

Spatial patterns of fatal domestic fire incidents in New Zealand: identifying strategies for injury prevention

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ABSTRACT

Residential fire incidents result in the deaths of approximately 27 New Zealanders each year, one quarter of them children. This paper discusses the use of geographic information system methods to analyse patterns of fatal events occurring in New Zealand in the time period 1986 to 1998. Such analysis is being undertaken to identify communities with a disproportionately high risk of fatal fire incidents, in order to identify how existing strategies to promote fire safety might be strengthened. The project is using Fire Service data, geocoding addresses of fatal incidents to census meshblock level. Geographic information systems technology will identify high-risk geographical locations together with characteristics of these locations. Analysis with New Zealand indices of deprivation whether there is any systematic bias toward fatal fires occurring in census meshblocks with particular deprivation characteristics. Traditional epidemiological methods will provide further information about the people who die in domestic fire incidents. The results of the project are expected to feed into the design, testing and implementation of prevention strategies in vulnerable communities.

Keywords and phrases: domestic fires, mortality, vulnerable populations, GIS, epidemiology

1.0 INTRODUCTION

Residential fire incidents are the principal cause of death from thermal injury for New Zealand children (Waller and Marshall 1993) and adults (Waller, Marshall *et al.* 1998). Fatal fire incidents also impact on the physical and mental health of survivors, many of whom show symptoms of psychological distress months after the event (Keane, Jepson *et al.* 1996). New Zealand Fire Service data indicate that from 1986-1998 an average of 27 people each year have died in their place of residence. Eighty-three deaths (25 per cent of the total) were of children aged under 15 years. Although absolute numbers are relatively small, fatal fire incidents are of public health interest because they result in preventable premature deaths, because population based studies have identified useful intervention strategies, and because such incidents illustrate important issues regarding household and community safety.

1.1 Previous research

The project builds on previous work in New Zealand and overseas which indicates that certain communities, and population groups are particularly vulnerable to fire-related injury. A review by Cropp (1997) of deaths occurring in fire incidents in New Zealand between 1995 and 1997 suggested that fire related deaths were more likely to occur in rental accommodation, and in the cheapest houses in the lowest-valued part of town. Median meshblock income for the addresses in which fatal fires occurred was at least eight per cent lower than the New Zealand average personal income. International literature demonstrates that fire risk is greater in geographical areas with low median income, lower property values, lower levels of owner occupied residences, and poor

quality housing (Mierley and Baker 1983; Ballard, Koepsell *et al.* 1992b; Runyan, Bangdiwala *et al.* 1992; Mallonee, Istre *et al.* 1996).

Irwin (1997) reviewed Fire Service data and identified characteristics of fatal fire incidents. Some characteristics relate to features of the fire itself and may help to identify appropriate preventive strategies. Others point to vulnerable population groups. The spatial study is part of a broader epidemiological analysis which will build a dataset which will help to identify the relative importance of each characteristic in relation to different population groups. For example it is likely that playing with matches is more relevant for children, but falling asleep holding a lighted cigarette may be more important for adults. The characteristics of fatal fires, as identified by Irwin (1997) include:

- *Time and day:* Fatal fire incidents occur most often in the early hours of morning (2-4 am). This contrasts with the pattern of all fires reported to the NZ Fire Service which occur most frequently between six and seven pm. Fatal fire incidents occur more commonly on Sundays.
- *Room of origin:* Fatal fires most commonly originated in the bedroom (38.2 per cent), compared with eleven per cent of all fires. Lounge or dining rooms were also over represented in fatal fires (25.9 per cent compared with all 14 per cent of all fires).
- *Age and gender:* For both males and females the age groups at greatest risk of dying in domestic fire incidents were under five year olds and the 75 to 79 age group. In addition males aged 20 to 24 years experienced relatively high rates of death and injury in domestic fires.
- *Equipment involved:* In over two thirds of fatal domestic fires, and over half of all other domestic fires there was no equipment involved in ignition. For the remainder the items of equipment most often involved in fatal fire incidents were portable heaters, ovens, stove tops and electric blankets.
- *Form of heat of ignition:* Smoking materials and other open flames (ie. cigarettes, matches, candles, and to a lesser extent lighters) were the source of ignition in over a third of fatal fires in New Zealand, but accounted for only 15.5 per cent of all fires. More fatal fires than expected also resulted from electrical arcing or overload (5.9 per cent of fatal fires, 1.6 per cent of all fires).
- *Form of material ignited:* The first items ignited were bedding (17.6 per cent of fatal fires, 4.7 per cent of all fires), upholstered furniture (7.6 per cent of fatal fires, 3.9 per cent of all fires) and fuel (5.3 per cent of fatal fires, 2.6 per cent of all fires). Although ignition of structural components (12.9%) and cooking materials (10.6%) account for a significant proportion of fatal fires; they account for an even greater proportion of all fires.
- *Ignition factors:* Frequently occurring ignition factors in fatal fires were falling asleep, including fires caused by smoking materials after the person smoking fell asleep, and abandoned heat sources including discarded cigarettes, cigars, tobacco embers or ashes. Falling asleep and abandoned heat sources together were ignition factors in only 4.9 per cent of all fires but accounted for 27 per cent of fatal fires.
- *Condition of victim prior to injury:* In almost 45 per cent of fatal fires the victim was asleep prior to injury compared with 32 per cent of non-fatal injury fires. A further ten per cent of fatalities were assessed by the firefighters at the scene to have been impaired by drugs or alcohol prior to death. Such impairment was reported in about five per cent of people suffering non-fatal injury.
- *Lack of escape:* There was insufficient information to assess conditions preventing escape in over 25 per cent of fatal fires, and no condition preventing escape for a further 18 per cent. Factors often preventing escape for the remaining 57 per cent were proximity to the fire (no time to escape - 18 per cent), and fire blocking access to the exit (15 per cent). These factors were much less common in all fires; there was no time to escape in about eight per cent of all fire incidents and the exit was blocked in just over five per cent of all fire incidents.

2.0 STUDY AIMS AND OBJECTIVES

The work presented in this paper is a part of a project undertaken with the support of the New Zealand Fire service contestable research fund. The project aims to describe physical and social characteristics of locations where fatal domestic fire events occur, with a view to identifying characteristics of communities vulnerable to such incidents. Identification of communities with a disproportionately high risk of fatal fire incidents is a first step in the process of identifying how existing strategies to promote fire safety might be strengthened.

Specific objectives of the spatial study are:

- To describe the geographical patterns of fatal domestic fire incidents in New Zealand; and
- To determine the magnitude of any relationship between social and economic deprivation at census meshblock level, and risk of death in a domestic fire incident in New Zealand.

3.0 METHODS

The spatial study is investigating fatal fire incidents in New Zealand using geographical information system techniques and analysis with New Zealand indices of social and material deprivation (NZDep91 and NZDep96). Geographic data will include climatic variables and community size. The deprivation indices measure community disadvantage, relative to the wider society, at census meshblock level. Fire incident report system (FIRS) data will be supplemented by Valuation NZ data concerning the decade of construction of the dwelling, and the Government Valuation of the property at the time of the incident. Tenure will be ascertained from fire investigation reports and coroners records.

Addresses of fatal domestic fire incidents in the years 1986-1998 were obtained from the FIRS database. Addresses were geocoded to census meshblock level, and plotted on a map of New Zealand. Conventional analysis at Territorial Authority and Census Area Unit level demonstrated regions and communities with higher than average rates of fatal incidents. Further analyses will use climatic and land use datasets to describe features of vulnerable localities. Locations of fatal fire incidents in relation to placement of fire stations will also be investigated.

For the broader epidemiological analysis data FIRS data will be matched with New Zealand Health Information Service (NZHIS) data, which provide more accurate information about individuals. Despite ongoing difficulties with the accuracy of health service ethnicity data, which may undercount Māori mortality by up to 25 per cent, NZHIS data is the best currently available. Additional data fields will be developed from a systematic review of fire investigation reports, coroners' verdicts, and media accounts of incidents. Such fields will include the degree of crowding in the dwelling, and the availability of adults to supervise young children.

The inclusion of ethnicity information is important as discussion with fire service staff suggest that Maori may be over represented in fatal fire statistics. Review of hospital discharge data shows that Māori are admitted to hospital for injuries from fire and flame at a rate three times that of nonMāori (Duncanson, Woodward *et al.* in press). The study will pay careful attention to accurate determination of ethnicity through health Service and coroners' data. The project is planned in partnership with Te Ropu Rangahau Hauora a Eru Pomare (TRRHAEP, The Eru Pomare Maori Research Centre) who will provide oversight to promote cultural safety and optimum outcomes for Maori at all stages of the project.

Initial results

New Zealand Fire Service data indicate that 282 people died in 239 domestic fire incidents from 1986-1998. A further 43 people died in 17 events in commercial premises (motels, hotels or boarding houses) or institutions for care of the elderly or disabled. Overall an average of 27 people each year have died in their place of residence. Eighty-three deaths (25 per cent) were of children aged under 15 years. Thirteen per cent of fatal residential fires resulted in multiple fatalities. Institutions and boarding houses were over represented in multiple fatality incidents. Investigation reports have not yet been received for all incidents. The total will be adjusted to exclude intentional injury (suicide and homicide).

4.0 METHODOLOGICAL ISSUES

Data limitations

Previous researchers have highlighted deficiencies in available data. Irwin (1997) and Cropp (1997) had access only to fire incident report system (FIRS) data, which may have missed deaths occurring after transfer to hospital, or in fire events to which the fire service was not called. FIRS data are compiled by firefighters at the scene of the incident, and are acknowledged to be incomplete and inaccurate at times (for example tenure information was available for only 25 of the 48 residential incidents analysed by Cropp). Cropp indicates that his study was also limited by the brief period of observation (two years) and the small sample size, and recommends further work to validate the relationship between housing values, household income, housing tenure and occurrence of fatal fires.

The planned study will use at least ten years of data (NZDep91 can be applied from 1988). Analysis will include both aggregate and annual data to determine if there is any discernible trend over time. FIRS data are considered sufficiently accurate for the initial spatial analysis. It was assumed that incident addresses would be recorded accurately to enable firefighters to reach the scene quickly. In fact up to 30 per cent of the addresses were incomplete. Obtaining fire investigation reports from regional offices improved the accuracy of addresses. In contrast to FIRS data, which are collected at the scene of the fire, fire investigation reports are written up over subsequent days and describe the details of the incident more fully. There has been no previous documented collation of the information held in fire investigation reports, which are held at regional level. With this additional data all but six addresses were successfully geocoded to census meshblock level.

Analysis

Descriptive and analytical epidemiological methods are able to identify demographic characteristics of victims of fatal fires (Marshall, Runyan *et al.* 1998). GIS technologies provide a new dimension to identifying vulnerable neighbourhoods. Mapping incidence according to statutory boundaries, particularly when displayed in a cartogram, gives a graphic illustration of geographical areas of high risk. The use of a Monte Carlo simulation will also be explored. This method can identify geographical areas at increased risk of fatal fire incidents. The key advantage of this methodology is independence from arbitrary subdivision of the land mass. Clustering of events across census boundary areas is therefore more readily identified.

5.0 POTENTIAL BENEFITS

The prevention of accidents is an important public health issue. They are unlikely to be prevented by blanket campaigns that attempt to cover all accidents, as the epidemiology and causes are so varied. Well researched multidisciplinary action on individual types of accident may be successful.

(Kemp and Sibert 1997)

The findings of this project will identify communities and population groups for whom additional fire safety strategies are a high priority. Linked with existing research about successful prevention strategies the findings will form a foundation for multidisciplinary intervention. Intervention strategies can operate at several levels, as identified by Mackenbach (cited in National Health Committee, 1998). Interventions to address broad areas of social policy, and specific local intervention to ameliorate the effects of deprivation, can be implemented concurrently.

The Ottawa charter for health promotion provides a framework for promoting the health of a community, which is relevant to this specific issue.

- *Build Healthy Public Policy:* New Zealand is in the minority of jurisdictions internationally by not requiring smoke detectors in detached, single family domestic dwellings (ISCAIP Smoke Detector Legislation Collaborators, in press). Legislation can also help to ensure that housing stock is affordable and safe for New Zealand households.
- *Create Supportive Environments:* Installation of smoke detectors is a simple, effective environmental strategy to provide early warning of a household fire.
- *Strengthen Community Action:* Communities at particular risk of fatal fire events require access to information to facilitate the participation of community members in the development of appropriate injury prevention strategies and advocacy support. This is particularly important in the development of strategies to reduce high risk behaviour.
- *Develop Personal Skills:* Involvement of community members in developing intervention strategies can lead to development of specific skills to improve the adequacy of housing stock (David Weinstein, personal communication, September 1999).
- *Develop community networks:* Identification of vulnerable communities allows contact to be made with key leaders, and extension to other groups within the community.
- *Reorient Health Services:* As health services recognise the value of prevention, which is impressive even in simple cost analysis, investment in preventive strategies becomes more likely. Health professionals are also well placed to advocate for development of a safer and healthier social and physical environment.

International literature suggests a strong relationship between socio-economic deprivation and the risk of death or injury in residential fires. "For deaths due to fire and flame the death rate for children in social class V is over 16 times that of children in social class I ... the explanation that is best supported by research evidence is that the gradients [for childhood mortality from injury] reflect differential exposure to health damaging physical and social environments. For fire deaths this entails exposure of children to temporary accommodation and substandard housing" (Roberts 1997). Social stress also plays a role in injury rates as parents who may "lack the means to resolve the recurrent setbacks which dominate their domestic lives ... are less well equipped to provide continuous and vigilant protection" for their children (Townsend, Davidson *et al.* 1992). Addressing inequalities in health status is an ongoing challenge to public policy makers in different sectors.

Smoking is an identified risk factor for residential fire injury. Cigarettes are the leading cause of fatal fires in the USA (Baker 1992). Ignition by smoking materials was five times as common in fatal fires in the USA than in non-fatal fires (Runyan, Bangdiwala *et al.* 1992). Up to 39 per cent of people who die are not the smokers of the cigarette, and may even live in a different household occupying an adjoining apartment (Mierley and Baker 1983). A population based case control study in the USA found the adjusted odds ratio for fire injury increased for households in which occupants smoked cigarettes (Ballard, Koepsell *et al.* 1992a). Production of cigarettes with reduced potential for ignition has been shown to be possible (Botkin 1988). Cigarette manufacturers have resisted attempts to improve the safety of cigarettes, however the possibility of legal liability if bereaved families bring suit against manufacturers who could have made a more fire-safe cigarette may force change (Brigham and McGuire 1995).

Lack of a smoke detector in a dwelling has been demonstrated to be a significant risk factor for fatal fires in rural USA (OR 3.4, CI 2.1 to 5.6); "the absence of a smoke detector was relatively more lethal ... when children were present" (Runyan, Bangdiwala *et al.* 1992). Distribution of smoke detectors in the population is uneven, with those at most risk least likely to have an early warning system (Roberts 1996). Mallonee, Istre *et al.* (1996) report an intervention study in which smoke detectors were distributed door to door in a target area within Oklahoma city identified as having a high rate of injuries from residential fires. The annualized injury rate fell from 15.3 per 100,000 population to 3.1 per 100,000 population during the four years after the intervention. Surveys of samples of homes which received smoke detectors at three and twelve months revealed that alarms were properly installed in over 50 per cent of the homes; at 48 months 45 per cent of the alarms were still functioning. The distribution of detectors was accompanied by a publicity campaign and education about fire prevention which may have contributed to the reduction in injury rates. Door to door distribution has subsequently been shown to be the most cost effective method of smoke detector distribution (Douglas, Mallonee *et al.* 1998).

6.0 CONCLUSION

Residential fires are preventable events which cause premature death, significant injury, and serious psychological, employment and economic consequences for families and the wider community. International literature indicates strong socio-economic determinants of death and injury in house fires. There are no robust published data linking occurrence of fires causing fatal injury with socio-economic determinants or ethnicity in New Zealand. There are also few published studies examining the effect of interventions on rates of fatal fire incidents. Geographical information systems technology complements and adds value to traditional epidemiological approaches in identifying characteristics of vulnerable communities and individuals. Better understanding of patterns of fatal injury in residential fires will help to identify modifiable risk factors among groups within the population at greater risk, and thus assist in strategic decisions about prevention policy. A health promotion approach, with community liaison and intersectoral consultation from the outset, will facilitate sustainable reduction of risk with opportunity for informed advocacy to improve social and economic conditions.

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