Fire Research Report

Follow-up survey of Auahi Whakatüpato smoke alarm installation project in the Eastern Bay of Plenty

University of Otago

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The project set out to assess the medium term effectiveness of a smoke alarm distribution programme undertaken among residents of eight communities in the Eastern Bay of Plenty. The key outcome measures were the proportion of households with at least one functioning smoke alarm and the functional status of installed alarms six months to two and a half years after installation.Installation teams visited 4453 households in the study area between November 1997 and September 1999. At the end of the installation programme 97% of households had at least one functioning alarm.

The follow-up survey was conducted in April and early May 2000 in 500 randomly selected households where alarms had been installed. The response rate was 87% (437 households). Among participating households, 72% had at least one functioning smoke alarm. Most of the non-functioning alarms had missing or flat batteries. Thirty households (7%) reported that the alarm had warned of fire. At least seven of these incidents had characteristics in common with documented fatal incidents, suggesting that they were potentially serious. It is recommended that the New Zealand Fire Service seek to identify, fund and develop strategies associated with smoke alarm installation projects to ensure longer term protection from fire.

Mavis Duncanson, Katherine Lawerence, Jean Simpson & Alistair Woodward
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Mavis Duncanson

Kath Lawrence

Jean Simpson

Alistair Woodward

Executive summary

Objectives
To assess the medium term effectiveness of a smoke alarm distribution programme undertaken among residents of eight communities in the Eastern Bay of Plenty.

Methods
Review of programme documents and door to door survey of randomly selected households.

Outcome measures
The key outcome measures were the proportion of households with at least one functioning smoke alarm and the functional status of installed alarms six months to two and a half years after installation.

Results
Installation teams visited 4453 households in the study area between November 1997 and September 1999. Alarms were installed in 4176 dwellings (94 per cent). Since a further 142 households had adequate existing alarms, 97 per cent of households had at least one functioning alarm at the end of the installation programme (see page 5).

The follow-up survey was conducted in April and early May 2000 in 500 randomly selected households where alarms had been installed. The response rate was 87 per cent (437 households). Among participating households, 72 per cent had at least one functioning smoke alarm. Alarms installed within 18 months of the survey were more likely to be functioning than alarms installed before October 1998 (see page 9).

Over ninety-five per cent of the alarms remained installed in the dwellings, however only 70 per cent of the alarms were functional. Most of the non-functioning alarms had missing (48 per cent) or flat batteries (10 per cent). One fifth of the non-functioning alarms had batteries that were not fully connected at installation or when battery was changed. Twenty alarms (8 per cent) were thought to be faulty (see page 14).

Thirty households (7 per cent) reported that the alarm had warned of fire. At least seven of these incidents had characteristics in common with documented fatal incidents, suggesting that they were potentially serious (see page 13).

Conclusion
Original programme data suggest that installation of a smoke alarm was acceptable to householders in the study area. The decline over time in the proportion of households with at least one functioning

smoke alarm is a challenge to smoke detector installation programmes. It is recommended that the New Zealand Fire Service seek to identify, fund and develop strategies associated with smoke alarm installation projects to ensure longer term protection from fire. Use of hard wired or long life (10 year) batteries could be considered in this regard.

Background

The Auahi Whakatüpato programme was an intersectoral approach to reducing the impact of fire related injury in an at risk population. In the two years prior to the programme there had been at least seven fire-related deaths in the study region. Eastbay Health (now part of Pacific Health), the Bay Waikato Fire Service, Te Puni Kokiri and local communities worked together to install smoke alarms in each dwelling in the region.

Installation programme

Installation rate

Installation teams visited 4453 households in the eight study communities during the Auahi Whakatüpato project and installed 5273 alarms in 4176 dwellings (94 per cent of total dwellings). In addition 47 alarms were installed in selected dwellings in Whakatane and Opotiki.

Of the 277 dwellings in which alarms were not installed, over half had adequate existing alarms, and almost one fifth were unoccupied (Table 2). If those with existing alarms are added to those where alarms were installed the total proportion of households with functional alarms increased to 97 per cent. The 45 households without existing alarms who refused installation represented one per cent of the total number of households visited. Even if all the households where there was no reason given for non-installation were also direct refusals, the refusal rate remains low at 1.8 per cent of the total households visited. The remaining 1.2 per cent of dwellings were unoccupied.

Table 1. Baseline data for participating communities in Auahi Whakatupati smoke alarm installation programme in Eastern Bay of Plenty November 1997-September 1999.

Community	Households visited (*n*)	Households with at least one existing alarm at baseline (%)	Existing alarms functional at baseline (%)	Households where alarms were installed (*n*)	Households with functional alarm at completion of installation (%)
Edgecumbe	560	66	85	534	98
Kawerau	2288	45	86	2175	96
Matata	235	44	89	222	100
Murupara	539	27	70	431	96
Ruatoki	172	9	68	170	99
Taneatua	220	28	55	216	99
Te Teko	292	13	60	290	100
Waimana	147	27	72	138	99
Total	**4453**	**40**	**83**	**4176**	**97**

Table 2. Reasons for non-installation of smoke alarms in households visited during Auahi Whakatüpato smoke alarm installation programme in Eastern Bay of Plenty November 1997-September 1999.

Reason	Number of dwellings	Percentage of dwellings where no alarms installed (*n* = 277)	Percentage of total dwellings (*n* = 4453)
Have adequate alarm(s)	142	51	0.8
Unoccupied (including 1 burnt out)	55	20	1.0
Refused	46	17	1.2
Unknown	34	12	3.2
Total	**277**	**100**	**6.2**

Follow-up survey objectives

1. To determine the proportion of installed alarms functioning up to 30 months after installation.

2. To determine whether there is a difference in the proportion of functioning alarms among households where installation occurred more than eighteen months previously compared with households where installation occurred less than eighteen months previously.

Methods

Examination of the installation database indicated that over 1000 dwellings had no telephone number. A door to door survey was therefore selected as the method of choice for the survey because it enabled wider participation, and had the added benefit of direct inspection of the smoke alarms. Unannounced home visits were found to be a useful method of information gathering to evaluate injury prevention programmes in the US (Shults *et al.*, 1998). A questionnaire was developed using the findings from a pilot survey conducted by the Kawerau Fire Brigade as a guide. Eight Fire Service volunteers were recruited locally and attended a training session in Edgecumbe in April 2000. The survey was conducted over the following four weeks, from 7 April to 2 May.

Sampling frame

The sampling frame was defined using the following parameters:

- Dwelling in which programme records recorded that at least one smoke alarm was installed during the Auahi Whakatüpato programme;

- Dwelling located in Edgecumbe, Kawerau, Matata, Murupara, Ruatoki, Taneatua, Te Teko or Waimana;

- Occupants did not refuse permission for follow-up evaluation of programme effectiveness.

Sampling procedure

Sample size calculations indicated that a sample of 400 dwellings would be required to assess the proportion of alarms functioning with a margin of error of ± 5 per cent, and to compare the proportion of alarms functioning more than 18 months after installation with the proportion functioning within 18 months of installation. Assuming a response rate of 80 per cent, a random sample of 500 dwellings was generated from the sample frame using the Epi Info computer statistics package.

Results

Response rate

Door to door interviews were completed with 437 households. Reasons for non response are shown in Table 3. Each dwelling was visited three times, at different times of the day and on different days of the week, before the occupants could be recorded as not at home. Properties without safe road access or with unrestrained dogs were not visited. Sample selection was made from the original installation database and in two cases the information given was not adequate to locate the dwelling. Four returned forms were invalid because the detector was not sighted or information was inconsistent. Six survey forms were not returned.

Over two thirds of interviews were completed at the first visit, the remainder of households required up to four visits to complete the interview (see Table 4).

Table 3. Reasons for non response in Auahi Whakatüpato follow-up survey April - May 2000.

Reason for non response	Number of dwellings	Percentage of non respondents (*n*=63)
Not at home	30	48
Unoccupied	14	22
Survey form not returned	6	10
High risk entry	3	5
Invalid form	4	6
Refused entry	4	6
Unable to locate	2	3
Total	**63**	**100**

Table 4. Number of visits to each respondent household in order to complete questionnaire for Auahi Whakatüpato follow-up survey April - May 2000.

Number of visits	Number of households	Percentage of respondents (*n*=437)
1	283	65
2	104	24
3	41	9
4	9	2
Total	**437**	**100.0**

Occupancy

The original occupants continued to live in 80 per cent of the 437 dwellings. As might be expected the proportion of original occupants was lower in the dwellings where installation occurred more than 18

months before the survey (219/289; 76 per cent) compared with those where alarms were installed more recently (127/148; 86 per cent) (see Table 5).

Proportion of households with functioning alarms

Among participating households, 72 per cent had at least one functioning smoke alarm. The proportion of households with at least one functioning alarm was higher in households where the installation occurred since 1 October 1998 (80 per cent), compared with installation before October 1998 (68 per cent). This difference is statistically unlikely to have occurred by chance (RR 1.23 95%; CI 1.07 – 1.4; p = 0.005). The relative risk of 1.23 quantifies this difference between proportions of detectors still functioning at different time periods since installation. Households with more recent installation (less than eighteen months before survey) were 23 per cent more likely to have a functioning detector compared with households with earlier installation (more than eighteen months since installation). The confidence interval indicates that it is possible the difference is a low as 7 per cent more likely, or as high as 40 per cent more likely.

The proportion of households with functioning detectors was also higher in owner occupied compared with rental dwellings and in households with occupant(s) over 65 years of age compared with households with no seniors. Of concern is the observation that households including children under five years were less likely than households without pre-schoolers to have a functioning alarm. Similarly a lower proportion of households including one or more smoker had a functioning alarm compared to households without smokers (**Table 6**).

Table 5. Occupancy status of households participating in Auahi Whakatüpato follow-up survey April - May 2000 with time since installation.

Time since installation	Less than 18 months		More than 18 months		Overall	
Dwellings	**(*n*)**	**%**	**(*n*)**	**%**	**(*n*)**	**%**
Original occupant	127	86	219	76	346	79
New occupant	21	14	70	24	91	21
Total	**148**	**100**	**289**	**100**	**437**	**100**

Table 6. Characteristics of households participating in Auahi Whakatüpato follow-up survey April - May 2000.

Characteristic	Number of households	Percentage of households (*n*=437)	Households with at least one functioning alarm (*n*)	Households with at least one functioning alarm (%)
Time since installation				
Less than 18 months	148	34	119	80
More than 18 months	289	66	196	68
Tenure				
Owner occupied	339	78	259	76
Rental	93	21	53	57
Smokers in household				
None	172	39	143	83
One or more	265	61	172	65
Children under 5 years of age				
None	302	69	230	76
One or more	135	31	85	63
Adults over 65 years of age				
None	357	82	70	70
One or more	80	18	83	83
Overall	**437**	**100**	**315**	**72**

Problems with alarm

Problems with the installed alarms were reported by 165 households (38 per cent). The most common cause of problems was the occurrence of nuisance alarms, i.e. alarm being set off by usual household activities such as cooking or showering. A further 36 households reported nuisance alarms but did not consider this to be a problem. All reports of nuisance alarms, in the total of 201 households, were grouped together for analysis since optimal siting of a smoke alarm may reduce the occurrence of nuisance alarms. As shown in Table 7 the most common causes of nuisance alarms were alarms set off by cooking (78 per cent) and steam (30 per cent). The total is higher than 100 per cent because a high proportion of households reported more than one cause of nuisance alarms. None of the households reporting nuisance alarms or other problems had informed the Fire Service of their concerns.

Table 7. Problems with smoke alarms reported by households in Auahi Whakatüpato follow-up survey April - May 2000.

Description of problem	Number of reports	Percentage of households reporting problems or nuisance alarms (*n*=201)	Percentage of all households (*n*=437)
Set off by cooking	157	78	36
Set off by steam	61	30	14
Faulty alarm	31	15	7
Set off by cigarettes	3	1	1
Set off by means of heating	5	2	1
Other	4	2	1
Total	**261**	**130**	**60**

Changing battery in alarm

Over half the households had changed one or more battery since installation day (243 households, 53 per cent). The most common reason for changing the battery was a 'beeping' alarm (152 households, 63 per cent of battery changers). Thirty four households (14 per cent) changed the battery on a nominated day (Table 8). Fourteen of these households had changed the battery in March 2000, which was the month in which daylight saving finished suggesting that they took heed of the slogan "change your clock, change your battery". Other nominated days were in October, December, and April (four households each), February (3 households), November and January (2 households each).

Table 8. Reason for changing battery given by households in Auahi Whakatüpato follow-up survey April - May 2000.

Reason for changing battery	Number of households	Proportion of households who had changed batteries (*n*=243)
Beeping alarm	152	63
Nominated day	34	14
Official reminder	22	9
Flat battery	4	2
Other	13	5
Not stated	18	7
Total	**243**	**100**

Fire warnings

Thirty households reported that an alarm in their dwelling had warned of fire. The majority of these warnings were for cooking fires, including pots left on the stove (50 per cent), ovens left on (9 per cent) and general cooking including burnt toast (22 per cent). At least seven incidents were potentially serious because the occupant was asleep at the time, or temporarily absent from the dwelling. The details of these potentially serious incidents listed in

Table 10 show that in two cases a neighbour who heard the alarm called emergency services. Without this intervention the fire may have become established and caused structural damage and possibly injury.

Table 9. Cause of potential fire incidents averted because of warning from smoke alarm installed during the Auahi Whakatüpato programme in Eastern Bay of Plenty November 1997–September 1999, as reported in follow-up survey April-May 2000.

Cause of fire	Number of incident	Percentage of incidents
Pot left on stove	16	50
General cooking	7	22
Oven left on	3	9
Car fire	1	3
Cigarette	1	3
Electrical	1	3
Plastic container	1	3
Not specified	2	6
Total	**32**	**100**

Table 10. Details of potentially serious fire incidents averted because of warning from smoke alarm installed during the Auahi Whakatüpato programme in Eastern Bay of Plenty November 1997–September 1999, as reported in follow-up survey April-May 2000.

Details of incident
• Went to sleep and left oven on. Alarm woke [occupant] up
• Smoker fell asleep while smoking. Cigarette fell onto mattress and mattress began smouldering
• Member of household put pot on stove and went out
• Pot left on stove. Alarm alerted neighbours, who alerted fire brigade
• Left pot on stove. Went to sleep. Slept through alarm. Fire in kitchen. 111 call from neighbour
• Left pot on stove with dripping in it, was on the phone when heard alarm. Just caught it in time before fire spread to walls. Never rang the fire brigade
• Car fire. Vehicle parked next to verandah inches away from house

Proportion of alarms functioning

In total 779 detectors had been installed in the surveyed houses. There were 256 non-functioning or missing alarms (33 per cent of the total). Over half of the non-functioning alarms had no batteries (48 per cent) or flat batteries (10 per cent). One fifth of the non-functioning alarms (20 per cent) had batteries that were not fully connected. One alarm was never installed, nine had been removed by the occupant (4 per cent), and 19 (7 per cent) had been damaged (see Table 11).

Table 11. Reason smoke alarm was not functioning when inspected during Auahi Whakatüpato follow-up survey April -May 2000

Reason alarm not functioning	Number of non-functioning alarms	Proportion of non-functioning alarms (%)
No batteries	123	48
Batteries not fully connected	52	20
Flat batteries	25	10
Faulty detector	21	8
Detector damaged	19	7
Detector removed	9	4
No reason given	6	2
Detector never fitted	1	1
Total	**256**	**100**

Discussion

The finding that 72 per cent of dwellings have at least one functioning smoke alarm up to 28 months after installation, and is comparable with reviews in three US areas showed between 58 and 73 per cent of alarms continuing to function up to four years after installation (Shults *et al.*, 1998).

Nuisance alarms, when the smoke alarm is set off by usual household activity, are a commonly raised issue with a negative effect on household compliance with smoke alarm installation. Correct siting of the alarm, away from the kitchen or bathroom, may minimise such alarms. Not all households who experienced 'nuisance' alarms considered them to be a problem. In fact, as described in Table 9, some of the fire warnings reported were of burning toast and other general cooking activities. One household changed the battery when they noticed that the alarm was no longer "going off to cooking". It is also of note that unattended cooking fires were the most common incidents where a smoke alarm alerted household members or neighbours and potential damage was avoided. Advising occupants to contact the fire service with any problems does not seem to be effective, as none of the households in this survey had done so. A smoke alarm distribution programme in Minnesota used formal follow-up until people knew they could contact staff with any problems (Shults and Harvey, 1996).

The recommended advice about changing smoke detectors regularly, on nominated day(s) each year, was followed by a minority of respondents. Most commonly, among those who did change the batteries, the low battery capacity 'beeping' of an alarm was the prompt to replace the battery. Beeping alarms also prompted householders to remove batteries, which were often not replaced. Further qualitative research could help to understand factors influencing alarm maintenance and lead to the development of appropriate 'battery change' campaigns. Alternatively use of hard wired or long life (10 year) batteries could be considered. The decision by Housing New Zealand to use long life battery alarms makes a community wide battery replacement campaign problematic, as occupants do not always know what type of alarm they have in the dwelling (personal communication, Paula Beever, New Zealand Fire service Commission May 2000).

Door to door installation has been shown to be the most efficient and cost effective method of distributing smoke alarms in high risk communities (Douglas *et al.*, 1998). This method may also prove useful in ensuring that alarms remain functional. Door to door visiting has the advantage of identifying remediable problems with installed alarms, including the relatively high proportion of replaced

batteries that are not properly connected to the alarm. The latter problem can be rectified immediately, and other problems can be dealt with at the scene. Follow up of distributed detectors in the USA found that in 83 per cent of non-functioning detectors, function could be restored by replacing the battery (Shults *et al.*, 1998). Personal contact may also be able to counteract the tendency of householders to disable, or less commonly remove, faulty or poorly sited alarms rather than seeking assistance from the Fire Service directly.

Although not reported fully, the fire warning anecdotes capture some of the possible benefits of the Auahi Whakatüpato programme. The original allocation of funding was made with a comment that preventing one serious burn injury would more than cover the cost of the programme. The incident where the occupant slept through an alarm sounding, and was rescued by a neighbour, shares many of the characteristics of fire incidents that result in serious injury or death.

Conclusion

The original programme data suggest that installation of a smoke alarm was acceptable to householders in the study area. Very few alarms had been removed and relatively few had been damaged. The key challenge raised by the findings of this survey is the need to develop strategies to ensure alarms are maintained in order to counteract the decline over time in the proportion of households with at least one functioning smoke alarm. Door to door visiting has the advantage of identifying remediable problems with installed alarms, including the relatively high proportion of replaced batteries that are not properly connected to the alarm.

Recommendations

1. That the New Zealand Fire Service seek to identify, fund and develop strategies to revisit households participating in the Auahi Whakatüpato programme, rectify problems with installed alarms and ensure that alarms remain operational and provide long term protection from fire damage. Use of hard wired or long life (10 year) batteries could be considered in this regard.

2. That future smoke alarm installation programmes include planned checking of alarms to detect and remedy problems, and ensure changing of batteries at appropriate intervals.

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