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Advances in Home Safety Systems

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Abstract

People need to be protected from the dangers of home invasion and fire. The elderly and the handicapped need additional protection which, when provided in the home environment, allows them greater independence than residence in an institution.

We discuss the characteristics of fires in domestic dwellings and look at strategies to protect those who are most likely to be injured by fire. We consider the behavior of criminals as they attack homes and look at methods of defense both now and in the future. In relation to this, we consider the impact of sophisticated artificial vision software such as facial recognition and behavior recognition. Behavior recognition is particularly important in monitoring the infirm; sensors installed in the home can record behavior, recognise healthy and aberrant behavior patterns and alert stakeholders using remote communication. However such systems are not currently practical.

Introduction

This paper is divided into three sections, each of which looks at an important aspect of home safety, namely, safety from fire, safety from burglary/assault and safety from collapse.

In the first section, statistics are presented for the risk of fire in New Zealand homes. The reasons why certain portions of the population have a higher than average risk of fire are considered, together with appropriate fire safety strategies.

In the second section, home invasion and burglary statistics are presented for New Zealand and other countries. The impact of burglary, the underlying reasons why people turn to burglary and patterns of burglar behavior are considered. The section finishes with measures which the homeowner can take to reduce the likelihood of burglary and a look at government strategies for reducing this type of crime.

The third section considers the safety risk of collapse or medical catastrophe for the elderly and describes the options for improving this risk.

Domestic fire safety

In New Zealand over the period 1995 to 2005, the fire service attended an average of about 3,140 residential fire incidents per year and these led to an average of 21 deaths and 240 injuries (Robbins et al., 2008). The most common and most effective fire detection device is a smoke detector (Ahrens, 2008) but there are no statistics on how many fires are prevented by these devices because the householder, alerted to a potential fire by the alarm, takes steps to remove the fire danger and does not report the non-fire event. Annual surveys by the New Zealand Fire Service indicate that approximately 90% of New Zealand's 1.7 million dwellings currently have at least one smoke detector, although the actual percentage is probably lower since some of the people surveyed would falsely claim to have a smoke detector because they knew that they should have one (Challands, 2010).

When there is a fire in a house fitted with a smoke detector, UK and USA data show that about half of the smoke detectors were not working (Peek-Asa et al., 2005; Rowland et al., 2001; Ahrens, 2008), usually because the battery had been removed because of unwanted activations or nuisance alarms from cooking smoke or from low-battery chirping. Fatalities from fires in homes are halved when there is a smoke detector. The effectiveness of a smoke detector depends upon its location, the level of background noise and upon the state of the resident. In terms of location, 90% of fatal fires start in bedrooms, lounge/dining rooms and kitchens (Duncan & Wade, 2001) so detectors should be close to these areas. Further, multi-storey homes should have at least one detector on each storey (Peek-Asa et al., 2005). Residents who are suffering from fatigue, drugs, alcohol, hearing loss and mental illness will have a decreased response to the alarm (Bruck, 2001).

There is an 80-96% increase in fire survival rate when the house has a sprinkler system and smoke alarm (Fuller, 1991). Sprinkler systems are very reliable, operating in about 95% of fires in NZ homes and only failing because of manual intervention (Duncan & Wade, 2001). They are designed primarily to contain a fire rather than extinguish it although they extinguish about 20% of fires. They also result in much less fire damage and water damage compared with unsprinklered homes. In the US from 1994-1998 about 2% of homes had automatic sprinkler systems (Robbins et al., 2008) but they are rare in New Zealand homes because of the high cost. According to the Homesafe website, the cost of installing a home sprinkler system in a new 3-bedroom house is about \$3,000 (NZ). The cost of retrofitting a

system is higher because of access to fit the pipe work. The New Zealand Building Code of Practice NZS4509 encourages home sprinkler systems as the best means to mitigate fire risk and in 2004 the New Zealand Fire Service began promoting sprinkler installation as a strategic initiative under the building standard NZS4517 (Department of Building and Housing, 2008). There are currently about 2,500 to 3,000 sprinkler systems installed in New Zealand homes. About 30% of these are in 'higher risk' homes (such as retirement homes, homes for the disabled, respite homes, etc.) and the rest are predominantly in more upmarket homes (Firestone, 2010).

Worldwide, domestic fire fatalities and injuries are highest for the poorest and most uneducated sector of the population (Peek-Asa et al., 2005; Istre et al., 2002). The same is true in New Zealand, where these people are three times more likely to be hospitalized from injuries from domestic fires (Hoskins et al., 2001) despite only making up about 15% of the population (Dixon & Maré, 2007). They have a higher risk of danger from fire because they are more likely to smoke, drink and take drugs, they prefer fried food, they have looser supervision of children because of stress or intoxication of caregivers, they are more likely to be cold and use unsafe cooking and heating practices, they have higher levels of mental illness, they lack fire safety awareness, they have low literacy levels (so they are not able to read the fire education pamphlets), they have a lower rate of installed smoke detectors, their smoke detectors are not maintained, their homes are overcrowded and they are more prone to make unsafe alterations to dwellings (Hoskins, et al. 2001). It is enormously important to consider this fact when trying to improve domestic dwelling fire safety. Promotion of smoke detectors and sprinkler systems and pamphlets outlining correct maintenance and positioning of smoke detectors will have limited success amongst the poorest people. Instead, a compassionate government will need to use strategies such as supporting smoke free legislation, lobbying for self extinguishing cigarettes, provision and maintenance of free or low cost smoke detectors and appropriate education on safe smoking habits, drugs and alcohol, safe heating and cooking and fire safety awareness (Hoskins et al. 2001).

Safety from home invasion or burglary

'Burglary' means 'house theft' and comes from the German words 'berg' meaning 'house' and 'laron' meaning 'thief' (Glick, 2005). It results in loss of property as well as possible bodily harm. Burglary victims feel shock at the invasion of privacy and the loss of a sense of security within the home as well as sadness at losing objects of sentimental value (Kearon & Leach, 2000). Life satisfaction surveys are used to get a number score showing how satisfied people are with various aspects of their lives such as health, relationships, income, etc. According to Cohen (2008) such surveys show that burglary victims suffer a reduction in life satisfaction equal to that for a person moving from excellent to good health. He estimates a compensating income equivalent of about \$85,000 (US) for a home burglary. The elderly feel particularly vulnerable to burglary and assault and this is often the main reason why they move from their own house into an old age institution (Taylor & Donnelly, 2006).

Burglary statistics

The number of burglaries per capita varies widely from country to country. Table 1 shows the average number of burglaries per capita for several countries over the period 1998 to 2000 (NationMaster crime statistics). Over this time, Australia had the highest per capita burglaries and New Zealand the 6th highest out of 54 countries.

Table i: Average annual burglaries per capita by country from 1998-2000

Rank	Country	Burglaries per 1,000 people
# 1	Australia	21.7
# 6	New Zealand	16.3
# 7	United Kingdom	13.8
# 17	United States	7.1
# 29	Japan	2.3
# 54	Saudi Arabia	4.2x10 ⁻⁴

Source: Seventh United Nations Survey of Crime Trends and Operations of Criminal Justice Systems, covering the period 1998-2000 (United Nations Office on Drugs and Crime, Centre for International Crime Prevention) via NationMaster

Current New Zealand Crime Statistics from Statistics New Zealand (2009) show that over the period 2007 to 2009 there were an average of 59,866 reported burglaries, of which 16.3% were resolved. Over this period the New Zealand population averaged 4,273,300 (Statistics New Zealand, 2010) which implies an average of 14.0 burglaries per 1,000 people. Whilst it is pleasing to see that the figure has dropped since 1998-2000, it is noteworthy that over 50 thousand burglaries per year are not resolved. Further, while burglary is one of the highest crimes reported to police, about 32% of home burglaries in New Zealand are not reported (Morris & Reilly, 2003).

In trying to model the behavior of burglars, researchers look at the data from resolved burglaries and from interviews with convicted burglars. It is important to realize that this represents a very small proportion of the total burglaries (16.3% for New Zealand) and relates to the most unsuccessful burglars, i.e., the ones that got caught. For example, Bernasco & Nieuwebeerta (2005) studied home burglaries in the city of The Hague in the Netherlands and found that only 5.3% of offenders were juveniles under 18 years old who were driven not only by a need for money but also by sensation seeking and gang loyalty. However, young burglars tended to operate impulsively; grabbing a single item and running away, so they were less likely to be caught and the burglary was less likely to be reported. Mature, repeat burglars used careful planning and preparation and took more items so the burglary was more likely to be reported to the police and the burglar caught. Hence, the proportion of juvenile offenders is likely to appear lower than it actually is.

The behaviour of burglars

There are many theories on criminal behavior, broadly categorised as sociological and psychological. Sociological theories assert that poverty and unemployment cause crime; a burglar cannot get a job and doesn't have enough money to live on, so he adopts burglary as a profession and spends his time researching potential target homes, establishing the routine behavior of the occupants and watching for signs such as an overflowing mailbox or a large television box put out for recycling, which indicate the best opportunity to burgle.

Psychological theories are based on the notion that the criminal has a different psychology and biology from other people. He lacks a conscience and self-restraint, is indifferent to the feelings of others and has an appetite for danger and adventure. He may have a biological propensity for burglary if he comes from a family of burglars.

It is likely that both theories are partly true and it has been suggested that the common denominator in the two theories is low intelligence. Hernstein & Murray, 1994, note that low intelligence often leads to failure at school and in the job market, resentment towards society and its laws and a lack of foresight which makes the immediate rewards from burglary outweigh the fear of being caught and punished. Statistically convicted criminals are known to have lower than average IQ (bearing in mind the caveat in the previous section and the notion that more intelligent criminals are less likely to be caught). Jensen, 1998 reports that

people with IQs between 70 and 90 have higher crime rates than those whose IQs are above or below this range. Rushton & Jenson (2005) narrow this to a peak range for crime for people with IQs from 80 to 90. There are many critics of the IQ theory of crime, for example, Gasper (2009).

Setting aside the underlying causes of why people become burglars, researchers agree on the following patterns of behavior common to burglary (Buck & Hakim, 1993; Morris & Reilly 2003; Tseloni et al., 2004; Bernasco & Nieuwbeerta, 2005):

- Burglars prefer to operate in familiar neighborhoods which are relatively close to their own residences and which are located a short distance from a major thoroughfare. This means the burglar can operate quickly, with known escape routes.
- Burglars prefer to target homes that are unoccupied, accessible (single storey/single family houses with doors and windows on the ground floor), offer places of concealment and are unguarded (either by alarms, dogs or a neighbourhood watch). However, sometimes the presence of security devices indicates valuable property and can make a house a more attractive target for burglars.
- Most burglaries occur during weekdays between 9 am and 5pm and the most common entry points are the doors and windows. Burglars look in all the common places where people leave spare door keys and will only break the door if they don't find the key.
- Households whose occupants have higher income, status and/or education have more valuable contents and are therefore more likely to be burglarised. Burglars will often burgle a house a second time, generally within 3 months, when the valuable items have been replaced.

Prevention strategies

There are several basic steps which homeowner can take to reduce their risk of being burgled. The New Zealand Police, State Insurance Company and ADT Home Security Company recommend the following:

- Make the house look occupied by getting neighbors to collect mail, using timers to turn interior lights on and off at night, parking a vehicle in the driveway and avoid leaving messages on the home phone or email saying that the occupants will be away.
- Secure the house with strong, solid-core doors, deadbolt locks, windows with burglar guards or locking mechanisms, a guard dog, exterior lighting (operated using a timer or a motion detector), a security alarm and warning signs indicating that there is a neighborhood watch, a dog and/or an alarm which is monitored by a security company.
- Change the locks and the alarm code when moving into a new home and keep a record of everyone who has keys or knows the alarm code.
- Keep a record of serial numbers of valuable items as well as photographs and receipts for insurance purposes. Do not advertise a new possession by putting its box out for recycling.
- Join community safety programmes such as the neighborhood watch and, in New Zealand, Operation SNAP (Serial Number Action Project).

In the United States, Buck & Hakim (1993) showed that homes which did not have security alarms were 2.7 times more likely to be burgled than alarmed ones. The New Zealand police recommend a basic security alarm (with sensors capable of distinguishing between human and pet movement, a touch pad, control unit with battery back-up and an internal and/or external alarm) which should be installed and monitored by a company holding a valid Security Guard's license. More sophisticated systems have the ability to alarm certain areas

of the house, detect intruders on the perimeter and have panic alarms which allow self-activation of the alarm.

There is also the relatively new concept of crime prevention through environmental design (CPTED); the design of the built environment to reduce opportunities for crime (Plaster Carter, et al., 2003). Strategies such as surveillance (either human or using cameras), access control (using fencing and limiting entry points) and territorial enforcement (using landscaping, lighting and signs to express ownership) make the risk of being caught seem more likely than the chance of a successful/lucrative burglary.

At the government level, there have been numerous attempts to reduce burglary and crime. In the United Kingdom, the Yew Tree Strategic Development Project used a policy of police crackdown and consolidation from 1999 to 2000 (Millie, 2005). The crackdown phase involved the deployment of a high visibility police team, dedicated community beat officers, known profiles of repeat offenders, the use of stop and search and key arrests, strict enforcement of bail conditions and the issue of civil orders (for possession and anti-social behaviour). Community consolidation involved publicising the programme (handing out crime-prevention packs, press releases, encouraging neighbourhood support groups), providing radios which the public could use to report suspicious people to the police, provision of youth activities (gardening and football coaching), property marking and improvement of the local environment (planting thorny bushes around entry points, clearing undergrowth from paths to limit hiding places etc.). The project was similar to the 'Weed and Seed' project in the United States, which aimed to reduce a variety of crimes including burglary. The Yew Tree Project resulted in an initial dramatic drop in home burglaries (to 1/3 of the burglaries prior to the programme) which lasted for a few (6) months but which then rose to about 1/2 the pre-programme burglaries.

Future prevention strategies

There are two probable routes for the future prevention of home burglary, namely the development of gated communities and the increased use of CCTV cameras.

A gated community is a residential area with restricted access. It is not a new concept, having been used during the Middle Ages and the Renaissance by royalty who used moats, drawbridges and towers to isolate themselves from danger. According to Drew & McGuigan (2005), the United States is being transformed into a nation of gated communities. In 2005, 8 million Americans lived in them and an estimated 8 out of 10 new urban projects were gated. Security is provided using walls, fences, surveillance cameras, infrared sensors, motion detectors, armed guards, etc. In order to enter, a visitor drives through a gate where a uniformed guard with a pistol checks the name against a visitors list. The advantage of a gated community is that there is less crime, the residents feel safer and have a greater community spirit. Critics of the scheme say that the residents become isolated from the mixed open society which fosters segregation.

There are three types of gated communities; lifestyle communities, elite communities and security zone communities. A typical example of a lifestyle community is a gated retirement community which provides the elderly with a greater level of security than can be found in individual homes in open communities. Elite communities are gated communities for the top one fifth of Americans and focus on image and status through exclusion. Security zone communities are communities which are gated by the residents themselves in a "fortress-mentality" style (Drew & McGuigan, 2005).

The United Kingdom has followed the second route and become one of the most monitored countries in the world with about 4 million cameras (1 for every 14 people). Britain has 1% of the world's population but 20% of its CCTV cameras. From 1996-2006, 500 million pounds had been spent on CCTV surveillance with about 200 million pounds for cameras in the London area (Hope, 2009). Bowcott (2006) reports that the investment has not had much impact on crime prevention, because little thought was put into how the police could use the images. However, it is

likely that the technology will become more effective as modern software tools become available. Work is being done to establish a London-wide database of images of suspects. There is facial recognition software and software which can track logos on clothing. Even without these tools, when a crime is committed, the images retrieved from nearby cameras can be put on the internet and television to have not only the police but a large proportion of the population involved in identification. This will also show criminals that they are under surveillance.

Safety from collapse

The elderly population is expected to increase significantly over the next few decades and to have a significant impact on health care (Koch & Hagglund, 2009). In the US and Britain, since the early 1990's, there has been a drive towards increasing in-home health care and reducing institution care (Taylor & Donnelly, 2006). According to a survey by Marschollek et al. (2009), the elderly are most afraid firstly of getting a serious disease and secondly of losing their independence. Technologies such as remote monitoring can ease the burden of health care facilities while allowing the elderly an improved quality of life as they live in their own homes, rather than in institutions. Examples of these technologies are wearable manual emergency call buttons, videophones, monitoring systems which record and classify daily activities and identify behavior patterns and continuous health monitoring systems.

Wearable manual call buttons and videophones have been available for many years. The call buttons are reliable and regarded by the elderly as very useful, particularly when combined with an automated fall detection system. In contrast, the elderly feel that the videophone has little advantage over a regular phone and is an invasion of privacy.

Monitoring technologies are relatively new. They work using sensors connected to electrical devices in the home (such as the kettle, stove, washing machine, blood pressure monitor, etc.) which communicate with a controller using radio waves. The controller then stores and transmits the data to appropriate monitoring people.

Continuous health monitoring systems take regular readings of vital signs such as blood pressure, pulse and temperature and send an alarm if these signs give any indication of poor health. However, they have been found to foster hypochondria which may make them inappropriate for everyone (Marschollek et al., 2009).

The idea behind monitoring daily activities is that it can establish a normal pattern of behavior of the occupant and send an alarm if abnormal patterns are detected. In order to test the technology, living laboratories have been set up to monitor the activities of individual residents who stay in the laboratory home for several days. One example of this is PlaceLab, a home laboratory located in a Cambridge, Massachusetts neighborhood and consisting of a lounge, dining room, office, bedroom and bathroom (Intille et al. 2005). Sensors collect data in the form of complete audio-visual record of activity, on-off and open-closed events such as the switching on of the stove or kettle and the opening and shutting of doors, the refrigerator, the washing machine etc. The temperature, light level, humidity and pressure of the interior are monitored, as is water and gas flow. There are movement sensors on movable objects and on the occupant. Researchers use the data to try to form patterns of normal behavior. For example the activity 'making a meal' would normally follow a sequence of events such as, open a cupboard to get ingredients, close the cupboard, get a pot, turn on the stove, wait for a period of time, turn off the stove, etc.. In theory, the controller forms a set of normal patterns but will send an alarm if something changes, for example if the stove remains on for an unusually long time. In practice, it is very difficult to abstract normal behavior patterns. The monitored data set is enormous and overwhelming (Jakkula et al. 2008) and individuals change their behavior and interleave tasks (such as putting clothes in the washing machine while the meal is heating). The complexities associated with having a visitor to the home and sensors recording the activities of both individuals simultaneously has not been considered.

It is possible that comprehensive home monitoring systems will become useful and economically feasible, but at present they seem impractical and intrusive. It seems more likely that simpler devices such as the manual call buttons will be used by the elderly, as well as monitoring by the social services.

Conclusions

One of the most effective ways of reducing the risk of fire in domestic dwellings, is the use of a smoke detector. Most New Zealand homes have them but as many as half are not working or are positioned inappropriately. Home sprinkler systems are also excellent fire safety devices but in New Zealand they are currently only common in very expensive homes and in 'high risk' homes such as retirement homes, homes for the disabled and respite homes.

Worldwide, domestic fire fatalities and injuries are highest for the poorest and least educated part of the population and this has to be taken into account when structuring policies aimed at improving fire safety.

New Zealand has surprisingly high home burglary, ranking 6th highest out of 54 countries. Only a small fraction of burglaries are resolved, both in New Zealand and the rest of the world, and this has to be taken into account when looking at burglary patterns which are based on the most unsuccessful burglars, namely the ones who got caught.

There are many theories on why people become burglars and while researchers do not agree on these, they do find some behaviors common to burglars. Burglars prefer to travel short distances to the target and operate in familiar neighborhoods. They prefer unoccupied homes with a single occupant and ground level access. Most burglaries take place during normal working hours and entry is usually via a door or window. There are many practical steps a homeowner can take to reduce the risk of burglary including installing a security system, making the access to the home harder and making the home appear to be occupied. In the future it seems likely that the risk of burglary will be reduced through schemes such as gated communities and the use of modern surveillance technology.

Keeping the elderly and handicapped safe from collapse or medical catastrophe allows them the freedom to remain independent and in their own homes and will help to relieve the burden on health services in the future. The most effective safety measures are simple manual call buttons. Home monitoring technology is currently not a practical solution for improving home health safety.

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