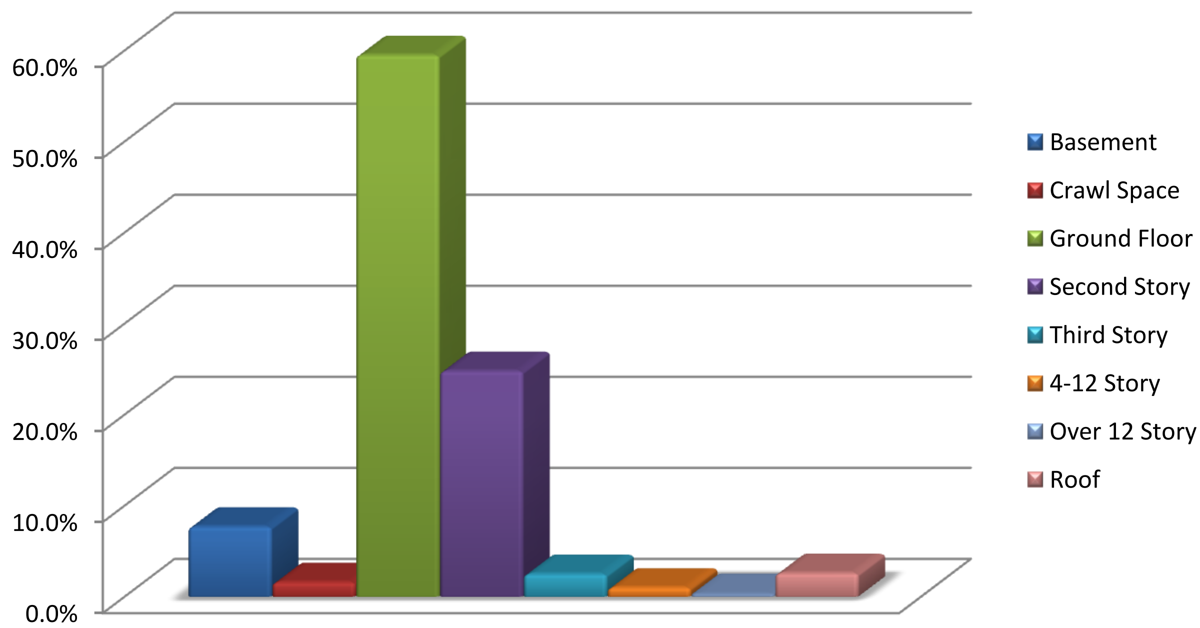


Arson related fires were primarily caused by an unknown motive (72.7 per cent). After removing those 312 arson fires, the majority of the remaining 59 arson fires were attributed to vandalism (69.5 per cent). Less than one-fifth (15.3 per cent) were attributed to revenge, whereas less than one in ten were attributed to either mental disorder or suicide (5.1 per cent), to cover up another crime (5.1 per cent), for intimidation (3.4 per cent), or for political, religious, or other civil reason (1.7 per cent). In the vast majority of arson cases (79.3 per cent), there was no suspect identified. In the 12 fires in which a suspect was identified, half the cases involved a child under the age of 11, and one-quarter were attributed either to a young offender (25.0 per cent) or to an adult (25.0 per cent).

Location of Origin and Spread of Fire

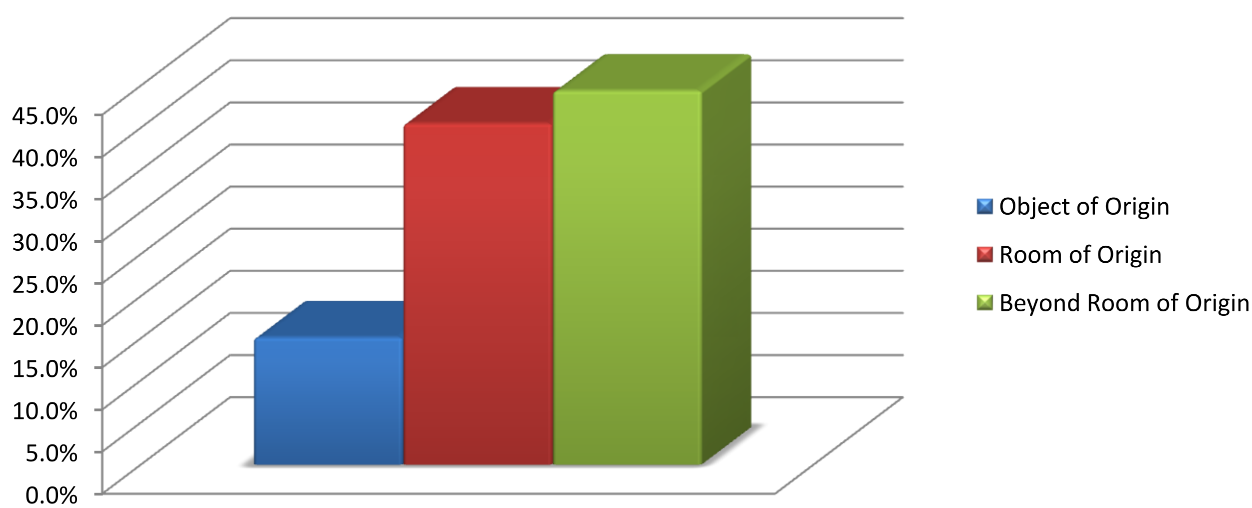
In the majority of residential fires, the fire originated on the ground floor (59.5 per cent) (Figure 13). Another one-quarter of residential fires originated on the second story floor (24.8 per cent). Very few residential fires originated in other locations within the house.

Figure 13: Location of Origin of Residential Fire (n = 3,400)



The severity of the fire was measured by the extent of spread throughout the residence. In nearly half of all cases (44.4 per cent), the fire spread beyond the room of origin (Figure 14). In another 40.5%, the fire was contained to the room of origin. In comparatively fewer cases, the fire was contained to the object of origin (15.1 per cent).

Figure 14: Spread of Fire from Origin (n = 3, 483)



Smoke Alarms

In 2,633 of the residential fires, the absence or presence of a smoke alarm was recorded (73.3 per cent of cases). As previously reviewed in the literature, smoke alarms are a primary prevention of fire related causalities. Despite this fact, more than one third (36.0 per cent) of residences involved in a fire did not have a smoke alarm installed. Furthermore, of the 1,554 residences that *did* have a smoke alarm installed, in half of the fires (49.5 per cent) the smoke alarm was not activated. In another 56 of these fires (3.6 per cent), the alarm activated but was unsuccessful as the resident was either unable to respond or the alarm was inaudible to the resident. Overall, of the 2,428 residences where smoke alarm information was available, less than one-third (30 per cent) had a functioning smoke alarm.

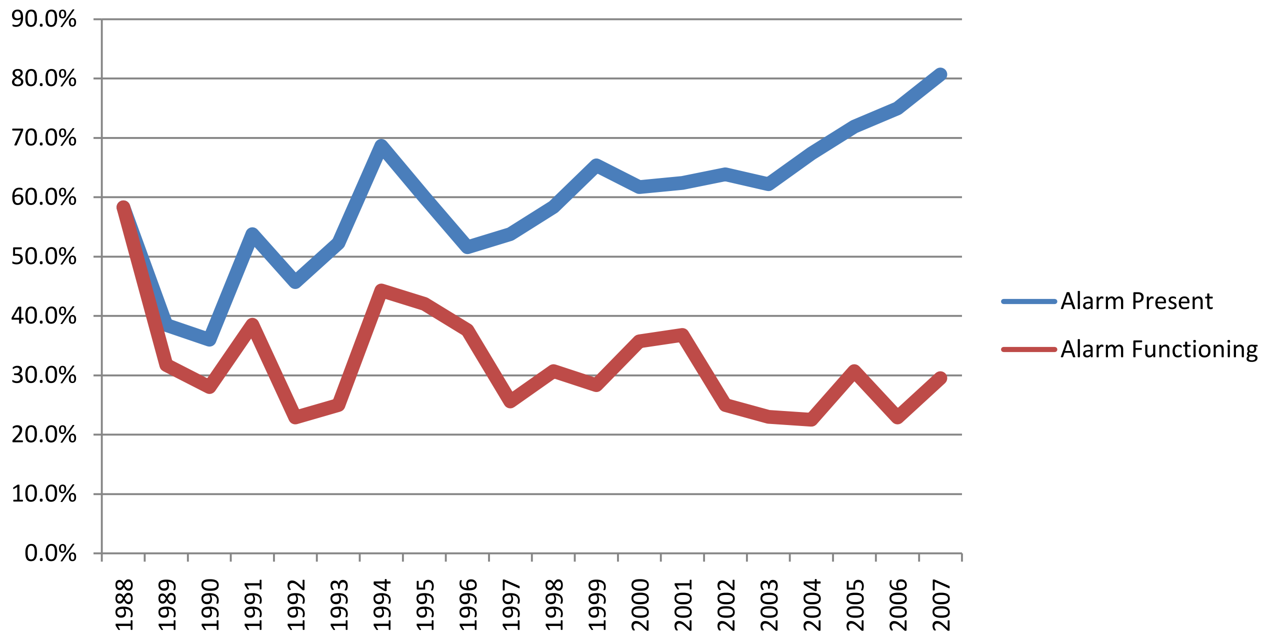
In the 770 fires in which the smoke alarm did not activate, the reason was primarily unknown (66.2 per cent). The remaining reasons were that the smoke alarm was located in an unsuitable place in the house (16.2 per cent), the battery was missing or dead (8.4 per cent), or the power was disconnected or turned off (7.7 per cent). In very few fires (1.4 per cent), the smoke alarm failed due to mechanical reasons.

Presence of Smoke Alarms by Year

Although the absence of a smoke alarm was relatively common when examining the full set of data, comparing the presence of a smoke alarm against the year of the fire revealed that, as expected, smoke alarms were not as common in the past. In other words, residential fires that occurred more recently were significantly more likely to have a smoke alarm present.[14] As shown in Figure 15, the proportion of residential fires in which a smoke alarm was present was largest in the most recent year of data available, at 80.7% in 2007. However, the proportion of residences that had a *functioning* smoke alarm had the opposite trend. In other words, while the presence of smoke alarms became increasingly common between 1988 and 2007, the likelihood that the smoke alarm would be functioning significantly decreased to the point where less than one-third of residences had functioning smoke alarms in place.[15]

[14] x^2 (19) = 108.82, p < .001
[15] x^2 (19) = 54.34, p < .001

Figure 15: Presence of Smoke Alarms and Functioning Smoke Alarms over the Previous 20 Years

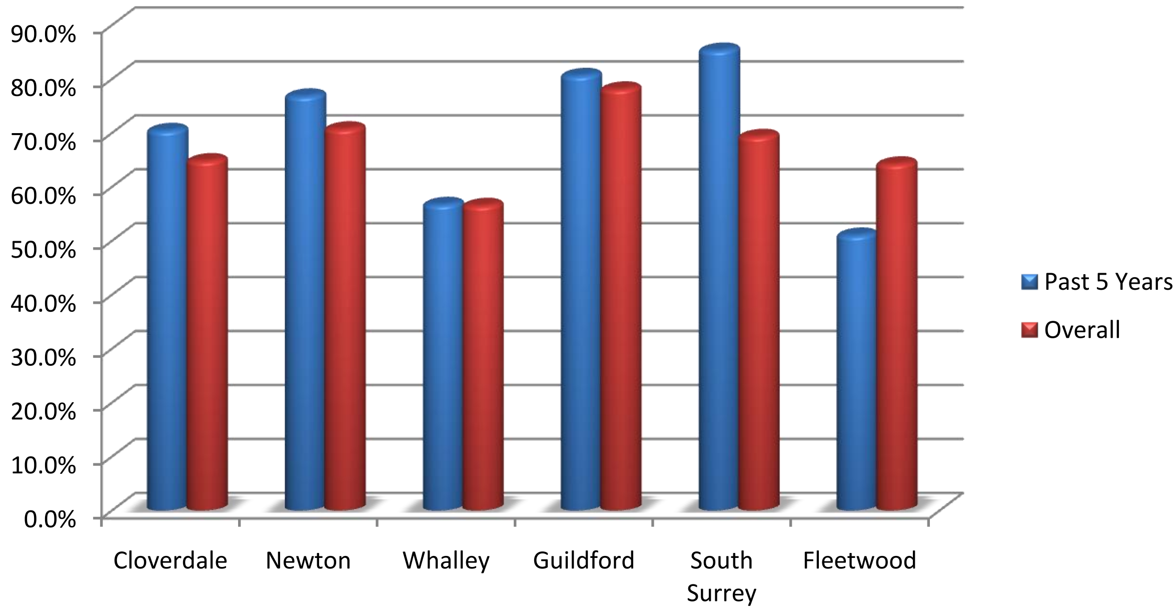


Smoke Alarms in Surrey Communities

The presence of smoke alarms was compared over the six communities in Surrey to determine whether particular communities were more or less likely to have a smoke alarm present. There was a significant relationship in that particular communities were more likely to have a smoke alarm present.[16] The community that was significantly least likely to have a smoke alarm present was Whalley (56.5 per cent) (Figure 16). In contrast, residences in Guildford were significantly more likely to have smoke alarms present (78.1 per cent); this may be a function of Guildford having the highest proportion of apartments. Also shown in Figure 16 are the percentages of residences who had a smoke alarm present in the previous five years. Generally, the presence of smoke alarms became more common over the years. However, this trend did not occur in Fleetwood. The other exception to this general trend was Whalley which had essentially the same proportion of residences with smoke alarms present between 1988 and 2007 (56.5 per cent) as they did in the most recent five years (56.7 per cent).

[16] x^2 (5) = 42.19, $p < .001$

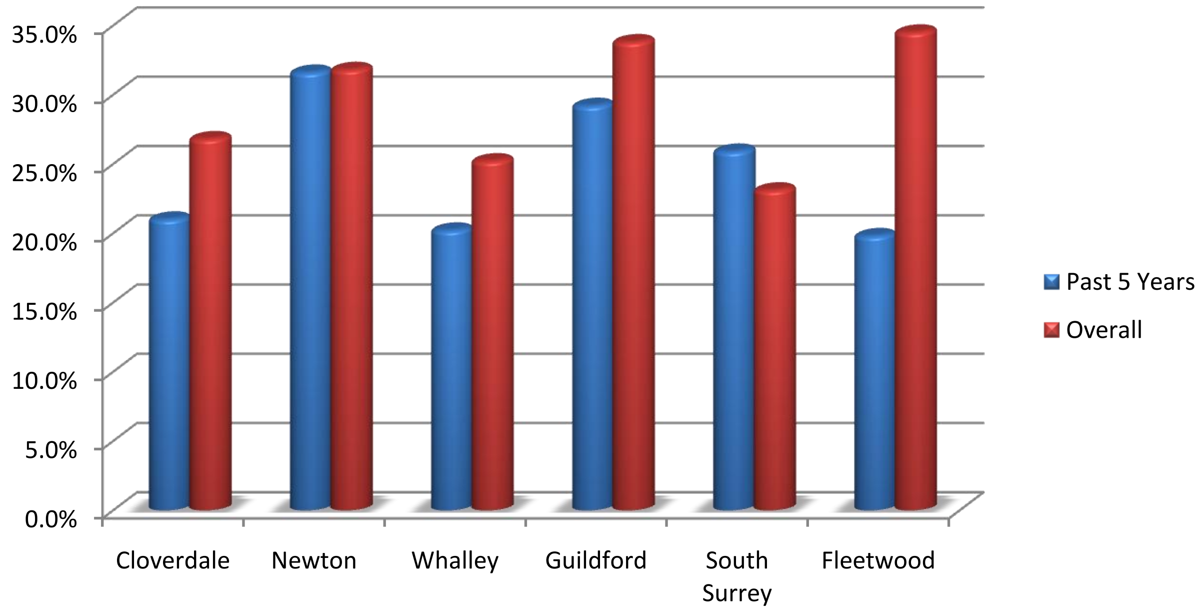
Figure 16: Presence of Smoke Alarms in Surrey Communities



While it was encouraging to see that the majority of residences had smoke alarms present, the proportion of residences that had a *functioning* smoke alarm present was substantially lower. Over all years of the data, residences in Guildford continued to be significantly more likely (33.8 per cent) to have a functioning smoke alarm than were residences in other communities, while residences in South Surrey were the least likely (23.1 per cent) to have a functioning smoke alarm present.[17] Interestingly, as shown in Figure 17, many of these percentages were lower in the past five years than over all years in which data was collected; this was particularly true of Fleetwood. In the most recent five years, Fleetwood was the least likely (19.8 per cent) community to have functioning smoke alarms installed. These results appear to indicate a declining trend in the proportion of smoke alarms that are properly maintained.

[17] x^2 (5) = 14.94, p < .05

Figure 17: Presence of Functioning Smoke Alarms in Surrey Communities



Smoke Alarms and Ownership

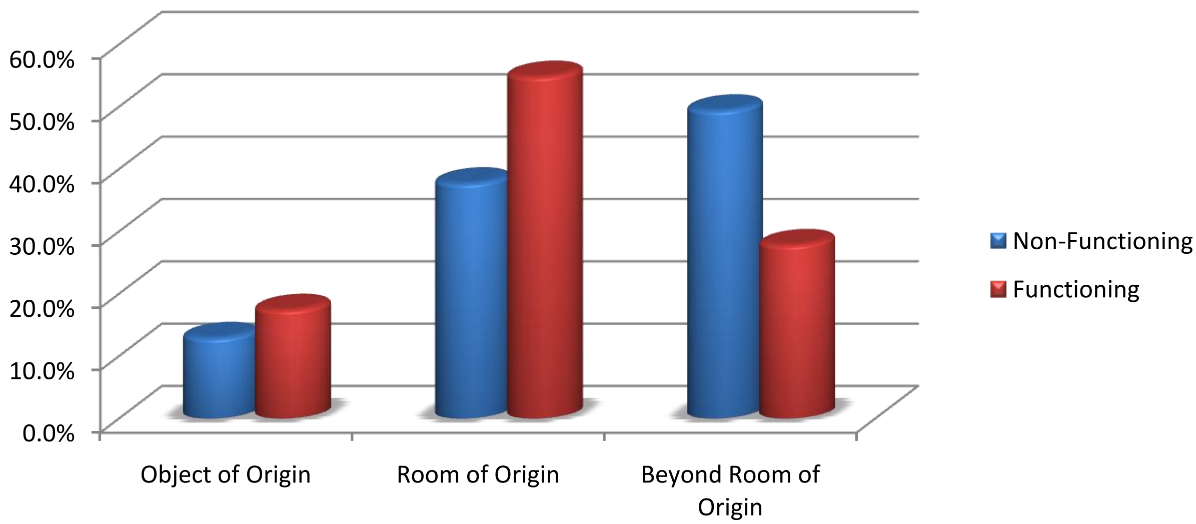
Smoke alarms were significantly more likely to be present in homes owned by the resident (68.5 per cent) than rented homes (49.0 per cent).[18] Likewise, privately owned homes were significantly more likely to have a *functioning* smoke alarm present (39.6 per cent) than were rented homes (25.0 per cent).[19]

Smoke Alarms and Severity of Fire

As previously mentioned, the severity of the fire was measured by the extent of spread beyond the object of origin. Perhaps unsurprisingly, the presence of a functioning smoke alarm was significantly related to a lesser extent of damage (Figure 18).[20] In effect, residential fires in which a smoke alarm was not functioning were more likely to spread to beyond the room of origin (49.4 per cent) than when a smoke alarm was functioning (27.8 per cent).

[18] x^2 (1) = 53.46, $p < .001$
[19] x^2 (1) = 32.13, $p < .001$
[20] t (1,633.99) = 4.63, $p < .001$

Figure 18: Spread of Fire when Smoke Alarm Present and Functioning (n = 2,403)



Cost of Residential Fires

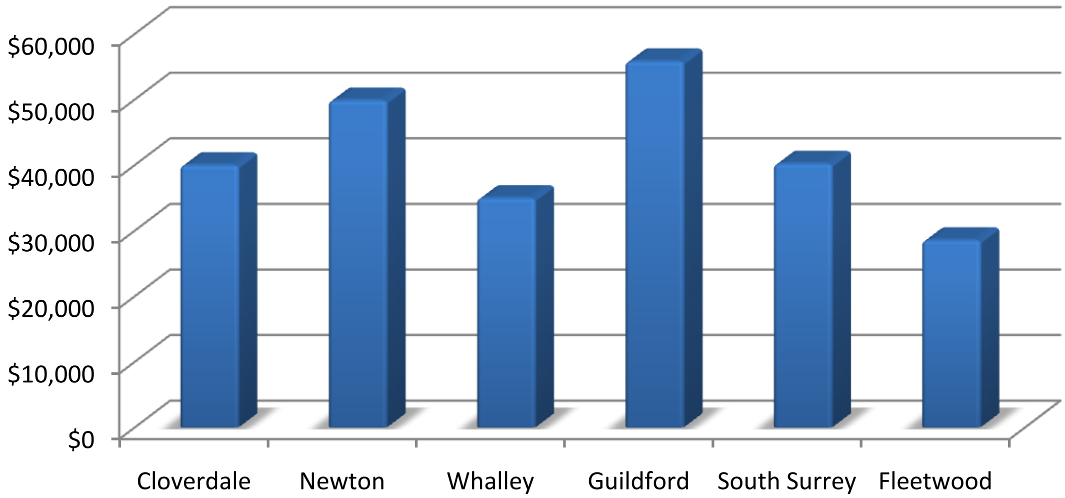
The total cost of the residential fires that occurred between 1988 and 2007 was estimated at $29,188,536. As the extent to which the fire spread increased, the associated property loss also increased.[21] There was a significant relationship between the amount of property loss and the timing of the fire; residential fires that occurred during the day resulted in a significantly higher amount of average loss ($53,622.57) than fires that occurred during the night ($28,203.80).[22] This may be a function of a longer response time to the fire during the day. Fires inside residences that are empty during the day time may burn for longer before the fire department is called to respond, resulting in more damage, as compared to fires that occur at night where a smoke alarm may alert those inside to the presence of a smouldering fire.

Cost Per Community

The average cost of residential fires across all six communities in Surrey was $42,427.16. While residential fires in Guildford resulted in a higher average loss than the other six communities, there was no significant relationship between communities and cost associated with residential fires (Figure 19).[23]

[21] $r(3,483) = .21, p < .001$
[22] $t(3,006.62) = 4.39, p < .001$
[23] $F(5) = 1.308, p > .05$

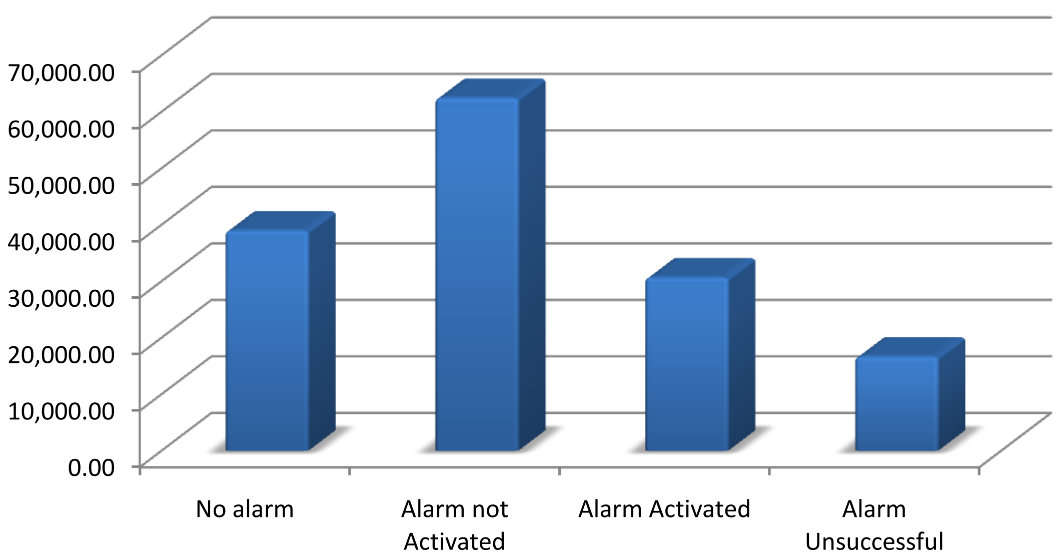
Figure 19: Average Loss Associated with Residential Fires in the Six Surrey Communities



Cost and Smoke Alarm Status

The cost of residential fires was significantly associated with the smoke alarm status.[24] Residential fires in which there was a smoke alarm present that did not activate resulted in the highest average amount of loss (Figure 20). Fires where the alarm was not activated resulted in significantly higher average loss ($62,454.72) than when the alarm was activated ($30,671.72).

Figure 20: Average Cost per Smoke Alarm Status



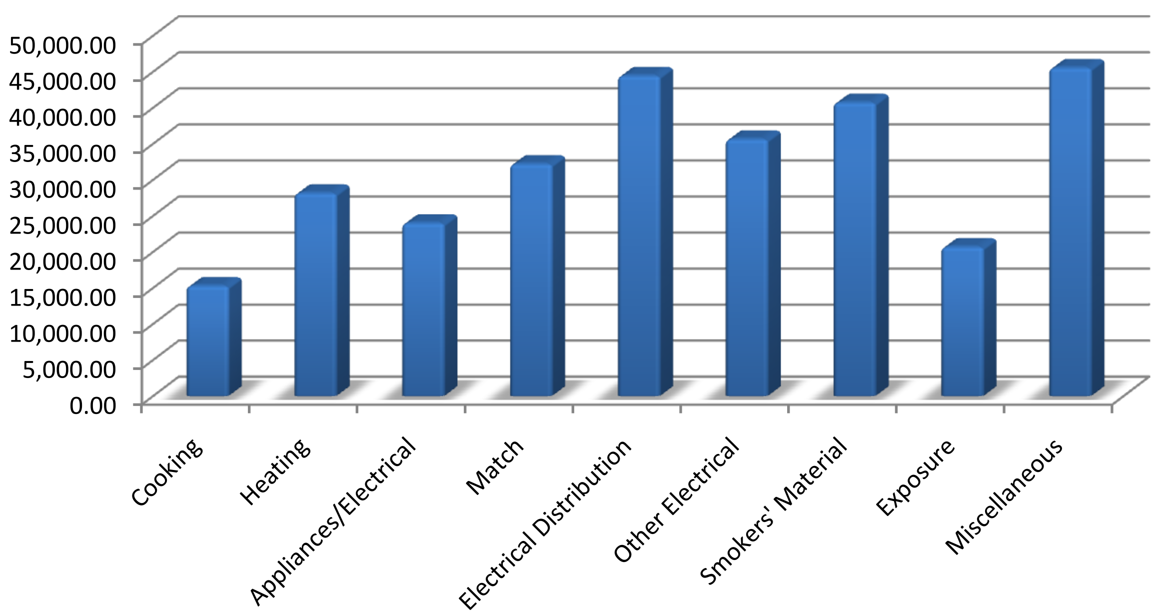
[24] $F(3) = 3.871, p < .01$

Likewise, the presence of a *functioning* smoke alarm was significantly associated with a lower average cost ($30,671.72) than fires without a functioning smoke alarm ($48,879.60).[25] In effect, residential fires where there was no functioning smoke alarm resulted in, on average, $18,207.88 more in damage.

Cost per Source of Ignition

The amount lost was also significantly associated with the source of ignition.[26] The highest average cost was associated with fires resulting from either a miscellaneous source or electrical distribution (Figure 21). Fires from cooking equipment resulted in a significantly lower average loss ($15,300.33) than did fires from a match or open flame ($32,213.58), electrical distribution equipment ($44,453.95), smokers' material ($40,739.74), or from a miscellaneous source ($45,553.24). This result was likely due to the faster response from a resident who accidentally started a fire when cooking as opposed to a less immediately noticeable source of fire resulting from a match, electrical equipment, smokers' material (e.g. cigarette), or other source.

Figure 21: Cost of Residential Fire per Source



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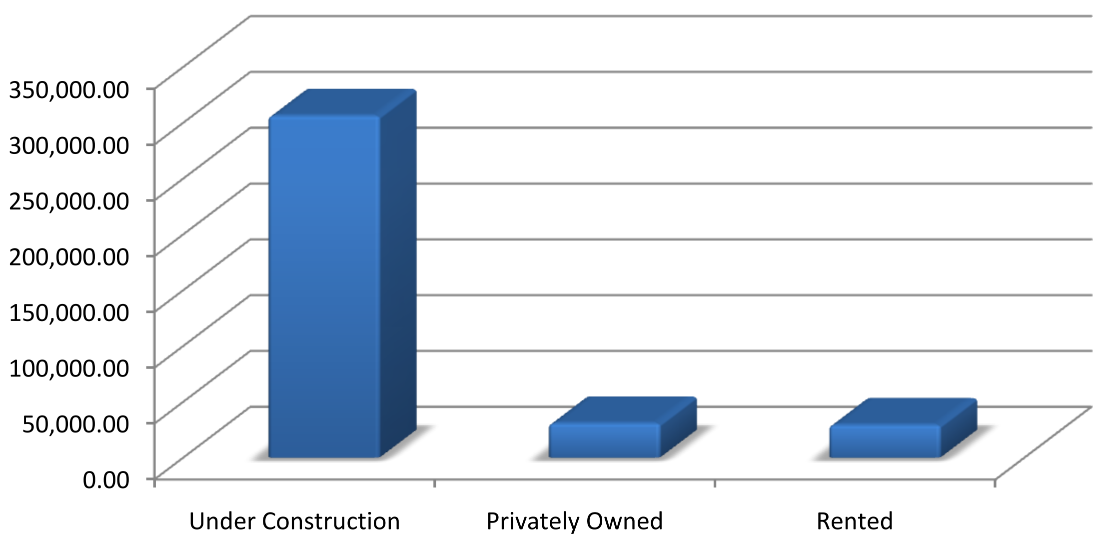
[25] t (2,424.18) = 2.78, p < .01
[26] F (8) = 7.31, p < .001

Cost of Fire per Ownership Status

The amount of loss was also significantly related to ownership status.[27] Residences that were under construction resulted in a significantly higher average loss ($306,255.60) when compared to privately owned residences ($30,675.72) and rented residences ($29,247.72) (Figure 22). This finding can be explained by the fact that buildings under construction have not yet been fitted with methods for fire resistance, such as windows, doors, drywalls, and fire separations. Given these conditions, a fire in a building under construction will be provided with sufficient oxygen and dry materials to grow, and will therefore spread more quickly and cause more extensive damage.

Figure 22: Average Cost of Residential Fires per Ownership Status

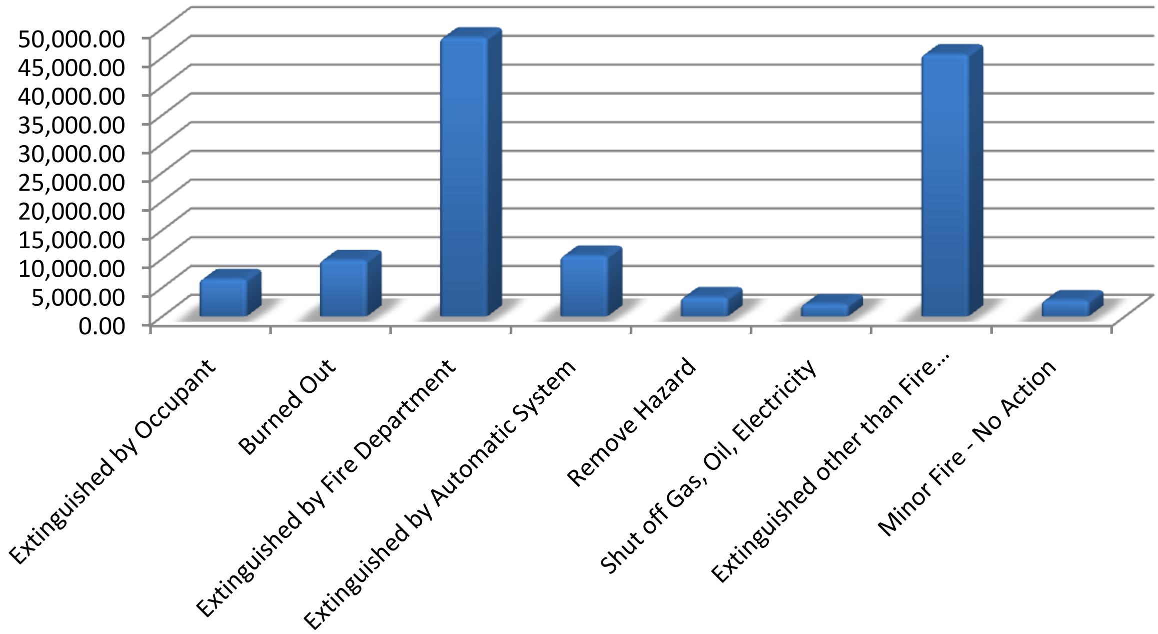


Cost of Residential Fires per Action Taken

The nature of the action taken in response to the fire significantly affected the average cost of the residential fire[28]. As shown in Figure 23, residential fires were associated with the highest average cost when they were extinguished by the fire department ($48,497.83) or by something other than the fire department ($45,572.01). Fires that were extinguished by the fire department were associated with a significantly higher average cost ($48,497.83) when compared to fires extinguished by the occupant ($6,500.65).

[27] $F\ (2) = 87.58$, $p < .001$
[28] $F\ (7) = 4.44$, $p < .001$

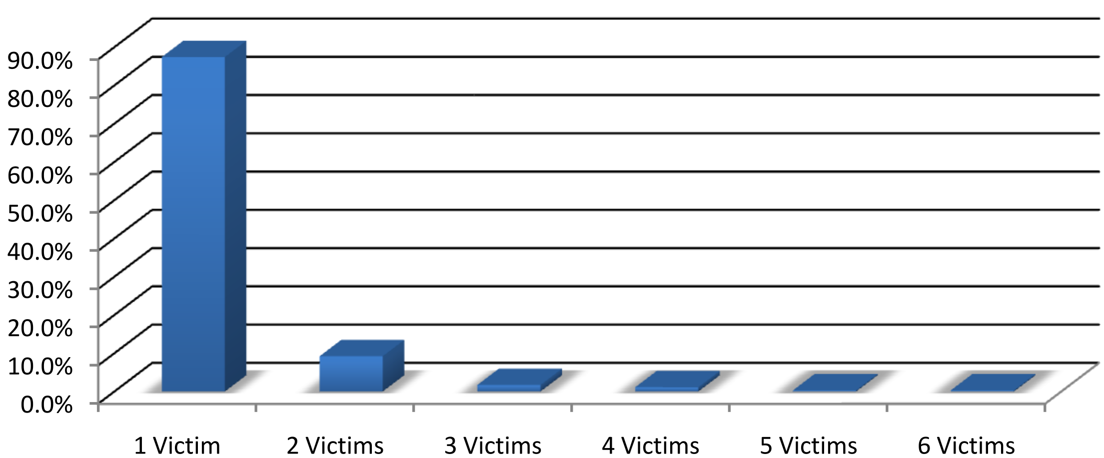
Figure 23: Cost of Residential Fire per Action Taken



Residential Fire Casualties

Approximately one in ten residential fires (9.8 per cent) resulted in an injury, while very few fires (0.8 per cent) resulted in a death. In the vast majority of cases where there was a casualty, there was only one victim injured (87.4 per cent) (Figure 24).

Figure 24: Number of Injured Victims in Residential Fires (n = 349)



Likewise, in nearly all 31 cases involving a fatality, there was only one victim (92.9 per cent); in fact, only two residential fire fatalities resulted in the deaths of two persons (7.1 per cent).

Casualties over 24-Hour Day

Consistent with prior research, residential fires that occurred overnight (8 pm to 7 am) were significantly more likely to result in an injury (64.2.0 per cent) than residential fires that occurred during the day (35.8 per cent).[29] While it is possible that this finding could be attributed to the fact that victims are less aware of a growing fire overnight, being asleep was only identified as a cause of fire in seven of the residential fires resulting in injury. However, it is important to note that the information regarding the victim characteristics was not available, and the *cause* of fire may differ significantly from the likelihood of injury.

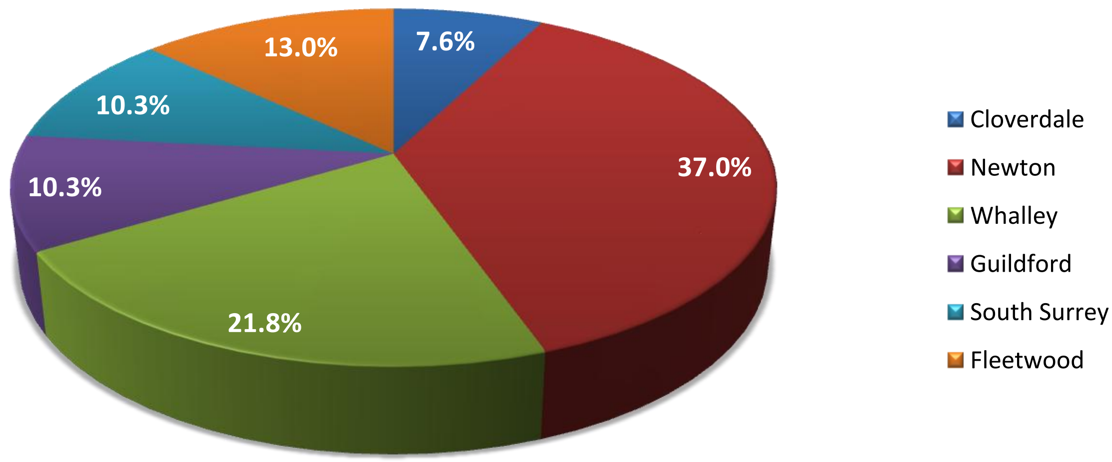
Interestingly, when looking specifically at the relationship between fire fatality and time of day, residents were significantly more likely to die during a daytime fire (67.9 per cent).[30] However, it is important to remember that this analysis is based on a small sample of only 28 fires resulting in death. Furthermore, there is limited data regarding the victims of fires; therefore, it is not possible to explain this relationship in terms of important victim characteristics, including age, disability, or intoxication. However, in five of the residential fires resulting in death, it was suspected that a potential cause of the fire was either impairment or falling asleep due to impairment. Disability was identified as a cause of fire in only one of the 25 deaths. Instead, the most common cause of fire identified was smokers' material (16 per cent; n = 4).

Casualties and Communities

Given that residential fires were most common in Newton, it was not surprising that Newton accounted for over one-third (37.0 per cent) of injuries in which community was recorded (Figure 25). However, after controlling for the number of residential fires, there was no significant association between communities and the likelihood of injury.[31] While Newton still accounted for the largest percentage of residential fire injuries (12.1 per cent), this was not significantly different from the number of residential fire injuries in Fleetwood (11.6 per cent), Cloverdale (9.6 per cent), South Surrey (8.7 per cent), Guildford (8.3 per cent), or Whalley (8.2 per cent).

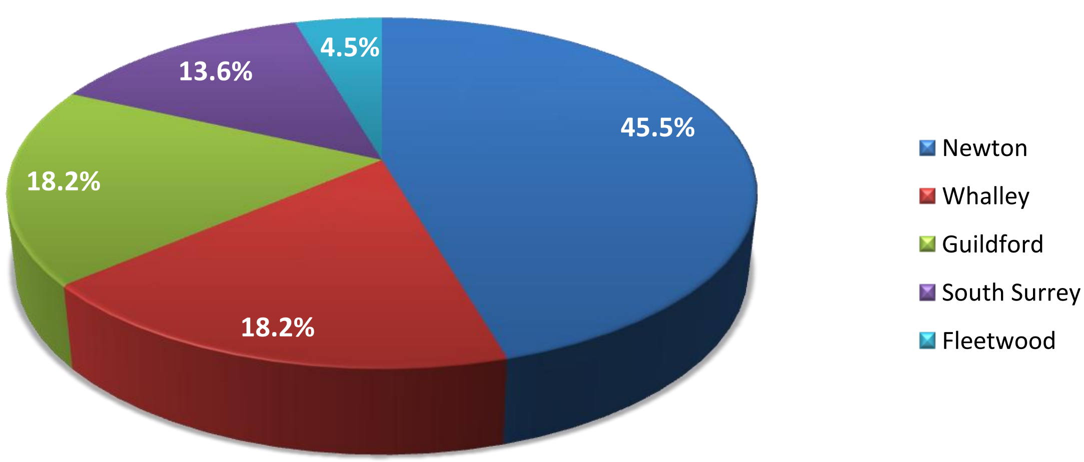
[29] x^2 (1) = 7.99, p < .01
[30] x^2 (1) = 7.04, p < .01
[31] x^2 (5) = 8.86, p > .05

Figure 25: Communities in which Injury Occurred (n = 262)



Similarly, Newton accounted for nearly half (45.5 per cent) of the 22 fires resulting in death (Figure 26). However, this was not significantly higher than any other community.[32] Specifically, 1.2% of fires resulted in death in either Newton or Guildford, 1% in South Surrey, and less than 1% in Whalley and Fleetwood (0.6 and 0.3 per cent, respectively). There were no fire-related deaths in Cloverdale.

Figure 26: Communities in which Death Occurred (n = 22)



[32] x^2 (5) = 5.38, p > .05

Casualties and Home Ownership

When comparing homes that were privately owned with those that were rented and the likelihood of injury or death occurring, there were no significant relationships. Homes that were owned by the resident were equally as likely (10.8 per cent) to result in injury as were rented homes (9.3 per cent).[33] Likewise, homes that were privately owned were just as unlikely to result in death (0.8 per cent) as were rented homes (0.9 per cent).[34] This is an interesting result, given that a previous analysis identified that private homes were significantly more likely to have functioning smoke alarms present than rented homes, which theoretically should reduce the likelihood of injury occurring.

Casualties and Smoke Alarms

Of the 244 fires resulting in injury, a significantly higher percentage involved fires in which there was no functioning smoke alarm (58.2 per cent) (41.8 per cent).[35] However, when examining the relationship between injuries and the presence of a smoke alarm, whether functioning or not, a significantly higher proportion of injuries occurred in situations where there was a smoke alarm present (73.8 per cent).[36] This was a very significant finding as it suggested that the presence of a fire alarm lowered the perceived risk of the resident as to the potential consequences of a fire. In other words, the presence of a smoke alarm may convince residents that they do not need to be as vigilant in preventing or responding to fire. This is a dangerous misperception as this attitude potentially resulted in a significantly higher proportion of injuries. This result also suggested that residents must be more vigilant in ensuring that their smoke alarms are functioning.

The presence of a functioning smoke alarm was compared across communities to determine whether they had an effect on the likelihood of injury in a particular area. Injuries in Newton were significantly more likely to occur in the absence of a functioning smoke alarm (55.6 per cent) than in the presence of one (44.4 per cent).[37] Interestingly, injuries in South Surrey were significantly associated with the *presence* of a functioning smoke alarm (57.1 per cent), as opposed to the absence of a functioning smoke alarm (42.9 per cent).[38] This relationship also occurred in Guildford, where there were more injuries associated with the presence of a functioning smoke alarm (55.6 per cent) than in the absence of one (44.4 per cent).[39] These results may be a function of an older population (South Surrey) or apartment dwellers (Guildford); in both situations, it may be more

[33] x^2 (1) = 1.24, $p > .05$
[34] x^2 (1) = .07, $p > .05$
[35] x^2 (1) = 17.62, $p < .001$
[36] x^2 (1) = 11.48, $p < .01$
[37] x^2 (1) = 5.80, $p < .05$
[38] x^2 (1) = 9.62, $p < .01$
[39] x^2 (1) = 4.14, $p < .05$

difficult for the resident to successfully execute an escape plan quickly enough to avoid injury.

Information regarding the presence of a functioning smoke alarm was available for 24 fire-related deaths. The data revealed that in more than eight out of every ten fire-related deaths, there was no functioning smoke alarm in place (83.3 percent). However, similar to the previous analysis, three-quarters of fire-related fatalities occurred in locations where there was a smoke alarm, whether or not it was functioning. These results suggested that smoke alarms were being installed, but not maintained in functioning status. For instance, residents may have installed the smoke alarm but removed the battery at a later date. As such, these results support the importance of regularly maintaining a smoke alarm to ensure functionality.

Additional information regarding functioning smoke alarms and the community in which the fire-related death occurred was available for 18 cases. Again, the data indicated that there was no functioning smoke alarm in many of the fires in which death occurred (Table 13). While the majority of residences in which death occurred had a smoke alarm installed, in all communities except Fleetwood, one-third or fewer had a functioning some alarm installed.

Table 13: Communities in which Death Occurred and Smoke Alarm Status

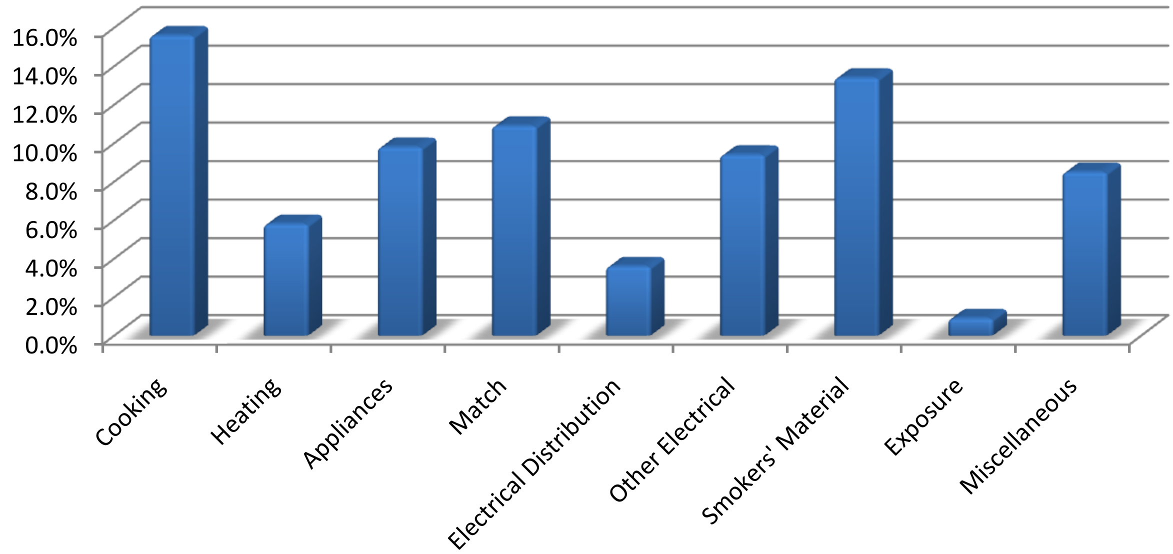
Community	Smoke Alarm Present	Smoke Alarm Functioning
Newton (n = 9)	66.7%	11.1%
Whalley (n = 3)	66.7%	33.3%
Guildford (n = 3)	100.0%	33.3%
South Surrey (n = 2)	100.0%	0.0%
Fleetwood (n = 1)	100.0%	100.0%

Casualties and Source of Ignition

The source of ignition was significantly associated with the likelihood of injury.[40] Injuries were significantly more likely to result from a fire caused by cooking equipment (15.6 per cent) than a fire caused by exposure (0.9 per cent) (Figure 27). In total, cooking related fires accounted for over half of all recorded injuries (55.2 per cent).

[40] x^2 (8) = 53.82, p < .001

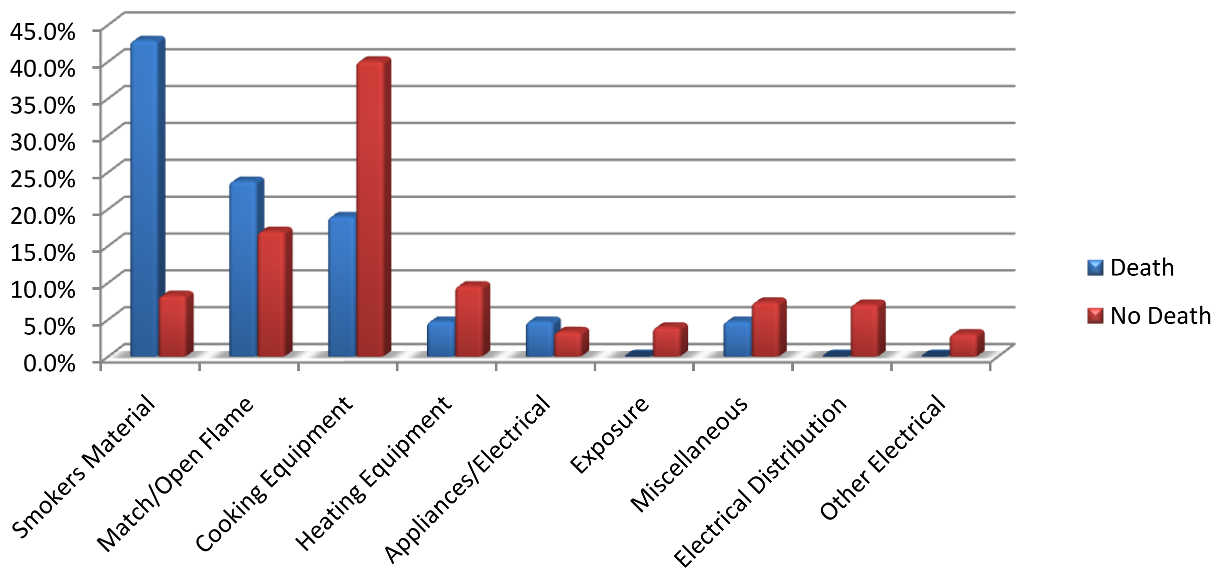
Figure 27: Sources of Ignition resulting in Injuries (n = 2,702)



Similarly, there was a significant association between the source of ignition and the likelihood of a fatality.[41] Smokers' material was the most likely source of ignition to result in death (42.9 per cent). Of the 21 fatalities in which information was available, three sources of fire were overwhelmingly responsible (Figure 28); smokers' material (42.9 per cent), a match or open flame (23.8 per cent), and cooking equipment (19.0 per cent). Presumably, with respect to the first two situations, the fire resulted from a resident falling asleep while smoking or while there was an open flame, such as candle, left burning. In the latter case, prior literature suggested that alcohol intoxication may be an important factor in death resulting from cooking equipment. However, data regarding intoxication of victims was not available in the current data set; therefore, the extent to which intoxication played a role in the current study cannot be determined.

[41] x^2 (8) = 35.80, p < .001

Figure 28: Source of Ignition for Fire-Related Fatalities (n = 21)



Predicting Likelihood of Injuries

A logistic regression analysis predicting the likelihood that an injury would occur was performed. The factors selected for inclusion in the model were: night-time fire; source of ignition (specifically, cooking, matches, or smoking); functioning smoke alarm; spread of the fire; and community. These factors produced a significant model (Appendix H).[42] Specifically, cooking as a source of ignition, smokers' material as a source of ignition, and a functioning smoke alarm were all significant predictors of injury. Fires that occurred as a result of cooking were 2.3 times more likely to result in an injury compared to fires that were a result of smokers' material (2.1 times likely). Interestingly, the presence of a functioning smoke alarm raised the odds of being injured in a fire nearly 1.5 times.

Predicting Likelihood of Death

The same analysis was performed using death as the outcome variable. However, given that previous analysis indicated that death was more likely to occur during the day than at night, daytime was considered. The predicting factors again produced a significant model[43]. However, only one variable emerged as a significant predictor: smokers' material (Appendix I). This factor raised the odds of death occurring substantially to 5.5 times more likely.

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[42] x^2 (11) = 41.81, p < .001
[43] x^2 (11) = 26.99, p < .01

Predicting Spread of the Fire

A multiple regression analysis was performed to identify which factors were predictive of greater spread of the fire. The factors that were tested in this analysis included: source of ignition (cooking, match, smokers' material); daytime fire; community; and presence of a functioning smoke alarm. The results were significant[44]. Three of the predicting factors emerged as significant predictors of spread of the fire (Appendix J). Specifically, daytime fires and fires in Newton were significantly more likely to involve greater spread, while cooking fires were significantly less likely to involve greater spread.

Predicting Presence of a Functioning Smoke Alarm

A final predictive analysis was run to determine the likelihood of a functioning smoke alarm being present. The factors used to predict this status were: community; ownership; height of building; and year of construction. The resulting model was significant[45]. Four of the factors were significant predictors of the presence of a functioning smoke alarm, including ownership status, living in Newton or South Surrey, and the year of construction (Appendix K). Specifically, those who owned and lived in their own residence were nearly 2.5 times more likely to have a functioning smoke alarm present. Newton and South Surrey were significantly less likely than Fleetwood residences to have functioning smoke alarms present. Finally, with each decrease in the years since constructed, the odds of a functioning smoke alarm being present were increased by 1. For example, a house built in 1990 would be ten times more likely to have a functioning smoke alarm in place compared to a house built in 1980.

Discussion

The available fire data analyzed in this report revealed some important trends in fire safety that will assist the fire department in better targeting future fire safety education campaigns. The data revealed that each community in Surrey has specific risk factors associated with negative outcomes resulting from residential fires.

The analyses indicated that, over the most recent five years, the rate of fires per 100,000 members of the population remained relatively consistent, at approximately 85 fires, dropping to less than 80 in the most recent year in which data was collected (2007). However, despite the recent drop in fire incidents in 2007, structure fires have generally become increasingly more commonplace. This suggests that there is a need for public education regarding safe fire practices and an increased awareness regarding fire hazards.

[44] $F(10) = 11.09$, $p < .001$; $r^2 = .07$
[45] $x^2(8) = 38.50$, $p < .001$

The majority of residential fires occurred in a year round use, single-family dwelling. A large proportion of the homes were privately owned and lived in, whereas approximately one-quarter were rented. This is somewhat inconsistent with the prior literature, as past research identified rental units as at a greater risk for fire. However, this result implied that education and distribution campaigns may have a greater chance of succeeding, given that the resident who will be provided with the smoke alarm will likely also be the one who can make the decision to have the alarm installed by the fire department. Likewise, they may also be more likely to accept the fiscal responsibility for maintaining the alarm in working condition. These conclusions are supported by the results suggesting that both the presence of smoke alarms, as well as the presence of functioning smoke alarms, were more prevalent in homes owned and lived in by the resident than those lived in by a renter.

With respect to the communities experiencing the greatest proportion of fires, the rate of residential fires over the 20 years in which data was collected indicated that Newton, Whalley, and Guildford all experienced the greatest number of residential fires. In contrast, Fleetwood and South Surrey experienced the lowest rates of residential fire, while the residential fire rate in Cloverdale steadily increased.

As previously mentioned, each community was associated with a particular set of risk factors for residential fire and subsequent outcomes. Over the most recent five years of data, Newton accounted for the largest proportion of residential structure fires. An important finding was that half of all residential fires occurring in Newton resulted from cooking equipment. This result indicated that there is an essential need to provide education to residents of Newton regarding fire safety in the kitchen. It may also be beneficial for residents living in Newton to be encouraged to install smoke alarms close to the kitchen to allow for a more timely response to the onset of fire. This suggestion is even more important given the results of the smoke alarm analysis. In effect, injures resulting from residential fire were significantly more likely to occur in the absence of a functioning smoke alarm. The relative risk for harm from residential fire in Newton can be reduced by encouraging residents to not only install, but also maintain, their smoke alarms in areas where they will be most efficient, including the kitchen.

The second highest proportion of residential fires occurred in Whalley. Over one-third of these fires resulted from cooking equipment, while slightly less than one in ten were caused by a match or open flame. Residential fires resulting from a miscellaneous source were significantly more likely to occur in Whalley than in most other communities, with the exception of South Surrey. Residents in Whalley were significantly less likely to install smoke alarms than residents in other communities. This information is important for distribution campaigns as they suggest that Whalley would be the community that would most likely benefit from receiving both information and a free smoke alarm.

In contrast, residents in Guildford were significantly more likely than in the other communities to have a smoke alarm installed. Guildford emerged as the third most common community to experience residential structure fires. Cooking equipment was identified as the most common source of ignition followed by a match or open flame. In the most recent five years of data, however, smokers' material has emerged as the second most common source of ignition.

The fourth highest proportion of fires occurred in South Surrey. Interestingly, South Surrey was the one community where the greatest proportion of fires was caused by something other than cooking equipment. In fact, a slightly higher percentage of fires in South Surrey were caused by a match or open flame. Similar to Guildford, in the most recent five years of data, smokers' materials were responsible for a higher proportion of residential fires, though these rates did not exceed the number of fires caused by cooking equipment, heating equipment, or match or open flame. Although South Surrey residents were no less likely than residents in most other communities to install a smoke alarm, they were the least likely to have a *functioning* smoke alarm. Therefore, rather than engaging in a distribution campaign in South Surrey, the results suggested that a more appropriate public outreach may involve awareness regarding the need to maintain smoke alarms on a regular basis.

The fifth highest proportion of fires occurred in Fleetwood. Approximately half of all residential fires occurring in Fleetwood resulted from cooking equipment. These residents could also benefit from an education campaign partnered with smoke alarm distribution as the results indicated that, in the past five years, approximately half of Fleetwood residences had a smoke alarm installed.

Although the proportion of residential fires has been increasingly recently in Cloverdale, this community continued to reflect the lowest proportion of residential fires. Next to South Surrey, Cloverdale experienced the second highest proportion of residential fires occurring from a match or open flame; however, the most common source of fires in this community continued to be cooking equipment. Interestingly, the greatest proportion of smoking-related fires over the previous two decades also occurred in Cloverdale.

The vast majority of residential fires were caused by an accident, rather than arson or a miscellaneous source. An important finding from this analysis was that regardless of community, cooking equipment consistently appeared as a leading cause of fires. This is important as it suggests that there is a need for greater public education regarding the potential fire hazards associated with cooking. This conclusion is especially relevant given that the majority of injuries occurred in residential fires caused by cooking. In fact, fires that were caused by cooking equipment were 2.3 times more likely to result in an injury than fires caused by other sources.

An interesting result, with respect to the trends in the source of fire ignition, was the recent increase in the proportion of fires resulting from smokers' materials. The proportion of citizens smoking cigarettes has generally been declining over the past two decades; therefore, it was unexpected to document increases in this category over the most recent years in which data was collected. It is important to study this phenomenon further, because fires started by smokers' material were 5.5 times more likely to result in death than fires starting from another source.

The fact that cooking and smoking related fires were associated with risk of injury or death from residential fires was an important finding, as both of these factors are modifiable through public education and awareness. In other words, the public can be made aware of how to reduce the risk for residential fire when engaging in these behaviours. Ideally, the proportion of fires resulting from human error will then be reduced, simultaneously reducing the risk for injury and/or death.

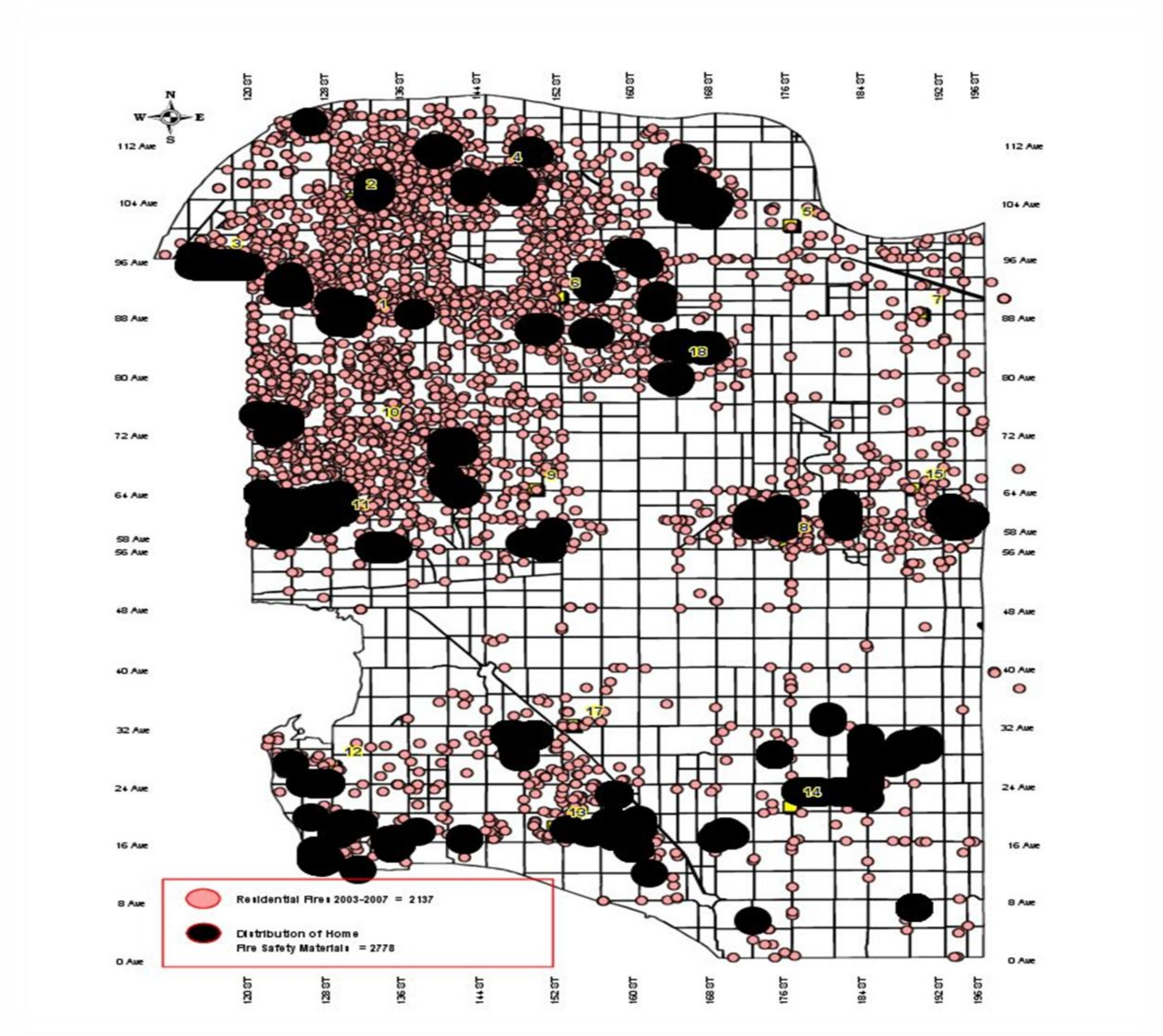
A theme consistently identified in previous literature was the importance of smoke alarms. In the current study, more than one third of residences did not have a smoke alarm installed. Moreover, of those who did, the alarm was not activated in nearly half of the residential fires. It is possible that these residents were not aware that their alarm was non-functioning; research by Douglas, Mallonee, and Istre (1999) identified that there was a 17% to 22% gap between residents who believed their smoke alarm was functioning (ranging from 66 per cent to 71 per cent) and those whose alarms actually did function during testing (49 per cent). In the current study, while the primary cause for this lack of activation was unknown, other common factors included that the alarm was located in an unsuitable place, the battery needed to be replaced, or the power was disconnected. These results suggested that it is imperative for the fire department to educate citizens regarding the beneficial effects of a functioning smoke alarm, not only in preventing injury and death, but also to prevent the spread of the fire and the associated financial losses.

However, an interesting relationship was discovered regarding the presence of smoke alarms and injury resulting from the fire, as the presence of a functioning smoke alarm was actually associated with an increased risk for injury. There are several plausible explanations for this unexpected finding. The first is that the injuries may have been associated with cooking fires. If a fire started from cooking and the alarm activated, the resident may have reacted by attempting to put out the flames, which increased the risk for injury. An alternative potential explanation is that the resident was unable to successfully execute their escape plan once the smoke alarm started; this is particularly likely to be true for young children and seniors, as they may not have been woken by the alarm. In addition, if they had been alerted by the alarm, the young children may have panicked and hidden, whereas the senior may have had limited response options due to age or disability; either situation would increase the risk for injury.

Future Research

As a first step in educating the public regarding the risk for fire and need for fire safety, the Surrey Fire Department recently engaged in a fire safety information campaign. During the 2008 Fire Prevention Week (October 5th-11th), Surrey firefighters went door to door in areas where fires were concentrated delivering information on typical sources of fire (e.g. cooking) and fire safety prevention techniques (e.g. smoke alarm installation) (Figure 29). They hand delivered nearly 2,800 fire safety brochures to residents in these neighbourhoods and engaged in discussion with residents regarding fire safety behaviours.

Figure 29: Fire Prevention Week Home Safety Brochure Distribution



In October 2009, initial analysis will determine whether the proportion of fires that occurred in the areas where brochure delivery was concentrated have decreased as compared to approximately 120,000 non-recipient residents. This analysis will be repeated over the next few years to determine whether the information campaign had any long-term effects on fire safety behaviours among residents in at-risk communities in Surrey.

A similar analysis will be conducted on any neighbourhood in which distribution campaigns are undertaken. This report identified certain communities who appear to be in need of smoke alarm distributions; should such a campaign occur, it is essential that its effects on fire prevalence by analyzed.

Given the important results regarding smoke alarms and risk for injury, additional data will be analyzed regarding victim characteristics, in order to determine why a functioning smoke alarm was associated with injuries occurring. Important characteristics to review will include impairment, age, and/or disability of the victim.

Another area of focus for future research will be on the increasing trend of smokers'-related fires. As stated previously, it was unexpected to find that a greater proportion of fires could be attributed to smokers' material in more recent years. Additional analyses are required to determine whether this result was a function of changing recording practices or whether these results indicate a possible increasing trend of marijuana cigarette use as a source of fire.

Conclusion

This report provided an initial exploratory and descriptive analysis of residential fires in Surrey, British Columbia. The data revealed that the most common source of fire is cooking, many homes involved in fire did not have a functioning smoke alarm present, and different communities within the City of Surrey had varying needs in terms of risk factors and appropriate interventions.

The frequency of residential fires occurring in the City of Surrey has been increasing over the past two decades. While this is to be expected on the basis of population growth, it was not expected to document a declining trend in the proportion of residences with functioning smoke alarms in place. Taken together, these statistics support the need for greater public education regarding the risk for residential fire and ways to reduce this risk.

The data reviewed for this current report provided important information regarding the fire risk and safety trends specific to communities within Surrey, B.C. While future analyses can benefit from the collection of additional data, including victim characteristics, the trends identified in the current report should be sufficient to assist the Fire Department in deciding which methods of education or awareness campaign are likely to be most effective in each community. Given that there is some evidence that public education can be successful in terms of promoting fire safety awareness, it is essential that such education occur in order to minimize risk of physical and financial harm to residents.

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Appendix A

Table 14: Rate of Fires Occurring over All Years Collected

Year	Fires per Year	Population Estimate	Rate of Fires per 100,000
1988	24	212,862	11.27
1989	217	212,862[46]	101.94
1990	177	271,396	65.22
1991	227	287,177	79.04
1992	220	302,823	72.65
1993	101	315,566	32.01
1994	241	327,348	73.62
1995	229	336,327	68.09
1996	231	347,030	66.56
1997	188	356,931	52.67
1998	229	363,705	62.96
1999	245	368,565	66.47
2000	261	374,597	69.67
2001	306	380,694	80.38
2002	344	388,486	88.55
2003	323	400,067	80.74
2004	363	409,280	88.70
2005	370	421,870	87.70
2006	386	437,685	88.19
2007	345	452,396	76.26

[46] Estimated using the same figure as data is only available for 1986

Appendix B

Table 15: Rate of Residential Fires in Whalley per 10,000 Residents

Year	Fires per Year	Population Estimate	Rate of Fires per 10,000
1994	24	83,178	2.89
1995	43	84,385	5.10
1996	36	85,171	4.23
1997	39	85,968	4.54
1998	41	86,370	4.75
1999	49	86,699	5.65
2000	49	86,967	5.63
2001	49	87,118	5.62
2002	55	87,772	6.27
2003	58	88,848	6.53
2004	73	89,408	8.18
2005	58	89,951	6.45
2006	65	92,069	7.06
2007	57	94,828	6.01

Appendix C

Table 16: Rate of Residential Fires in Guildford per 10,000 Residents

Year	Fires per Year	Population Estimate	Rate of Fires per 10,000
1994	13	46,275	2.81
1995	13	47,854	2.72
1996	20	49,278	4.06
1997	18	50,746	3.55
1998	8	51,557	1.55
1999	23	51,867	4.43
2000	26	52,362	4.97
2001	20	53,445	3.74
2002	25	54,468	4.59
2003	35	55,381	6.32
2004	27	56,221	4.80
2005	25	57,636	4.34
2006	47	58,545	8.03
2007	31	59,559	5.20

Appendix D

Table 17: Rate of Residential Fires in Fleetwood per 10,000 Residents

Year	Fires per Year	Population Estimate	Rate of Fires per 10,000
1994	8	40,198	1.99
1995	22	41,813	5.26
1996	20	44,796	4.46
1997	17	46,653	3.64
1998	23	47,344	4.86
1999	24	47,978	5.00
2000	18	49,059	3.67
2001	19	50,046	3.80
2002	20	51,938	3.85
2003	38	53,913	7.05
2004	31	55,372	5.60
2005	23	56,386	4.08
2006	18	58,268	3.09
2007	13	59,210	2.20

Appendix E

Table 18: Rate of Residential Fires in Newton per 10,000 Residents

Year	Fires per Year	Population Estimate	Rate of Fires per 10,000
1994	18	81,580	2.21
1995	50	83,614	5.98
1996	44	86,148	5.11
1997	34	88,982	3.82
1998	54	91,827	5.88
1999	52	93,681	5.55
2000	51	95,711	5.33
2001	56	97,336	5.75
2002	81	99,761	8.12
2003	70	103,070	6.79
2004	66	106,268	6.21
2005	87	111,972	7.77
2006	77	117,020	6.58
2007	73	119,536	6.11

Appendix F

Table 19: Rate of Residential Fires in Cloverdale per 10,000 Residents

Year	Fires per Year	Population Estimate	Rate of Fires per 10,000
1994	2	26,336	0.76
1995	9	27,596	3.26
1996	16	28,833	5.55
1997	15	30,552	4.91
1998	12	31,560	3.80
1999	11	32,306	3.40
2000	12	32,844	3.65
2001	10	33,763	2.96
2002	17	34,419	4.94
2003	15	36,792	4.08
2004	11	38,232	2.88
2005	24	40,845	5.88
2006	24	45,329	5.29
2007	30	49,113	6.11

Appendix G

Table 20: Rate of Residential Fires in South Surrey per 10,000 Residents

Year	Fires per Year	Population Estimate	Rate of Fires per 10,000
1994	10	49,779	2.01
1995	16	51,065	3.13
1996	23	52,803	4.36
1997	14	54,030	2.59
1998	24	55,047	4.36
1999	13	56,036	2.32
2000	20	57,653	3.47
2001	31	58,986	5.26
2002	20	60,128	3.33
2003	25	62,063	4.03
2004	28	63,779	4.39
2005	32	65,080	4.92
2006	35	66,455	5.27
2007	23	70,149	3.28

Appendix H

Table 21: Factors Predicting Injuries

Factor	B	Significance	Odds Ratio
Night-time	.24	.22	1.27
Source of Ignition			
Cooking	.82	.00	2.28
Match	.51	.09	1.66
Smokers' Material	.72	.03	2.05
Functioning Smoke Alarm	.37	.04	1.44
Spread of Fire	.06	.32	1.06
Community			
Cloverdale	-.17	.67	0.85
Newton	.25	.34	1.29
Whalley	-.24	.41	0.79
Guildford	-.33	.35	0.72
South Surrey	-.56	.16	0.57
Fleetwood	-	-	-

x^2 (11) = 41.81, $p < .001$

Appendix I

Table 22: Factors Predicting Death

Factor	B	Significance	Odds Ratio
Day-time	1.07	.06	2.90
Source of Ignition			
Cooking	0.12	.89	1.13
Match	1.45	.51	4.27
Smokers' Material	1.73	.03	5.65
Functioning Smoke Alarm	-0.57	.39	0.56
Spread of Fire	0.20	.27	1.22
Community			
Cloverdale	-16.22	.99	0.0
Newton	1.27	.24	3.55
Whalley	-1.00	.48	0.37
Guildford	0.98	.41	2.65
South Surrey	0.44	.72	1.56
Fleetwood	-	-	-

x^2 (11) = 26.99, $p < .01$

Appendix J

Table 23: Factors Predicting Spread of Fire

Factor	t	Significance	Beta
Day-time	3.19	.00	.09
Source of Ignition			
Cooking	-7.28	.00	-.23
Match	-.67	.50	-.02
Smokers' Material	.29	.77	.01
Functioning Smoke Alarm	-1.53	.13	-.04
Community			
Cloverdale	-	-	-
Newton	2.25	.03	.11
Whalley	1.15	.25	.05
Guildford	1.05	.29	.04
South Surrey	0.90	.37	.03
Fleetwood	1.68	.09	.07

$F\ (10) = 11.09$, $p < .001$

Appendix K

Table 24: Factors Predicting Presence of Functioning Smoke Alarm

Factor	B	Significance	Odds Ratio
Owned by Resident	0.89	.00	2.43
Community[47]			
Cloverdale	-0.29	.52	0.74
Newton	-0.73	.02	0.48
Whalley	-0.16	.58	0.85
Guildford	-0.48	.15	0.62
South Surrey	-1.41	.03	0.25
Height	0.25	.09	1.3
Year Constructed	0.02	.05[48]	1.0

x^2 (8) = 38.50, p < .001

[47] Fleetwood was treated as the reference variable.
[48] p = .045