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New Zealand Fire Service
Contestable Research Fund 2011/12

Development of a Micro-Simulation Statistical Model for Household Fire Risk Identification

Final Report by McDermott Miller *Strategies*

30 September 2013

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LIST OF EXHIBITS

PREFACE AND ACKNOWLEDGMENTS

PREFACE

This report has been prepared for the New Zealand Fire Service Commission by McDermott Miller Limited.

McDermott Miller are consultants in strategy planning, marketing planning and management, incorporating an economics and marketing research capability.

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Other McDermott Miller Reports for New Zealand Fire Service Commission:

Delivery Mechanisms for 'Hard to Reach' Groups (2013)

Impact of Emerging Social Change and Technological Developments on Fire Service Operations and Changes in Community Self-Reliance and Implications for Fire Safety Messages and Emergency Response. Research Report Number 121 (2012)

Community Self-Reliance Report. Research Report Number 119 (2011)

Scoping a Social Marketing Programme for Fire Safety Research in the Community. Research Report 12 (2001).

Review of Fire Areas within NZ, Report to NZ Fire Service Commission on behalf of Fire Areas Review Committee (1997)

New Zealand Fire Service Independent Review: Report to Chief Executive New Zealand Fire Service (1993).

ACKNOWLEDGEMENTS

McDermott Miller gratefully acknowledges the help and advice of the following New Zealand Fire Service Personnel:

Members of the Advisory Panel:

Brian Davey, National Manager Operational Standards (to 2012)

Neil Challands, NZFS Strategic Information Analyst

Elizabeth Grieve, Formerly Principal Project and Risk Adviser (to 2012)

Rob Saunders, National Risk Reduction Manager (from 2013)

Information & Library Services Officers:

April Flux, Manager Information and Library Services

Emma Roache, Senior Information Officer

We also thank:

James Newell of **MERA** for advice on use of Statistics NZ microdata for micro-simulation modelling

National Library of New Zealand for assistance with the literature review.

EXECUTIVE SUMMARY

EXEC 1 RESEARCH AIMS, AND BACKGROUND AND RESEARCH PROGRAMME

McDermott Miller *Strategies* was commissioned in June 2012 under the 2011/12 round of New Zealand Fire Service Commission Contestable Research Fund to carry out a research project entitled *Development of a Micro-Simulation Statistical Model for Household Fire Risk Identification.*

Research Commission

The commissioned research is to equip the New Zealand Fire Service (NZFS) to assess household fire risk at a more detailed spatial level (to at least meshblock level and preferably to individual household units) than hitherto, using the modelling technique of Micro-simulation.

Research Purpose

The stated purpose of a putative micro-simulation model is to give the NZFS a better understanding of how household factors affect fire risk and a method of assessing the spatial distribution of risk. This, in turn, should help NZFS cost-effectively achieve its outcome of reducing the consequence of fire.

Household fire risk is related to a complex range of factors, including socio-economic status, disability, building standards, alcohol consumption, home ownership and home heating systems, active fire protection systems installed, and, fire preparedness.

Micro-simulation of these factors helps quantify the linkages between NZFS fire risk management activities and household fire risk and therefore can contribute to improved fire safety outcomes. Micro-simulation modelling could also have utility in the operational area, specifically in fire-fighting resource allocation.

Research Objectives

The specific objectives of the project are to:

- Explore and test the potential for micro-simulation as a method for improving household fire risk spatial modelling and forecasting for the Fire Service.
- Develop a "pilot" micro-simulation model for household fire risk spatial modelling and forecasting in a study area.

- Use this to model spatial and temporal changes in household fire risk in the study area under different scenarios.
- Develop and cost a work programme for development of a national micro-simulation model of household fire risk.

Introduction to Micro-simulation

Micro-simulation is an approach to spatial and dynamic modelling of social, health and urban/regional processes that has been developed and applied in various sectors for some 30 years.

Its distinguishing characteristic is that it is based on simulating the characteristics and behaviour of large samples of individuals or single households.

In the context of fire risk, this means:

- Constructing a dataset of "synthetic" households, with each individual household in the dataset characterised by variables which determine the probabilities it will have a fire in a certain year, and the consequences of a fire if it has one.
- Running a set of simulations in which each household is deemed to experience a fire event (or not) in each modelled year, based on generation of random numbers and the probabilities.

Approach

The objective of our research aimed to develop a pilot micro-simulation model for projecting household fire risk. We achieved this by researching and developing a model for forecasting household fire risk in Counties-Manukau Fire Area, under scenarios of New Zealand Fire Service fire risk management intervention. Counties-Manukau was selected as the study area because it encapsulated the following factors:

- it is an area of rapid growth and consequently has changing needs for Fire Service resources;
- it includes concentrations of "at risk" communities.
- it includes suburbs at contrasting levels of deprivation, ie wealthy as well as deprived suburbs
- it has a range of housing densities that includes both urban and rural land.

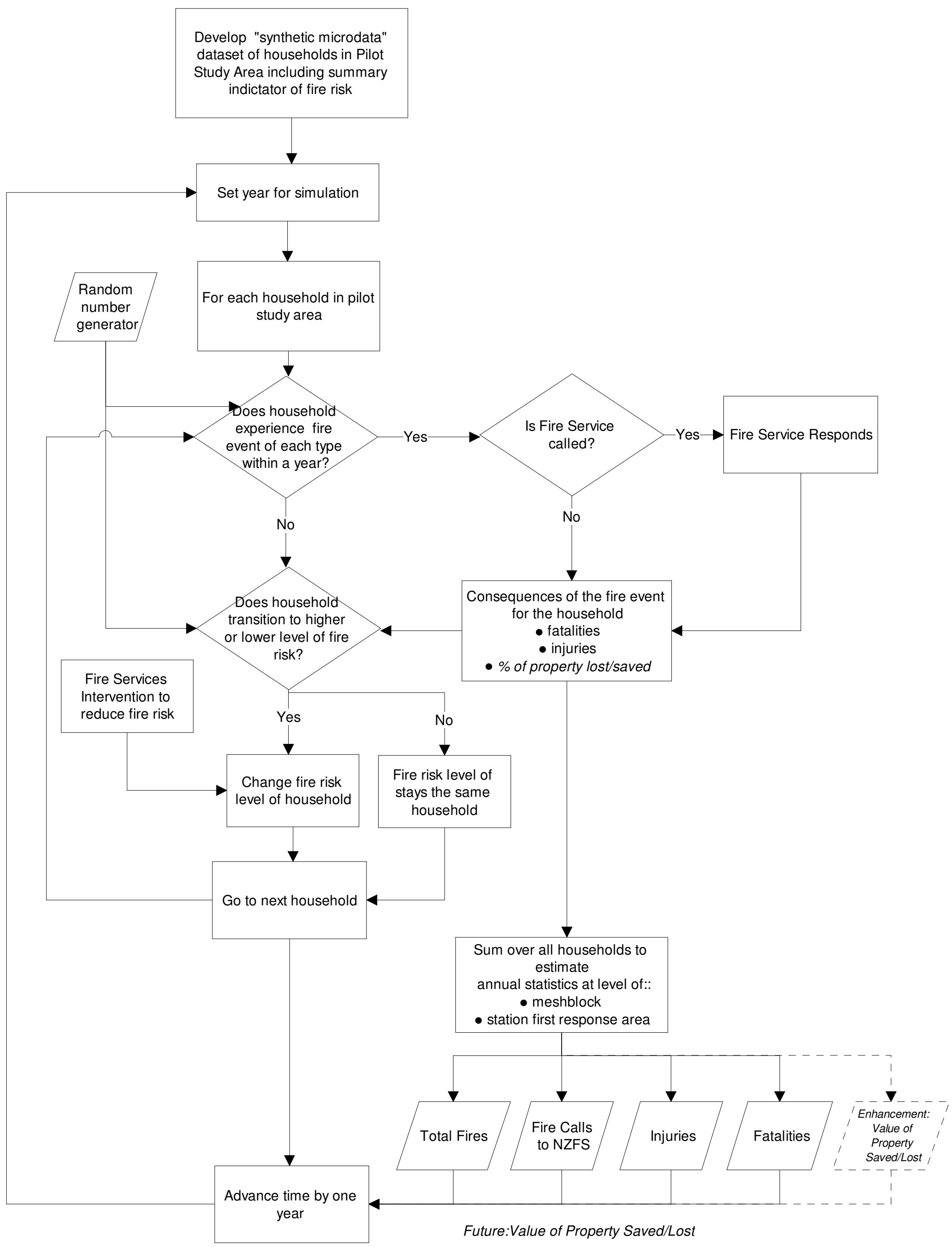
A map of the study area is presented in **Figure 3.1** (**Section 3**).

Outputs of the research include the pilot model and documentation; current distribution of household fire risk in the pilot study area; results of simulating alternative futures (including alternative intervention by NZFS); and, a work programme to develop a full-scale nationwide household fire risk micro-simulation model.

EXEC 2 **PILOT MICRO-SIMULATION MODEL LOGIC**

Figure 1 below illustrates the logic of the pilot micro-simulation model. This chart was developed in Stage 2 *Scope and Specify the "Pilot" micro-simulation model.* It guided the building of the pilot model (refer Section 4 for full explanation of building, calibrating and operating the model).

Figure 1 Micro-Simulation Statistical Model: Model Structure



Modelled Fire Service Intervention Scenarios

The transition probabilities (**Sections 4.5 & 4.6**, **Table 4.1**) are affected by Fire Service intervention strategies; higher levels of intervention increase the probability as synthetic household moves from a lower to a high preparation level and reduces the probability of it moving down.

The household transition probabilities under each intervention scenario are based on the professional judgement of members of the Advisory Panel.

There is a baseline scenario of constant Preparedness – no change in household's preparation levels, to provide a baseline for comparisons.

The **Intervention Scenarios** are:

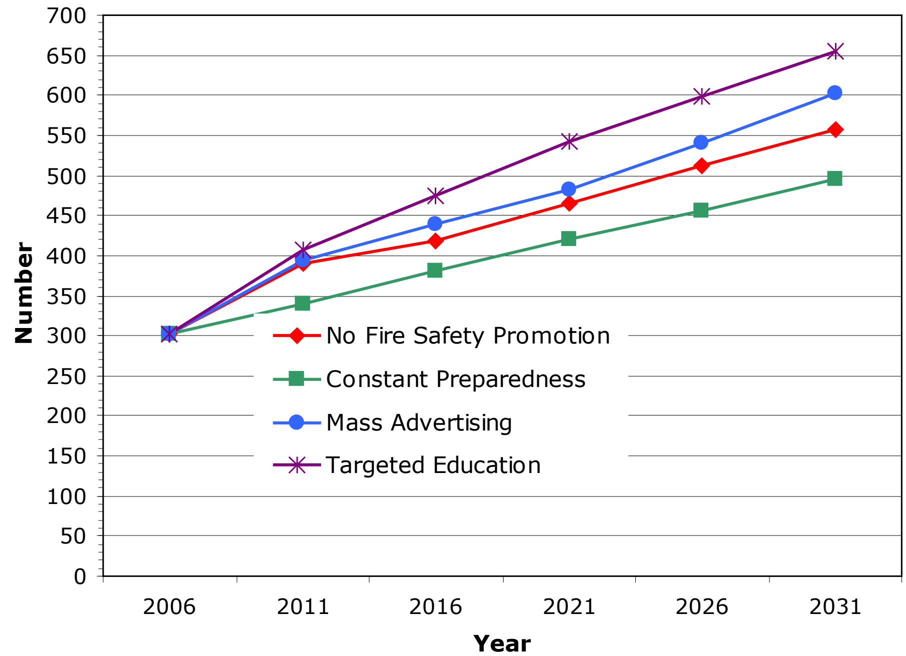
- **No Fire Safety Promotion** – with no activity, household's preparation level is assumed to slip back.
- **Mass Advertising** - can be targeted at specific segments, but only mainstream media are used.
- **Targeted Education** – in addition to mass advertising, NZFS conducts targeted fire risk management education of "at risk" communities through community networks.

EXEC 3 MAIN FINDINGS

Key insights from Simulations using Pilot Micro-simulation Model in Counties-Manukau

- Household growth in the Area is forecast (by Statistics NZ) to be so strong (average annual increase of 2.1% p.a. over 2011-2021, and 1.8% p.a. over 2021-2031 to 2021), that fires and fire calls are modelled to grow under all Fire Service intervention scenarios.
- **Figure 2 below** illustrates that domestic fire calls increase at higher levels of fire service intervention.

Figure 2: Modelled Residential Structure Fire Calls



Note: Assuming No Home Fire Safety Checks
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- The "**Targeted Education**" scenario could reduce fatalities by 26-40% compared to what it could be if there is no change in household fire preparedness (**Section 5.4)**.
- The apparently marginal effectiveness of the HFSC programme in Counties-Manukau is because of the small number of households checked in relation to total household stock – around 4.5 households per 1000 households in deprived meshblocks (NZDep 7 and over) per year.
- The pilot micro-simulation model could be used to estimate the number of HFSC per year that would be required to generate significant fire risk management benefits.
- Under all scenarios, nearly 70% of growth in fire calls is like to be in the first response areas of four stations (Mangere, Papatoetoe, Otara and Manurewa) (**Section 5.4**).
- Within this high-growth group of four first-response areas, the ranking varies between different scenarios. Papatoetoe has the largest share (22%) under the **"No Fire Safety Promotion"** Scenario, but Mangere has the highest share under the "**Mass Advertising**" scenario (at 19%).

- Within these station first response areas, the model can help pinpoint area units, and even meshblocks, where growth in fire call is most likely to arise.

Options for Developing a National Model

The options for developing a national micro-simulation Model for household fire risk are as follows (refer **Section 6.3**)

- **Option 1: Extend Pilot Model methodology to all other Areas.**
  - The main **advantage** of this option that it is the fastest route to a National micro-simulation model, and that there are likely to be cost-effectiveness benefits from simultaneously developing 24 further fire area sub-models within a coherent national model.
  - Its **disadvantage** is that it would carry a relatively high cost in the short term.
- **Option 2: Progressively build a suite of fire area models, starting with identified high priority fire areas**.
  - The **advantage** of this approach would be lower cost.
  - Development resources could be allocated to Fire Areas designated to be high priority (eg high growth fire areas, or areas which contain large populations of "at risk" communities).
  - Its **disadvantage** would be no nation-wide strategic analysis of fire risk management interventions could be carried out until a national suite of fire-area models is complete (if ever). Nor could model outputs be linked to the National Fire Resource Allocation process.

Refinement and continuous improvement are common to both options. This could involve:

- Bringing in additional explanatory variables that affect household fire risk (refer Section 6.4).
- Improving the synthetic household dataset by making use of 2013 Census CURF (Section 6.5)
- Improving estimates of how individual households' fire preparedness affects their fire risk, and how fire preparedness "transition probabilities" are influenced by NZFS fire risk management interventions (Section 6.8).

EXEC 5 CONCLUSIONS

Benefits of a National Micro-simulation Model for Fire Risk Management

We consider the Pilot Micro-simulation Model to be "proof of concept" for a micro-simulation model for spatial household fire risk modelling and forecasting.

The Pilot model has demonstrated that micro-simulation can be used to explore scenarios of Fire Service fire risk management intervention strategies in terms of residential structure fire calls and the consequences of such fires (injuries and fatalities). This can be input to benefit-cost analyses of fire risk management strategies.

The detailed data that is generated also has utility for Fire Service resource allocation, as it indicates at a fine spatial level (meshblocks), as well as at fire-station first response areas, how residential structure fires calls could grow over time.

Costs of Developing a National Micro-simulation Model

One of the Research Objectives (Refer **Section 1.1**) is:

- *To develop and cost a work programme to develop the micro-simulation model to full-scale.*

Core research and development of the model has been completed by McDermott Miller developing the pilot micro-simulation model. These costs therefore are sunk and we estimate only marginal extra costs of rolling out the pilot model to all fire areas throughout New Zealand. However, our estimated cost of development of an operational national micro-simulation model Household Fire Risk Identification must be qualified due to uncertainty over:

- The software platform the operational national model would run on, and the cost of developing an application on that platform;
- Incorporating model outputs as a layer in the Fire Service's GIS spatial information system;
- The cost of any refinements in the methodology that may be introduced such as utilising the full range of data that will be available from the 2013 Census and other sources.

As an indicative cost, we estimate the average cost before tax per fire area of further models using the same methodology as the Counties-Manukau area would be in the order of $15,000 per fire area.

For 24 further fire areas to achieve a nation-wide set of 25 fire area micro-simulation models of household fire risk models would mean a cost of $360,000. Adding a basic (non GIS) module for running and reporting on nationwide simulations would bring the cost close to $400,000.

Refinements to the existing methodology that may be required following the NZ Fire Service pilot model assessment process (see Recommended Next Steps below) could also accrue additional costs.

These gross costs, of course, need to be set against the potential benefit value of reducing fire risk enabled by application of the micro-simulation models in planning, operations and fire risk management of the New Zealand Fire Service. Estimating the value of such benefits is beyond the scope of McDermott Miller's research, but is fundamental to a decision to move beyond the pilot micro-simulation for household-based fire risk modelling and forecasting.

RECOMMENDED NEXT STEPS IN DEVELOPING A NATIONAL MICRO-SIMULATION MODEL

McDermott Miller's pilot micro-simulation model achieves the stated "**Research Purpose**" (see **EXEC 1** above) of demonstrating that micro-simulation can be used to indicate and assess the spatial distribution of household fire risk at geographic areas down to the meshblock level, both at present and over time.

McDermott Miller **recommends** the following "**next steps**" be taken by the New Zealand Fire Service in developing a national micro-simulation model of household fire risk:

1. The pilot Counties-Manukau micro-simulation model of household fire risk be assessed by operational and fire risk management managers in the Counties-Manukau Fire Area, and in Region 1. Their input should be sought on matters such as:
    - Interpretation of the model outputs presented in the Section 5 of this report;
    - Resource allocation and other operational implications of the Pilot Model's outputs by fire station first response area and meshblock over time;
    - Fire Risk management implications of the Pilot Model's outputs by meshblock over time;
    - Format Area managers would need results to be presented in (ie meshblock level-GIS)
    - Possible applications of the Model in the Counties-Manukau Fire Area;

- Improvements to model outputs which would be required to enhance the utility of the micro-simulation model for resource allocation or fire risk management purposes.

2. A similar assessment should be carried out by National Headquarters operational and fire risk management managers.
3. The New Zealand Fire Service should further clarify the specific applications that a national micro-simulation model would be put to. Such policy clarification is essential to ensuring cost-effective research and development of a national micro-simulation risk management model. Two areas of opportunity are apparent:
   - Operational applications – in particular helping allocate resources to fire stations as part of the National Resource Allocation process; and,
   - Fire risk management applications – helping to develop, test and evaluate effective fire risk management interventions that focus on communities and geographic areas most "at risk"

   In the process, NZFS needs to identify the relative net benefits to NZFS of each of these.

4. Consideration be given to improving the survey and incident information base (see **Section** 6.8) with the purpose (inter alia) of supporting a national micro-simulation model.
5. A benefit-cost analysis should be carried out for developing a national micro-simulation model of household fire risk, in view of the model applications and refinements identified in steps 1-4 above. A key issue to be examined in the benefit-cost analysis would be whether it would be more cost-effective to develop a full national model consisting of a complete set of fire-area sub-models (which would achieve economies or scale) or to build models for high-priority fire areas only.

[ENDS]

McDermott Miller *Strategies*
Wellington
30 September 2013

1. INTRODUCTION: RESEARCH AIMS, AND BACKGROUND

1.1 AIMS AND OBJECTIVES

McDermott Miller *Strategies* was commissioned in June 2012 under the 2011/12 round of New Zealand Fire Service Commission Contestable Research Fund to carry out a research project entitled *Development of a Micro-Simulation Statistical Model for Household Fire Risk Identification.*

Research Commission

The commissioned research is to equip the New Zealand Fire Service (NZFS) to assess household fire risk at a more detailed spatial level (to at least meshblock level and preferably to individual household units) than hitherto, using the modelling technique of Micro-simulation.

Research Objectives

The specific objectives of the project are to:

- Explore and test the potential for micro-simulation as a method for improving household fire risk spatial modelling and forecasting for the Fire Service.
- Develop a "pilot" micro-simulation model for household fire risk spatial modelling and forecasting in a study area.
- Use this to model spatial and temporal changes in household fire risk in the study area under different scenarios.
- Develop and cost a work programme for development of a national micro-simulation model of household fire risk.

1.2 BACKGROUND

It has long been understood (see for example CRF RR 5, 2000) that fire risk faced by individual households is related to a complex range of factors. Examples include socio-economic status, disability, building standards, alcohol consumption, home ownership and home heating systems. Others include the quality and operability of active fire protection systems installed, fire knowledge/preparedness of the household, and level of urbanisation.

A finer, more detailed understanding of the most important of these risk factors and consequent spatial distribution of household fire risk will help the Fire Service better achieve its Outcome "Reduction in the consequence from fires to people property, communities and the environment" through targeting resources committed to "Output class 1 Fire safety education, prevention and advice communities and the environment" more effectively.

It will also help with decisions on locating its firefighting resources (Output Class 2 "Firefighting and other emergency service operations"). Further, a dynamic and detailed micro-simulation model has potential to help explore the linkages, spatially and over time, between Fire Service activities and improved fire outcomes.

1.3 INTRODUCTION TO MICRO-SIMULATION

Micro-simulation is an approach to spatial and dynamic modelling of social, health and urban/regional processes that has been developed and applied in various sectors for some 30 years.

Its distinguishing characteristic is that it is based on simulating the characteristics and behaviour of large samples of individuals or single households.

In the context of fire risk, this means:

- Constructing a dataset of "synthetic" households, with each individual household in the dataset characterised by variables which determine the probabilities it will have a fire in a certain year, and the consequences of a fire if it has one;
- Running a set of simulations in which each household is deemed to experience a fire event (or not) in each modelled year, based on generation of random numbers and the probabilities.

In this project we developed a pilot micro-simulation model for forecasting household fire risk in Counties-Manukau Fire Area, under scenarios of New Zealand Fire Service fire risk management intervention.

The model could, in principle, be extended to simulate scenarios of demographic change, socio-economic conditions and adoption of new fire safety technologies.

1.4 REPORT OUTLINE

Section 2: **Selective Review of Literature and Possible Data Sources.** This section presents a selective review of the pertinent micro-simulation literature, followed by a review of sources of data that could be drawn on for a New Zealand micro-simulation model of household fire risk.

Section 3: **Scope and Specification of Pilot Micro-simulation Model.** This section specifies the geographic scope of the Pilot micro-simulation model and presents a flow chart of the model logic.

Section 4: **Building and Calibrating the Pilot Micro-simulation Model** This section outlines the steps taken in building and then calibrating the pilot micro-simulation model of household fire risk in the Counties-Manukau Fire Area.

Section 5: **Using the "Pilot" micro-simulation model to explore scenarios: Results & Interpretation** This section presents results of the Counties-Manukau Fire Area Pilot Micro-simulation model runs.

Section 6: **Development of a "Full Scale" Micro-simulation model.** This section evaluates the potential for developing a "full scale" national model for household fire risk identification based on the experience of developing the pilot model for Counties-Manukau Fire Area.

Section 7: **Conclusions:**

Annex A: **Selective Bibliography** of micro-simulation literature and other documents relevant to this study.

2. SELECTIVE REVIEW OF LITERATURE AND POSSIBLE DATA SOURCES

In this section we first present a selective review of the pertinent micro-simulation literature. We then review sources of data that could be used to build a New Zealand micro-simulation model of household fire risk.

2.1 SELECTIVE LITERATURE REVIEW

A selective review of the international and New Zealand literature on micro-simulation modelling application in fire risk management and analogous fields was carried out.

The papers of most utility to development of the micro-simulation model are cited below. Others are listed, with notes, in the bibliography (**Annex A** attached).

No papers were found in the literature search on applications of micro-simulation in fire risk management or fire service operations. However, references were found in the fields of health and crime which had sufficient parallels with fire risk management to give us confidence the approach could be relevant (refer bibliography).

The key references are:

- Williamson et al (1998) reviewed a range of approaches for generating synthetic microdata datasets for small geographic areas from sample records through "combinatorial optimisation". We adopted the "hill-climbing" approach discussed in the paper and in Kurban et al (2011) (see **Section 4.4**).
- Pearson et al (2006) present flowcharts and text on applying survey-derived probabilities of health events via a random allocation process to individuals in a synthetic base-file. This provided useful guidance for developing a similar procedure in the pilot micro-simulation model of fire risk.
- Perry (2012) presents a procedure for calculating "equivalised incomes", ie household incomes adjusted for the number of adults and children in the household. Unlike NZ Deprivation Index (NZDep), which can only be applied at the meshblock level at minimum, equivalised income can be calculated for individual households and is a useful, simplified indicator of household deprivation (or prosperity). We use this method to calculate equivalised income for the synthetic households used in the Pilot micro-simulation model.

2.2 POSSIBLE DATA SOURCES

Census data at the area unit level and meshblock level.

We have reviewed the full range of data available from the 2006 Census at the meshblock and area unit levels, with reference to:

- Data Dictionary, 2006 Census of Population and Dwellings, Statistics NZ (October 2006): www.stats.govt.nz/Census/about-2006-census/2006-census-data-dictionary.aspx
- Data available in the 2006 Census Meshblock dataset listed at: www.stats.govt.nz/Census/2006CensusHomePage/MeshblockDataset.a spx?tab=Variables

Of the available household data at meshblock level, the key data for fire risk is number of usual residents, household composition and household income, and tenure of household.

Of other variables that affect household fire risk, age of the dwelling, is not collected in the Census. Age of oldest resident in a household is available via a custom tabulation.

A cross-tabulation of household size and income was purchased for the 276 area units covering the Counties-Manukau Fire Area study area.

Statistics NZ Microdata

It is possible to analyse census microdata (individual census records) via Statistics NZ's Datalab.

This has theoretical potential for application in this project, but on the advice of James Newell of MERA (who has used census microdata extensively), we did not use it for the pilot micro-simulation model. This is due to the costs of using it, the time required to do so, but, most importantly, the restrictions placed on it. For example, the records are required to be destroyed at the completion of a project, but for a micro-simulation model they would need to be kept permanently for model runs. Also, matching of record-level data between census and other sources is prohibited by Statistics NZ.

The other form of micro-data is Confidentialised Unit Record File (CURFs) which are a sample of individual records. These can be used for national level analyses, or to construct synthetic datasets in geographic areas using micro-simulation techniques. However, no CURF is available for the 2006 Census.

The possibility of using the CURF that is to be released for the 2013 Census in the next stage of developing a national micro-simulation model for fire risk is discussed in **Section 6.5**.

Household Surveys for NZFS

Two household surveys commissioned by the NZFS have potential to provide useful data for micro-simulation modelling purposes; the Fire Knowledge survey (carried out annually), and the Fire Efficacy (so far a one-off survey carried out in 2011).

- **Fire Knowledge Survey**
  - McDermott Miller has access to confidential individual records from the Fire Knowledge survey; records including selected variables were obtained from TNS.
  - There are a total of 5024 records in the dataset, compiled from the 2008 to 2012 Fire Knowledge surveys.
- **Fire Efficacy Survey**
  - Carried out by McDermott Miller for NZFS in 2011 (see McDermott Miller 2011).
  - We have access to 1990 individual records for this survey.
  - We have developed a procedure for matching records between similar households in the Fire Knowledge Survey, as part of the Delivery Methods for Hard to Reach Groups study.
  - The matched data set was considered for use in the micro-simulation model.

  Estimates of the probability a household has a fire that they call the Fire Service to in a given year derived from the two surveys are similar.

  However, the questions on whether the households had experienced any fire event (including those the Fire Service not called to) in the last 5 years in the two surveys were different (because of the two surveys' differing purposes) and the results could not be reconciled. This prevented use of the combined dataset to build the synthetic household dataset for the Pilot Micro-simulation model.

We opted to use the Fire Knowledge Survey dataset only for developing the pilot micro-simulation model because:

- there is a much larger dataset of individual records to draw on, which is particularly important for sub-samples, eg large low income households;
- the NZFS is committed to carrying out the Fire Knowledge survey annually (unlike the so-far one-off Fire Efficacy Survey) meaning this dataset is being updated and expanded;
- development of an eventual National model is more straightforward if it only depends on a survey that Fire Service is committed to repeating;
- if the Fire Service does commit to regularly repeating the Fire Efficacy Survey then both surveys could be drawn on for the putative National Micro-simulation model.

NZFS Incident Statistics and Resource Allocation Model

Fire Service compiles detailed spatial data on fire history and risk assessments per address:

- The NZFS Strategic Information Analyst provided a list of the spatial layers available from his GIS system.
- He provided data on counts of residential structure fires over 6 years (04/05, 05/06, 06/07, 07/08, 08/09, 10/11). The years 09/10 and 11/12 were not included owing to missing data from industrial action. Dividing by 6 gives an annual risk. Meshblocks are 2006 census.

Other Possible Data Sources

- New Zealand Deprivation Index (NZDEP06). We have been informed by the NZFS Strategic Information Analyst, that the Fire Service has NZ Deprivation index in GIS layer for all NZ meshblocks. The Strategic Information Analyst provided us with incident analyses he has performed using this data, building on the methodology pioneered by the University of Otago Research Team in CRF Research Report 5 (2000). His analysis confirms the strong correlation between high deprivation and fire fatalities.
- While this basic finding helped guide the development of the pilot micro-simulation model, the NZDEP scores are calculated at the small-area level, not at the level of individual households. However, the latter is required for micro-simulation modelling. Calculating an index of deprivation (or similar, related to fire risk) that can be

applied to individual households is a possibility still under investigation.

- Quotable Value NZ valuation and property data. Based on the Fire Service's past experience in ordering record-level data (as discussed with NZFS Strategic Information Analyst), and McDermott Miller's own experience, this would be prohibitively expensive for use in the pilot simulation model. However, summary Housing Age Profiles at the meshblock level has potential utility in a micro-simulation model, as discussed in **Section 6.5.**

3. SCOPE AND SPECIFICATION OF PILOT MICRO-SIMULATION MODEL

In this section we specify the geographic scope and logic for the Pilot micro-simulation model.

3.1 GEOGRAPHIC SCOPE OF PILOT MICRO-SIMULATION MODEL

Rationale for Selecting Counties-Manukau Fire Area as Study Area

The limited resources and time available to the projects means a choice had to be made between two alternative forms of "Pilot" micro-simulation model:

- a robust, detailed model that covers a limited spatial area; or,
- a "broad brush", indicative model that is national in scope.

Discussion with the Advisory Panel indicated the area-specific case study approach is likely to have more merit. A strong candidate for the case study area is Counties-Manukau Fire Area because:

- it is an area of rapid growth and consequently has changing needs for Fire Service resources;
- it includes concentrations of "at risk"[1] communities.
- it includes suburbs at contrasting levels of deprivation, ie wealthy as well as deprived suburbs
- it has a range of housing densities that includes both urban and rural land.

The Advisory Panel and the McDermott Miller team agreed that Counties-Manukau Fire Area would be an appropriate case study for the pilot micro-simulation model of household fire risk.

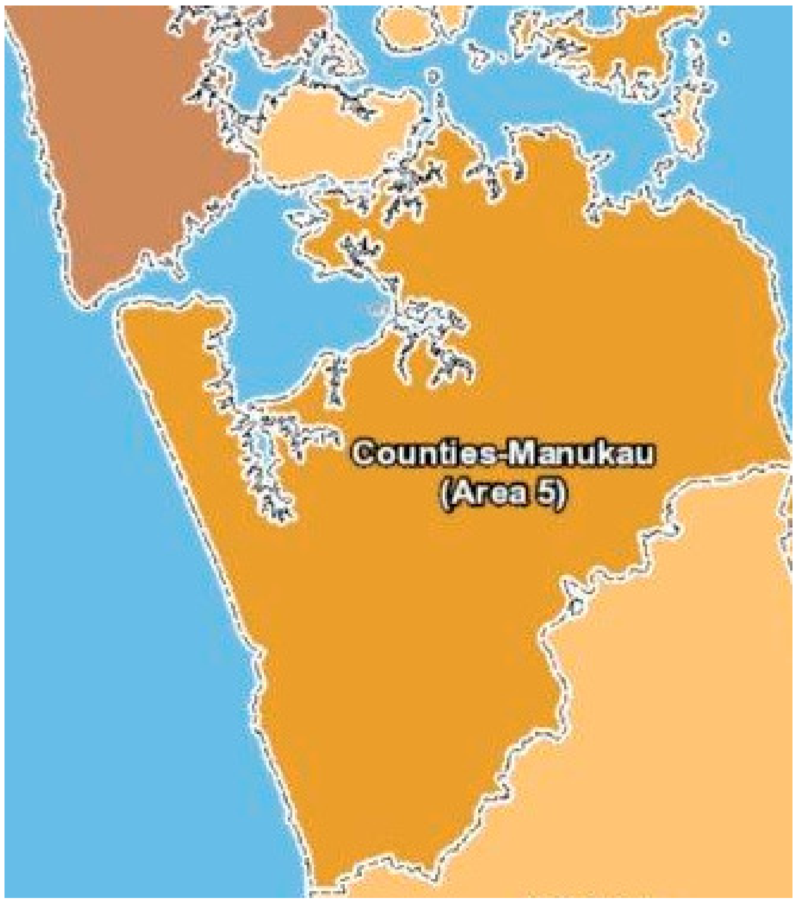
Location of Counties-Manukau Fire Area

The Counties-Manukau Fire Area is shown in the map below, prepared by the NZFS Strategic Information Analyst. The Information Analyst also provided us with a table of fire station names and their associated station numbers.

[1] The Fire Service identifies the following groups as being particularly "at risk" of death or injury by fire (p 28 National Fire Risk Management Plan 2010): Children; Older people; Lower socio-economic people; Maori and Pacific Island people; Disabled people; People in rental property; and, People in rural property.

Of these stations, two are industrial brigades leaving 20 stations which have first response areas that cover multiple meshblocks.

Figure 3.1 Study Area: Counties-Manukau Fire Area and constituent Fire Station First Response Areas



Source: NZFS Strategic Information Analyst

There is no necessary correspondence between the First Response areas or the Fire Area, with Territorial Local Authority and Area Unit boundaries. However, the first response areas and therefore the Fire Area are defined in terms of constituent Meshblocks (NZFS Strategic Information Analyst, pers. comm.).

NZFS Strategic Information Analyst provided McDermott Miller with a spreadsheet file that links the 20 fire station first response areas in Counties-Manukau Fire Area to their constituent meshblocks. Some 2920 meshblocks are within the first response area of these stations.

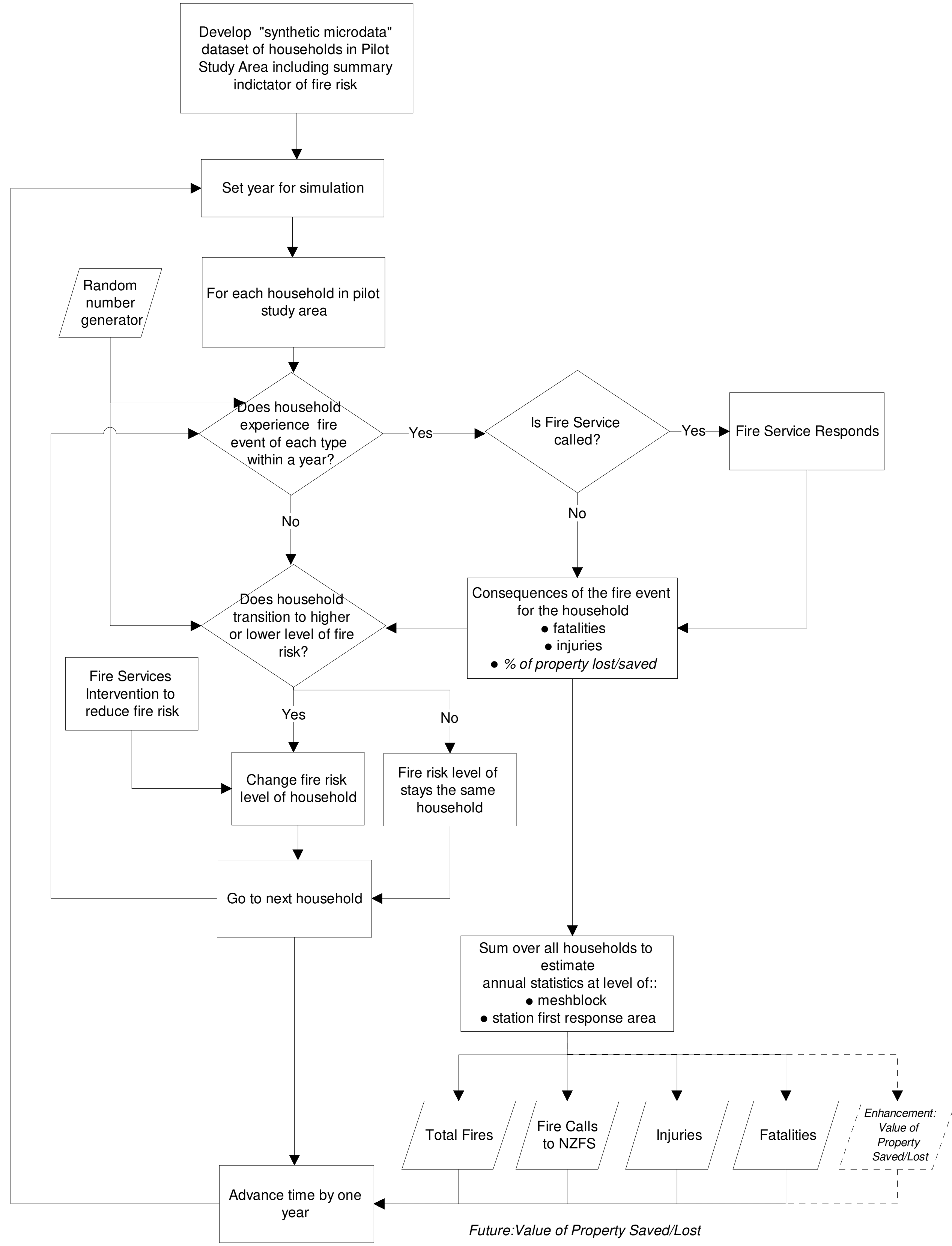
We have also defined a slightly broader geographic area which includes the entirety of the 145 Statistics NZ Area Units which have at least one meshblock lying within the

Counties-Manukau Fire Area; it was necessary to adopt this area for cross-tabulation analysis of census data on household income by household size.

3.2 PILOT MICRO-SIMULATION MODEL LOGIC

Figure 3.2 below illustrates the logic of the pilot micro-simulation model. This chart was developed in Stage 2 *Scope and Specify the "Pilot" micro-simulation model.* It guided the building of the pilot model. Full explanation of building, calibrating and operating the model is given in Section 4 below.

Figure 3.2 Micro-Simulation Statistical Model: Model Structure



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4. BUILDING AND CALIBRATING THE PILOT MICRO-SIMULATION MODEL

In this section we outline the steps taken in building and then calibrating the pilot micro-simulation model of household fire risk in the Counties-Manukau Fire Area.

4.1 STEPS IN BUILDING AND CALIBRATING THE PILOT MICRO-SIMULATION MODEL

The following steps were required to build and calibrate the Pilot Micro-simulation model:

- Devise the model structure (refer **Section 3.2)**
- Compile and Analyse Data
- Calculate Model coefficients: Key Determinants of Household Fire Risk
- Develop "synthetic microdata" dataset of households
- Effect of Fire Service Interventions
- Transitioning between Preparation Level by Fire Service Intervention Scenario
- Construct the Pilot Model
- Calibrate the Pilot Model
- Event probability and transitioning

These steps are explained in **Sections 4.2** to **4.7**

4.2 COMPILE AND ANALYSE DATA

Compiling and analysing the data for the pilot micro-simulation model involved:

- Defining the Study Area in terms of its constituent area units and meshblocks;
- Compiling a base file of household data for each area unit and meshblock in the study area;
- Devising a typology of fire events incidents (type and severity) to use in the micro-simulation model;
- Compiling data set of residential structure fire incidents over last five (or so) years in the study area by meshblock;
- Reviewing analyses carried out by (and for) the NZFS comparing incident data with household/property data to identify factors which are key indicators of fire risk;

- Using Fire Efficacy and Fire Knowledge Survey data to estimate:
  - likelihood of households experiencing a fire, and, if so, probability of the Fire Service being called;
  - preparation level of households based on segmenting households by the fire risk management equipment and practises.

4.3 CALCULATE MODEL COEFFICIENTS

Key Determinants of Household Fire Risk

At the core of the micro-simulation model are coefficients representing the probabilities that an individual household in the synthetic dataset will experience a fire in a given year. These probabilities were calculated from the Fire Knowledge Survey and Fire Efficacy data.

We generated cross-tabulations of responses to Fire Knowledge Survey and Fire Efficacy questions on whether a household had a fire in the last 5 years, and, if so, whether the Fire Service was called - against household size and demographic, variables, particularly those identifying them as" at risk".

- Cross-tabulations against age indicated that older age groups are less likely to have had a fire in the last five years (however, rare severe consequence fires are not included).
- Cross-tabulations against ethnicity indicated Maori and Pacific Island respondents to the two surveys were more likely to have had fires resulting in calls to the Fire Service than Europeans. However, we accord with the view in the NZDep literature (eg CRF RR 5) that it is deprivation that drives high risk of adverse health outcomes, etc, rather then ethnicity per se, so we have not used ethnicity as an explanatory variable in the Pilot micro-simulation model.
- Cross-tabulations against household income indicated higher probability of fires at low incomes, an effect that is more marked for equivalised (household size) adjusted incomes. Equivalised income is used as a variable in the pilot micro-simulation model.
- The probability of fires also increases with increasing household size. Household size is also used as a variable in the pilot micro-simulation model.

Household Preparation Level & its determinants

Respondents to the Fire Knowledge survey were assigned to "Preparation level" based on having smoke alarms – and checking them, plus having an evacuation plan and practising it.

- "High" preparation households have an evacuation plan and practice it, have a fire extinguisher or blanket, and have a working smoke alarm that is tested at least every 6 months.
- "Low" preparation households are those without a smoke alarm, or test their smoke alarms less than once a year (or never).
- All other households are assigned to the "Medium" preparation group.

According to the Fire Knowledge survey, probability of having a fire incident in a year (whether or not Fire Service is called), is around 3.1% for a "Low" preparation household, 2.5% for a "Medium" preparation household, and 2.3% for a "High" preparation household.

Propensity for calling the Fire Service is higher among "High" preparation households – some 23% of those households who experienced a fire incident in the previous 5 years called the Fire Service, compared to 13% of "Low" and 11% of "Medium" preparation households.

4.4 DEVELOP "SYNTHETIC MICRODATA" HOUSEHOLD DATASET

The following steps were involved in developing the synthetic microdata household dataset:

- Assign respondents to the Fire Knowledge Survey to:
  - Jensen Equivalised Income bands based on household income and number of adults and children in the household.
  - Preparation level based on having smoke alarms – and checking them, plus having an evacuation plan and practising it.
- For each meshblock:
  - Randomly select the number of records from the Fire Knowledge Survey dataset that equate to number of households in the meshblock.
  - Calculate the % distribution of households by size of household and income in this initial synthetic data set

and compare with 2006 Census distribution of households by income and size.

- Select another record from the Fire Knowledge Survey dataset and experimentally use it in the synthetic dataset instead of an existing record. If this improves fit with actual distribution of size and income, adopt it. Otherwise, select another record.
- Iterate through the experimental selection process until no significant improvement in fit is achieved.
- Calculate a cross-tabulation of income by household size at Area Unit level using this synthetic data and compare with cross-tabulation of census data.

- Project growth at the meshblock level:
  - Project household growth at the area unit level drawing on Statistics NZ's latest area unit population projection and TLA household projections.
  - Allocate area unit household growth to meshblocks assuming constant share (a simplifying assumption) and set growth target in each future year.
  - Randomly select synthetic households within a meshblock and duplicate them until target number of households in the meshblock in each future year is achieved; this assumes new households in the meshblock are similar to existing households.

The "synthetic microdata" dataset at the core of the model (refer the flowchart, **Figure 3.2**) consists of nearly 140,000 synthetic households (drawing on the NZFS Fire Knowledge Survey dataset). Household records are randomly selected and checked against Statistics NZ's 2006 Census Meshblock Data in an iterative process that converges when household size and income distributions of the synthetic set closely matches the actual (2006) distributions at the meshblock level.

4.5 EVENT PROBABILITY AND TRANSITIONING

Event Probability

Households' probabilities of having a fire and, if so, of calling the Fire Service, is calculated from the Fire Knowledge Survey for household size, equivalised income, and preparation level.

Probabilities of injuries and fatalities, if a fire occurs, are calibrated to national level data in Tables 39 and 40 of Emergency Incident Statistics 2009-2010 .

Each synthetic household is assigned an initial probability of having a fire, if so whether the fire service is called, an injury occurs, or a fatality occurs based its size (number of people), equivalised income, and preparation level.

The preparation level of synthetic household is updated annually according to the transition probabilities (see **Table 4.1** below).

If a synthetic household moves from a one preparation level to another in a year, its probability of having an event is updated accordingly.

Transitioning between Preparation Level

The Pilot Micro-simulation model includes an algorithm for households to change fire risk level, as indicated in the flow chart on **Figure 3.2.**

The likelihood of a household moving from its existing level of fire safety preparedness (as evidenced by fire safety measures recorded in the Fire Knowledge survey refer **Section 4.3**) to a lower or higher level of risk is modelled as a function of Fire Service fire risk management interventions and consequent adoption of fire safety equipment and practices by the household.

The NZFS Strategic Information Analyst advised on coefficients to quantify the relationship between NZFS Fire Risk Management Activities and households' fire safety practises. These coefficients are given in **Table 4.1** below.

4.6 MODELLED FIRE SERVICE INTERVENTIONS

Intervention Scenarios

The transition probabilities (**Table 4.1**) are affected by Fire Service intervention strategies; higher levels of intervention increase the probability as synthetic household moves from a lower to a high preparation level and reduces the probability of it moving down.

The household transition probabilities under each intervention scenario are based on the professional judgment of members of the Advisory Panel.

There is a baseline scenario of constant Preparedness – no change in household's preparation levels, to provide a baseline for comparisons.

The Intervention Scenarios are:

- **No Fire Safety Promotion** – with no activity, households' preparation level is assumed to slip back.
- **Mass Advertising** - can be targeted at specific segments but only mainstream media are used.
- **Targeted Education** – in addition to mass advertising, NZFS conducts targeted fire risk management education of "at risk" communities through community networks.

Table 4.1: Assumed Transition Probabilities by Scenario

Scenario	Previous Preparation Level	New Preparation Level Low	Medium	High	Total
No Fire Safety Promotion					
	Low	95%	5%	0%	100%
	Medium	30%	60%	10%	100%
	High	0%	10%	90%	100%
Constant Preparedness					
	Low	100%	0%	0%	100%
	Medium	0%	100%	0%	100%
	High	0%	0%	100%	100%
Mass Advertising					
	Low	90%	10%	0%	100%
	Medium	10%	70%	20%	100%
	High	0%	10%	90%	100%
Targeted Education					
	Low	80%	20%	0%	100%
	Medium	5%	70%	25%	100%
	High	0%	5%	95%	100%

Table 4.2 below shows modelled households by preparation level in Counties-Manukau Fire Area over 2006-2031, under each of the intervention scenarios.

Table 4.2: Modelled Counties-Manukau Fire Area Households by Preparation Level –No HFSC

		2006	2011	2016	2021	2026	2031
No Fire Safety Promotion							
	Low	53,100	100,900	117,400	132,700	147,700	162,300
	Medium	72,200	29,500	30,000	32,400	34,400	37,200
	High	15,100	26,800	27,500	28,400	30,100	31,900
	Total	140,400	157,200	175,000	193,500	212,200	231,300
Constant Preparedness							
	Low	53,100	59,500	66,200	73,300	80,500	87,700
	Medium	72,200	80,800	89,900	99,300	108,800	118,700
	High	15,100	17,000	18,900	20,900	22,900	24,900
	Total	140,400	157,200	175,000	193,500	212,200	231,300
Mass Advertising							
	Low	53,100	58,200	58,600	60,500	63,500	67,300
	Medium	72,200	46,600	48,800	53,600	58,400	63,500
	High	15,100	52,300	67,600	79,400	90,200	100,500
	Total	140,400	157,200	175,000	193,500	212,200	231,300
Targeted Education							
	Low	53,100	32,700	24,300	21,500	20,900	21,000
	Medium	72,200	48,600	43,200	43,300	45,300	47,800
	High	15,100	75,900	107,500	128,700	146,000	162,500
	Total	140,400	157,200	175,000	193,500	212,200	231,300

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Home Fire Safety Checks

Another intervention is Home Fire Safety Checks (HFSC) programme. This was modelled on request of the Advisory Panel.

The NZFS Strategic Information Analyst provided information on the HSFC program and data on the number of checks carried out in Counties-Manukau.

These involve visits from fire crews to households in high-deprivation meshblocks (households have to respond to invitations to participate). Currently around 280 HFSC visits are carried out in Counties-Manukau per year. **Table 4.3** below shows modelled Home Fire Safety Checks over 2011-2031.

These are an "option" that can be modelled in parallel with all four scenarios.

Table 4.3: Modelled Counties-Manukau Fire Area Annual Home Fire Safety Checks

Year	Checks
2011	319
2012	336
2013	350
2014	326
2015	316
2016	324
2017	344
2018	364
2019	355
2020	384
2021	342
2022	356
2023	395
2024	366
2025	360
2026	387
2027	405
2028	393
2029	424
2030	400
2031	417

A modelled household selected to receive a HFSC in the micro-simulation model moves up to a "Medium" or "High" level of fire preparedness and is assumed to have 0% chance of moving down from this level of preparedness for at least two years (**Table 4.4** below).

Table 4.4: Assumed Transition Probabilities by Scenario

Scenario	Previous Preparation Level	New Preparation Level Low	Medium	High	Total
Low	Low	0%	50%	50%	100%
Medium	Medium	0%	0%	100%	100%
High	High	0%	0%	100%	100%

Note: Households are not allowed to transition down in Fire Preparedness for at least two years following HFSC
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Like **Table 4.2** above, **Table 4.5** below also shows modelled households by preparation level in Counties-Manukau Fire Area over 2006-2031, under each of the intervention scenarios. However, **Table 4.5** includes the additional effect of Home Fire Safety Checks.

Table 4.5: Modelled Counties-Manukau Fire Area Households by Preparation Level – With HFSC

		2006	2011	2016	2021	2026	2031
No Fire Safety Promotion							
	Low	53,100	100,700	116,700	131,300	145,800	160,200
	Medium	72,200	29,600	30,100	32,600	34,900	37,500
	High	15,100	26,900	28,200	29,600	31,500	33,700
	Total	140,400	157,200	175,000	193,500	212,200	231,300
Constant Preparedness							
	Low	53,100	59,400	65,500	72,000	78,500	84,900
	Medium	72,200	80,700	89,300	98,100	107,000	116,300
	High	15,100	17,200	20,200	23,400	26,700	30,100
	Total	140,400	157,200	175,000	193,500	212,200	231,300
Mass Advertising							
	Low	53,100	58,200	58,000	59,700	62,700	66,600
	Medium	72,200	46,600	48,900	53,600	58,200	63,200
	High	15,100	52,500	68,100	80,100	91,300	101,600
	Total	140,400	157,200	175,000	193,500	212,200	231,300
Targeted Education							
	Low	53,100	32,800	24,200	21,400	20,500	20,900
	Medium	72,200	48,400	42,800	43,100	45,200	47,500
	High	15,100	76,000	108,000	129,000	146,400	162,900
	Total	140,400	157,200	175,000	193,500	212,200	231,300

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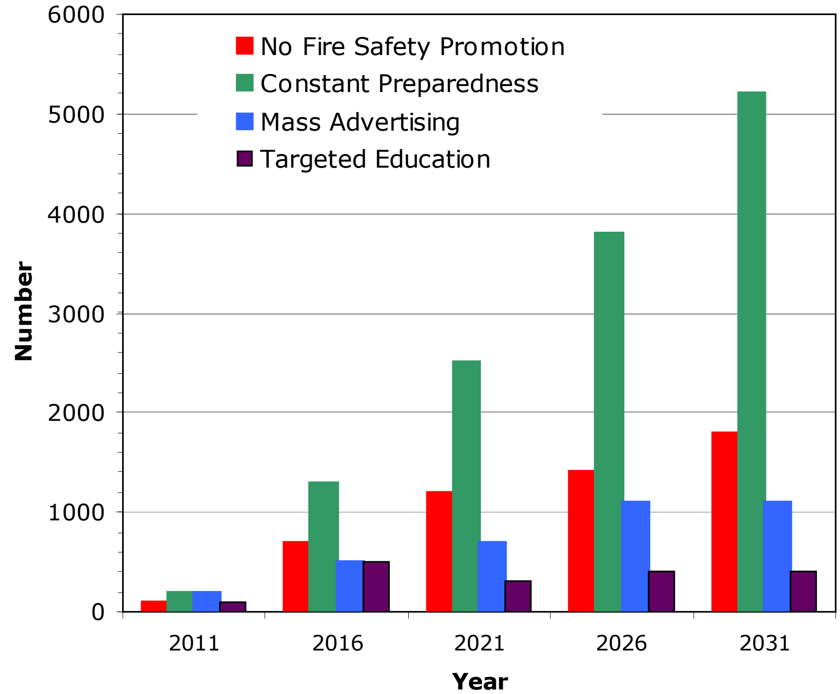
Figure 4.1 below illustrates the difference the Home Fire Safety Check makes in addition to each intervention scenario.

Note that in the "Constant Preparedness with Household Fire Safety Checks" case, once a household is boosted in preparedness due to receiving an HFSC it stays at the new level permanently.

Figure 4.1: Difference in "High" Preparedness Households Due to Home Fire Safety Checks



4.7 RANDOM ALLOCATION PROCESS

This sub-section outlines the operation of the Pilot Micro-simulation Model (refer **Figure 3.2**).

Random Allocation Model Process

The random allocation process at the heart of the pilot micro-simulation model uses the following logic:

- For each modelled household, use random numbers to generate a spread of values distributed according to estimated probability distributions for key variables and identify whether the household experiences a fire event during the year, or not.
- Run model multiple times to build up a probability distribution of fire events.
- Calibrate model so that base year distribution of modelled events reflect actuals.
- Construct transition probabilities for residences, ie the probability that a residence will transition either to a higher or a lower risk level from one year to the next.

- For each household in turn, generate a random number and, on that basis, transition the household to a lower or higher risk level for the next year's event simulations.

Model Operation

Under each Fire Service Intervention scenario:

- For each synthetic household under each meshblock, for each year:
  - A random number (range 0 -1) is generated
  - Based on this value and the event probabilities a household is deemed to experience (or not experience) a fire event in the year.
  - If a fire does occur based on further random numbers, the Fire Services is deemed to be called, or an injury or fatality occurs (in which cases the Fire Service is called).
  - These simulation runs are repeated 30 times. The results reported in the next section of the presentation are averages of the 30 runs.

Model Calibration

- The pilot micro-simulation was calibrated to actual fire calls data in Counties-Manukau Fire Area as follows: In an initial run of the micro-simulation model, modelled residential structure fire calls to the Fire Service in 2011.
- The modelled fire calls are then compared to actual fire calls for meshblocks within the study area at each NZDep decile. Generally fire calls based on Fire Knowledge Survey-derived probabilities overstate the actual fire calls.
- Taking this into account, we calculate a calibration factor for each NZDep decile which brings modelled fires into line with actuals.
- The model is then re-run for current and future years with this calibration factor included.

Table 4.6 below compares actual data on residential structure fire incidents within the Counties-Manukau Area over the 2005-2011 period at each level of deprivation (as indicated by NZDep Index) with results from the Model.

Note that structure fires per 100 households rise sharply in meshblocks at high levels of deprivation

Table 4.6: Comparison of Residential Structure Fire Calls – Actual and Modelled within the 145 Area Units that cover the Counties-Manukau Area

Meshblocks by NZDep Decile	No, of Meshblocks	Total households 2006 Census	Total Fires over 6 Years	Fires/100 Households over 6 yrs	Avg Fires/Yr	Probabilty of Fire/year/hhld	**Modelled Fires (Avg of 30 Runs)**	Difference (Modelled-Actual)	Difference (Modelled-Actual) (%)
1	274	12,273	60	0.49	10	0.08%	**11**	1	11.3
2	315	14,916	92	0.62	15	0.10%	**17**	2	13.0
3	295	13,440	104	0.77	17	0.13%	**18**	0	1.0
4	240	10,785	93	0.86	16	0.14%	**17**	1	8.8
5	253	11,175	108	0.97	18	0.16%	**17**	-1	-5.6
6	227	10,239	100	0.98	17	0.16%	**17**	0	1.0
7	198	9,477	120	1.27	20	0.21%	**19**	-1	-3.3
8	347	15,435	253	1.64	42	0.27%	**39**	-4	-8.5
9	464	18,963	428	2.26	71	0.38%	**72**	0	0.3
10	600	23,064	816	3.54	136	0.59%	**133**	-3	-2.0
Total	**3,218**	**139,821**	**2,174**	**1.55**	**362**	**0.26%**	**360**	**-3**	-0.8

Table 4.7 below presents micro-simulation model results presented by fire station first response area.

Table 4.7: Residential Structure Fire Calls Area by Station in Counties-Manukau Area

Station Number	Station Name	No, of Meshblocks	Total households 2006 Census	Total Fires over 6 Years	Fires/100 Households	Avg Fires/Yr	Probabilty of Fire/year/hhld
1440	Oneroa	41	1,998	19	0.95	3	0.16%
1441	Onetangi	27	1,341	16	1.19	3	0.20%
1430	Manurewa	432	20,778	387	1.86	65	0.31%
1435	Mangere	372	13,881	396	2.85	66	0.48%
1431	Otahuhu	196	6,630	206	3.11	34	0.52%
1433	Otara	326	11,973	255	2.13	43	0.36%
1443	Beachlands	39	1,935	20	1.03	3	0.17%
1444	Kawakawa Bay	9	318	2	0.63	0	0.10%
1432	Howick	446	24,423	185	0.76	31	0.13%
1434	Papatoetoe	286	13,320	241	1.81	40	0.30%
1446	Clevedon	27	888	5	0.56	1	0.09%
1438	Papakura	295	13,212	209	1.58	35	0.26%
1755	Pukekohe	169	7,203	88	1.22	15	0.20%
1756	Patumahoe	33	1,287	8	0.62	1	0.10%
1758	Waiau Pa	12	786	1	0.13	0	0.02%
1751	Tuakau	60	1,920	23	1.2	4	0.20%
1757	Waiuku	94	4,359	34	0.78	6	0.13%
1753	Port Waikato	10	294	8	2.72	1	0.45%
1748	Mangatangi	11	414	9	2.17	2	0.36%
1750	Mercer	35	1,011	18	1.78	3	0.30%
1436	Mangere Airport	0					
1739	Glenbrook Steel	0					
Total		**2,920**	**127,971**	**2130**	**1.66**	**355**	**0.28%**

5. USING THE "PILOT" MICRO-SIMULATION MODEL TO EXPLORE SCENARIOS

5.1 INTRODUCTION

In **Section 5** we present results of the Counties-Manukau Fire Area Pilot Micro-simulation model runs.

The baseline "Constant Preparedness", and the three Fire Service intervention scenarios are simulated.

The results here are illustrative only. They are intended primarily to investigate the potential for using a micro-simulation model to generate projections of residential fire risk under different levels of fire risk management interventions.

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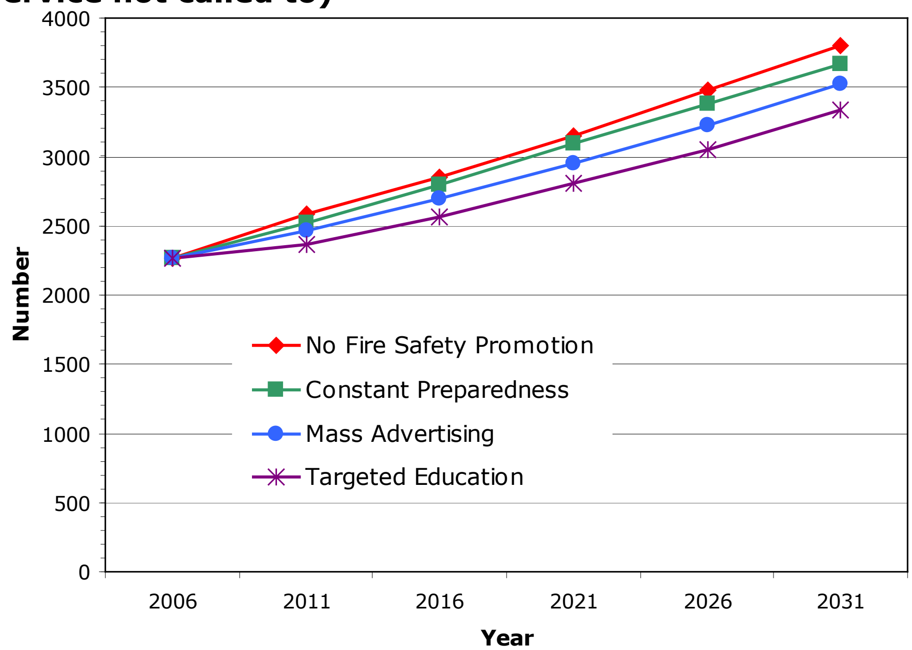
5.2 RESULTS FOR COUNTIES-MANUKAU AS A WHOLE

Modelled Fire Events by Scenario

Figure 5.1 presents modelled residential structure fires – total fires including those the Fire Service is not called to. Modelled residential fires increase over 2011-2031:

- Under the No Fire Safety Promotion scenario by 47% overall or average of 2.0% p.a.
- Under the Constant Preparedness scenario by 45% overall or average of 1.9% p.a.
- Under the Mass Advertising scenario by 43% overall or average of 1.8% p.a.
- Under the Targeted Education scenario by 41% overall or average of 1.7% p.a.

Figure 5.1: Modelled Residential Fires (incl. those Fire Service not called to)



Note: Assuming No Home Fire Safety Checks
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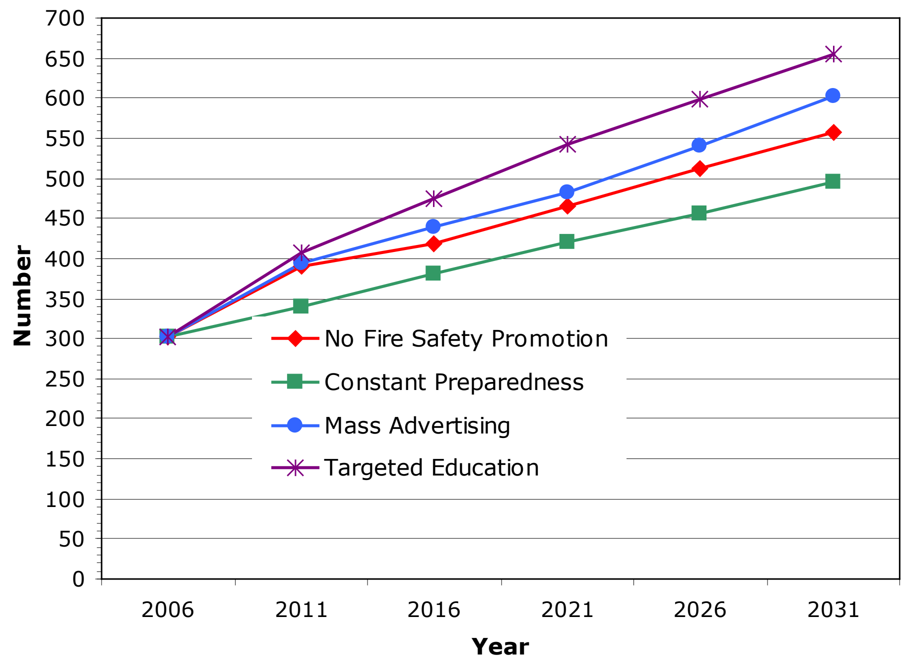
Modelled Residential Structure Fire Calls by Scenario

Figure 5.2 presents modelled residential structure fire calls to NZFS over 2011-2031. These increase over 2011-2031:

- under the No Fire Safety Promotion scenario by 43% overall or average of 1.8% p.a.
- under the Constant Preparedness by 45% overall or average of 1.9% p.a.
- under the Mass Advertising by 52% overall or average of 2.1% p.a.
- under the Targeted Education by 61% overall or average of 2.4% p.a.

Figure 5.2: Modelled Residential Structure Fire Calls



Note: Assuming No Home Fire Safety Checks
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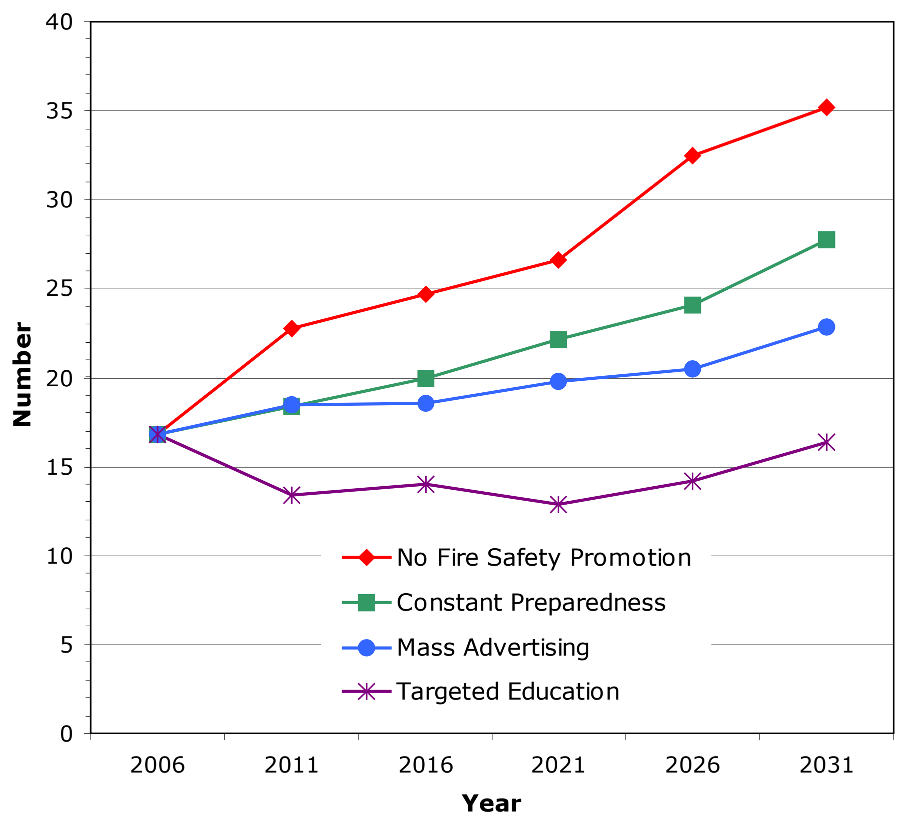
Modelled Injuries from Residential Structure Fires by Scenario

Figure 5.3 presents modelled injuries from residential structure fires. These increase over 2011-2031:

- under the No Fire Safety Promotion scenario by 54% overall or average of 2.2% p.a.
- under the Constant Preparedness by 51% overall or average of 2.1% p.a.
- under the Mass Advertising by 24% overall or average of 1.1% p.a.
- under the Targeted Education by 22% overall or average of 1% p.a.

Figure 5.3: Modelled Injuries from Residential Structure Fires



Note: Assuming No Home Fire Safety Checks
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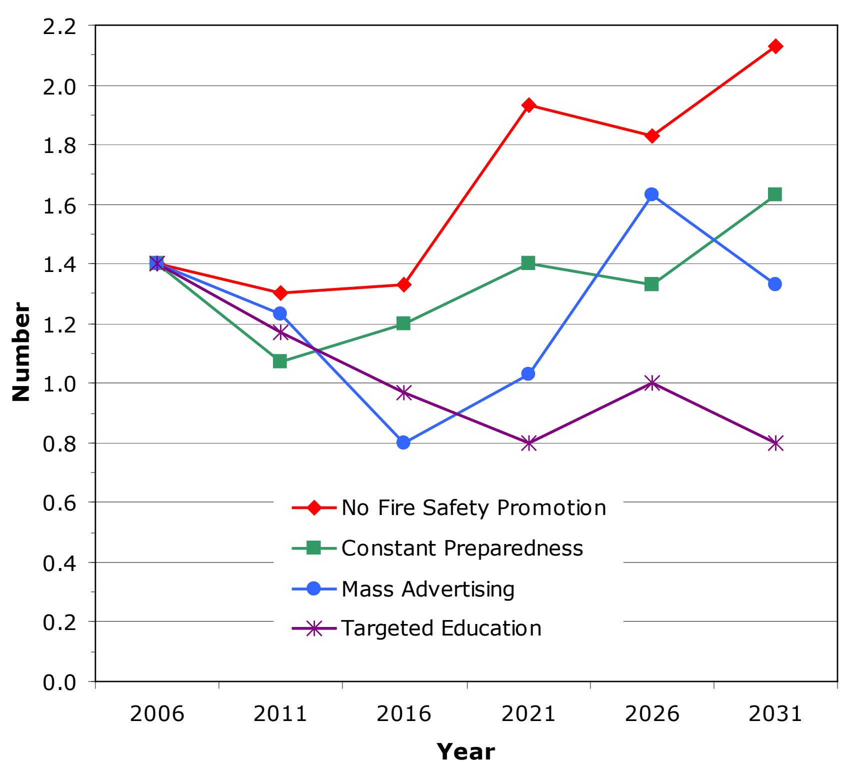
Modelled Fatalities from Residential Structure Fires by Scenario

Figure 5.4 presents modelled fatalities from residential structure fires. These increase over 2011-2031:

- under the No Fire Safety Promotion scenario by 64% overall or average of 2.5% p.a.
- under the Constant Preparedness by 52% overall or average of 2.1% p.a.
- under the Mass Advertising by 8% overall or average of 0.4% p.a.
- under the Targeted Education by -2% overall or average of -1.9% p.a.

Figure 5.4: Modelled Fatalities from Residential Structure Fires



Note: Assuming No Home Fire Safety Checks

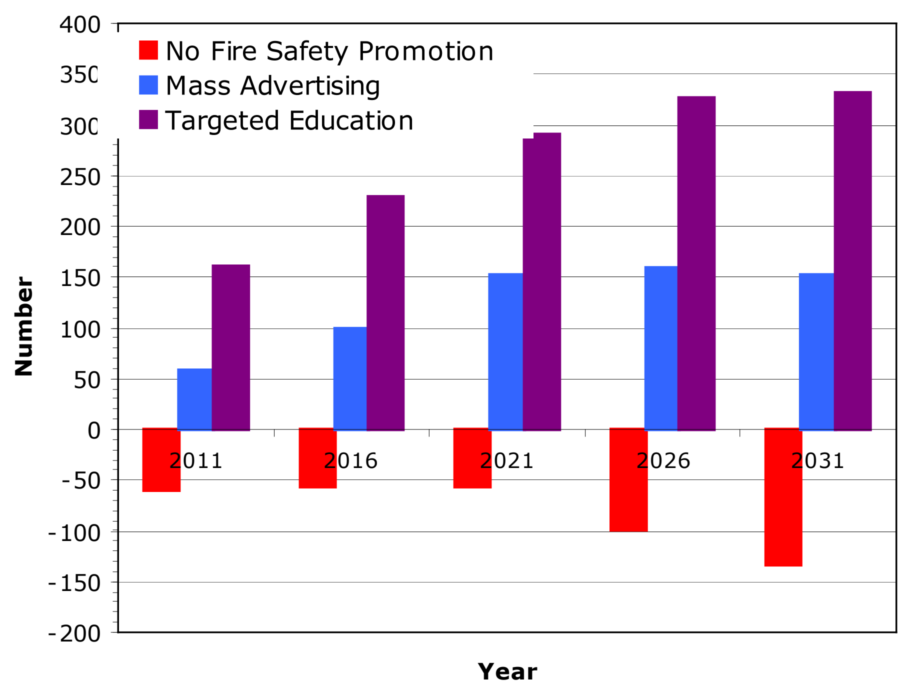
Benefits of Intervention Scenarios: Reduction in Modelled Residential Structure Fires

Figure 5.5 illustrates the benefits of the Fire Service intervention scenarios in terms of modelled residential structure fires with and without the intervention.

In 2021, compared to "Constant Preparedness" Scenario there would be:

- 133 or 1.8 % more modelled residential structure fires under the "No Fire Safety Promotion" scenario.
- 152 or 4.9% fewer modelled residential structure fires under the "Mass Advertising" scenario.
- 331 or 9.4% fewer modelled residential structure fires under the under the "Targeted Education" scenario.

Figure 5.5: Reduction from Constant Preparedness Scenario: Total Residential Fires (including those FS not Called)



Note: Assuming No Home Fire Safety Checks
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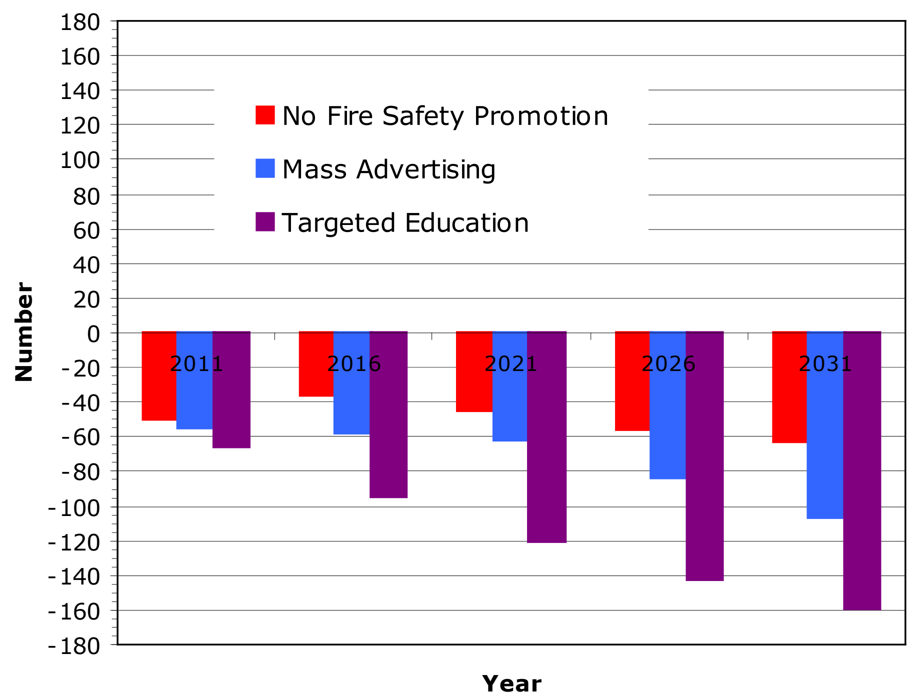
Benefits of Intervention Scenarios: Residential Structure Fire Calls

Figure 5.6 illustrates the benefits of the Fire Service intervention scenarios in terms of residential structure fire calls with and without the interventions.

In 2021, compared to "Constant Preparedness" Scenario there would be:

- 45 or 10.6% more modelled fire calls under the "No Fire Safety Promotion" scenario.
- 61 or 14.6% more modelled fire calls under the "Mass Advertising" scenario.
- 121 or 28.7% more modelled fire calls under the under the "Targeted Education" scenario.

Figure 5.6: Reduction from Constant Preparedness Scenario: Residential Structure Fire Calls



Note: Assuming No Home Fire Safety Checks
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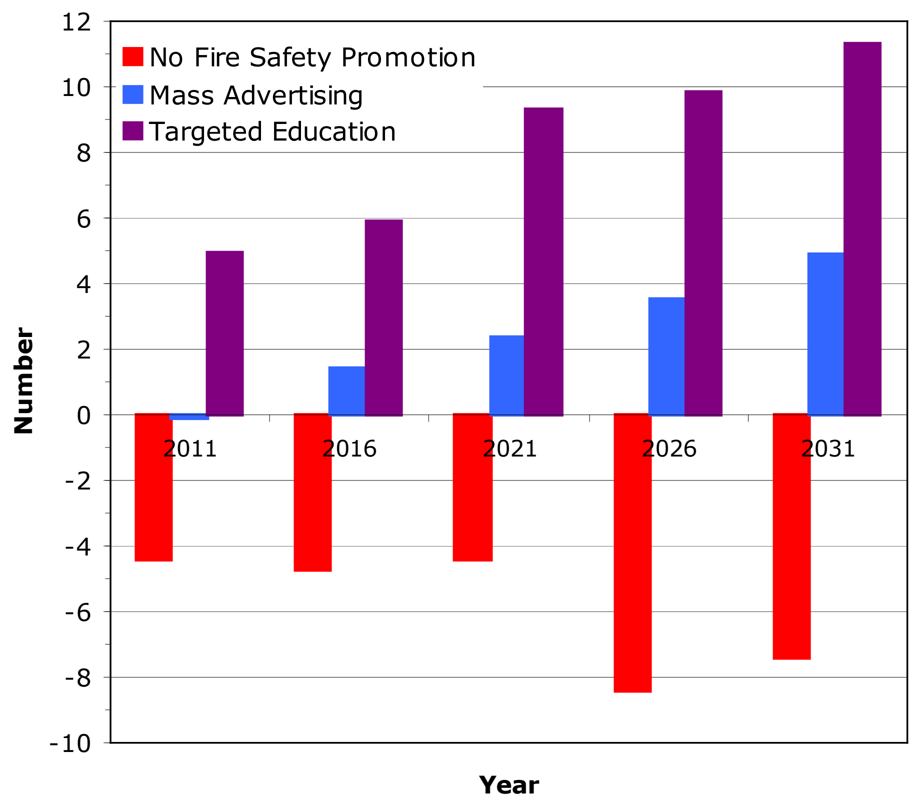
Benefits of Intervention Scenarios: Injuries from Residential Structure Fires

Figure 5.7 illustrates the benefits of the Fire Service intervention scenarios in terms of injuries from residential structure fires, with and without the intervention.

In 2021, compared to "Constant Preparedness" Scenario there would be:

- 4.4 or 20.0% more modelled injuries under the "No Fire Safety Promotion" scenario.
- 2.4 or 10.7% fewer modelled injuries under the "Mass Advertising" scenario.
- 9.3 or 42.1% fewer modelled injuries under the under the "Targeted Education" scenario.

Figure 5.7: Reduction from Constant Preparedness Scenario: Injuries from Residential Structure Fires



Note: Assuming No Home Fire Safety Checks

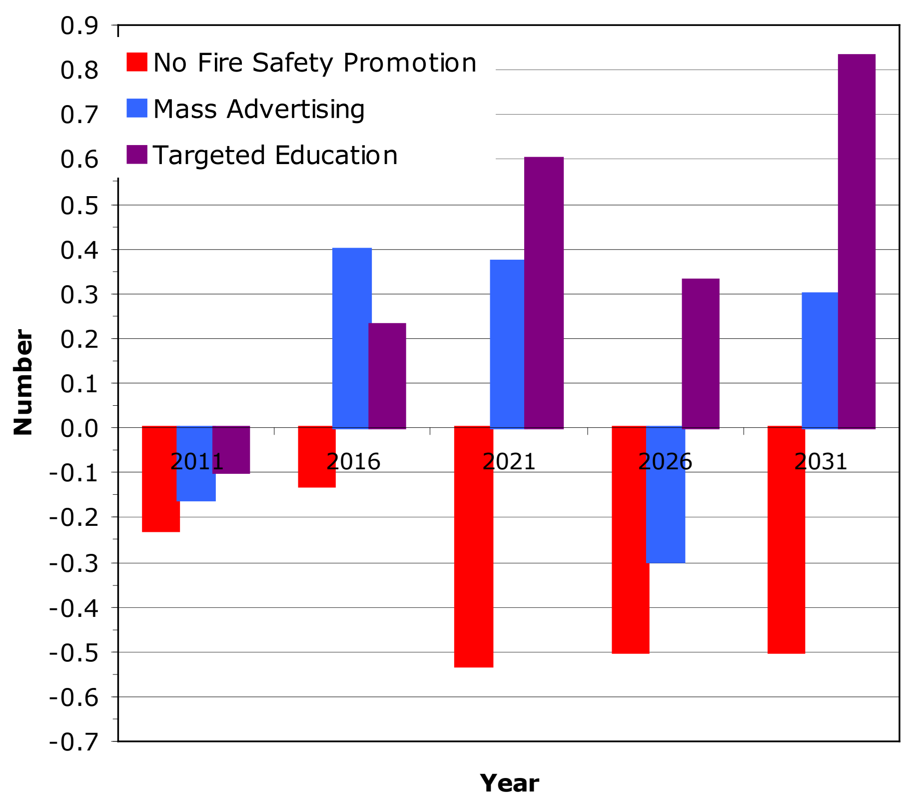
Benefits of Intervention Scenarios: Fatalities from Residential Structure Fires

Figure 5.8 illustrates the benefits of the Fire Service intervention scenarios in terms of fatalities from residential structure fires, with and without the intervention.

In 2021, compared to "Constant Preparedness" Scenario there would be:

- 0.5 or 37.9% more modelled fatalities under the "No Fire Safety Promotion" scenario.
- 0.4 or 26.4% fewer modelled fatalities under the "Mass Advertising" scenario.
- 0.6 or 42.9% fewer modelled fatalities under the under the "Targeted Education" scenario.

Figure 5.8: Reduction from Constant Preparedness Scenario: Fatalities from Residential Structure Fires



Note: Assuming No Home Fire Safety Checks
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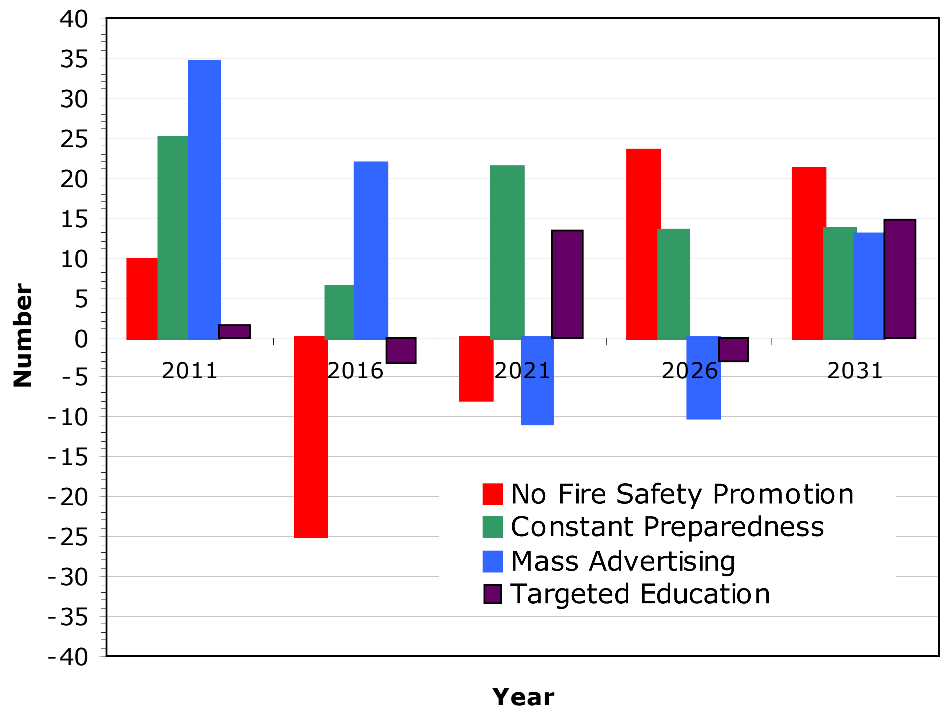
Benefits of Home Fire Safety Checks: Additional Reduction in Modelled Residential Structure Fires

Figure 5.9 illustrates the additional benefits of the Home Fire Safety Checks programme, under each intervention scenario, in terms of modelled residential structure fires.

The modelled changes in residential structure fires in 2021 with the addition of Home Fire Safety Checks are not significant, ie differences are within error margins.

Figure 5.9: Additional Reduction with Home Fire Safety Checks: Total Residential Fires (including those FS not Called)



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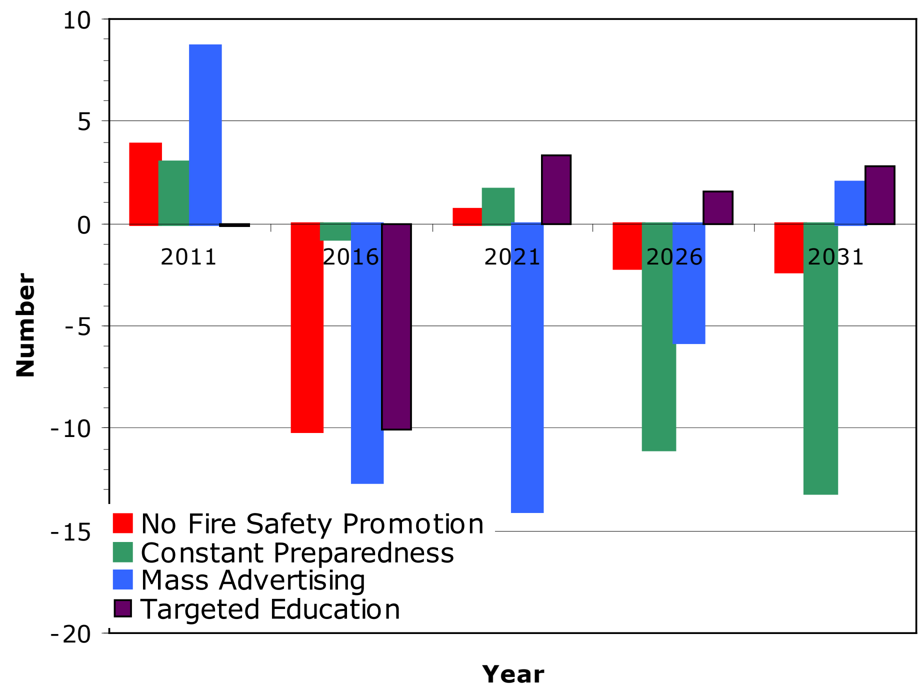
Benefits of Home Fire Safety Checks: Residential Structure Fire Calls

Figure 5.10 illustrates the additional benefits of the Home Fire Safety Checks programme, under each intervention scenario, in terms of residential structure fire calls.

The modelled changes in residential structure fire calls in 2021 with the addition of Home Fire Safety Checks are not significant, ie differences are within error margins.

Figure 5.10: Additional Reduction with Home Fire Safety Checks: Residential Structure Fire Calls

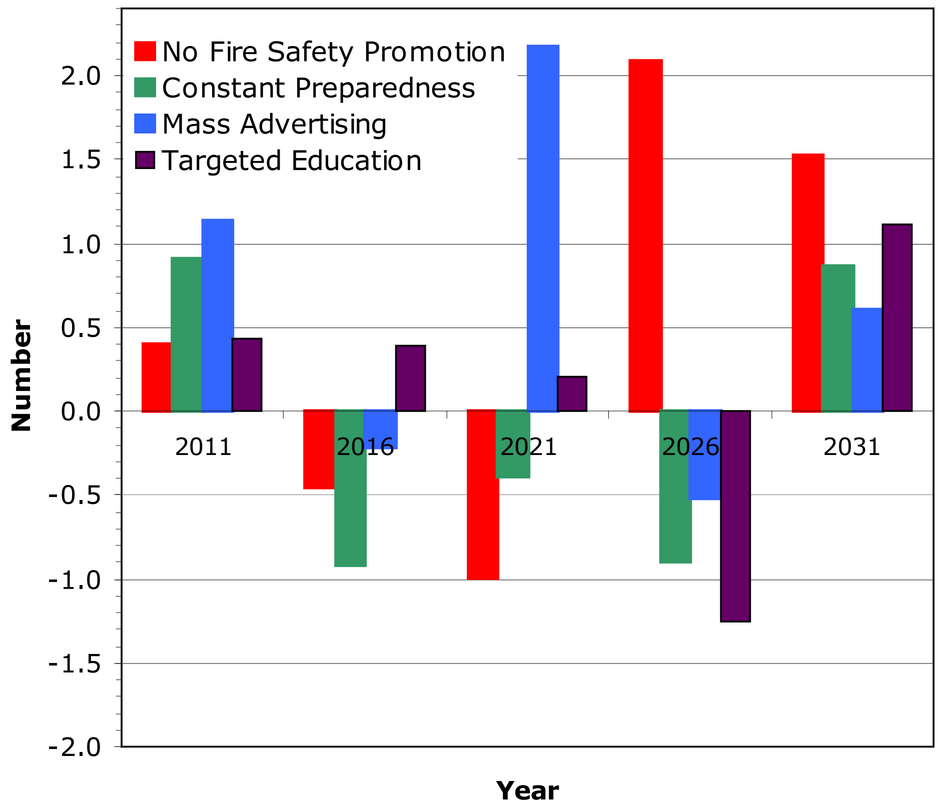


Benefits of Home Fire Safety Checks: Injuries from Residential Structure Fires

Figure 5.11 illustrates the additional benefits of the Home Fire Safety Checks programme, under each intervention scenario, in terms of injuries from residential structure fires.

The modelled changes in injuries from residential fires in 2021 with the addition of Home Fire Safety Checks are not significant and within error margins.

Figure 5.11: Additional Reduction with Home Fire Safety Checks: Injuries from Residential Structure Fires



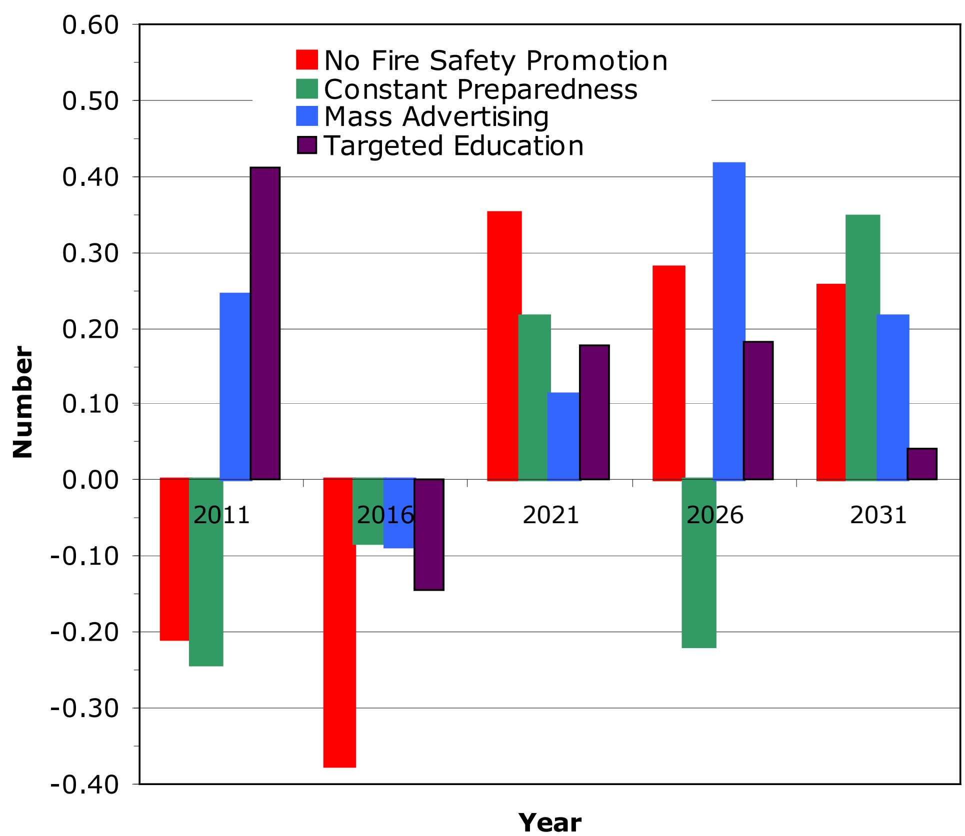
Benefits of Home Fire Safety Checks: Fatalities from Residential Structure Fires

Figure 5.12 illustrates the additional benefits of the Home Fire Safety Checks programme, under each intervention scenario, in terms of Fatalities from Residential Structure Fires.

The additional modelled fatalities from residential fires in 2021 with the addition of Home Fire Safety Checks are not significant, ie differences are:

- 0.35 or 18.2% fewer under the "No Fire Safety Promotion" scenario.
- 0.22 or 15.4% fewer under the "Constant Preparedness" scenario.
- 0.11 or 10.9% fewer under the "Mass Advertising" scenario.
- 0.18 or 22.3% fewer under the "Targeted Education" scenario.

Figure 5.12: Additional Reduction with Home Fire Safety Checks: Fatalities from Residential Structure Fires



5.3 MODELLED RESIDENTIAL STRUCTURE FIRE CALLS BY FIRE STATION FIRST RESPONSE AREA

Tables 5.1, 5.2, 5.3, and **5.4** present modelled residential structure fire calls by station first response area under each of the Fire Service fire risk management intervention scenarios in turn.

The station first response areas are sorted in descending order of modelled growth in fire calls over the 2011-2031 period.

Table 5.1: Modelled Residential Structure Fire Calls by Station First Response Area: "Constant Preparedness" Baseline

Station Number	Station Name	No, of Meshblocks	Year 2011	2016	2021	2026	2031	Shift 2011-2031	Share of Growth	Cumulative Share of Growth
1434	Papatoetoe	286	39	44	52	64	74	35	22.6%	22.6%
1435	Mangere	372	55	65	72	79	86	31	20.2%	42.8%
1433	Otara	326	39	48	54	57	62	23	15.1%	57.9%
1430	Manurewa	432	71	77	81	84	91	21	13.3%	71.2%
1431	Otahuhu	196	26	30	33	35	39	12	8.0%	79.2%
1432	Howick	446	31	34	37	42	42	10	6.6%	85.8%
1755	Pukekohe	169	14	17	17	19	22	8	4.9%	90.7%
1438	Papakura	295	35	36	39	41	42	7	4.8%	95.4%
1751	Tuakau	60	5	6	6	7	7	2	1.3%	96.7%
1443	Beachlands	39	2	2	4	4	4	2	1.1%	97.8%
1440	Oneroa	41	4	5	5	6	6	1	0.8%	98.6%
1441	Onetangi	27	3	3	4	3	4	1	0.7%	99.4%
1750	Mercer	35	2	2	2	2	3	1	0.5%	99.9%
1757	Waiuku	94	7	7	8	8	8	1	0.5%	100.4%
1446	Clevedon	27	1	1	1	1	1	0	0.3%	100.7%
1444	Kawakawa Bay	9	0	0	0	1	0	0	0.0%	100.7%
1748	Mangatangi	11	1	1	1	1	1	0	0.0%	100.6%
1758	Waiau Pa	12	1	1	1	1	1	0	0.0%	100.6%
1753	Port Waikato	10	1	1	1	1	1	0	-0.1%	100.5%
1756	Patumahoe	33	2	2	2	2	2	-1	-0.5%	100.0%
Total		**2,920**	**341**	**381**	**421**	**456**	**495**	**155**	**100.0%**	

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Table 5.2: Modelled Residential Structure Fire Calls by Station First Response Area: "No Fire Safety Promotion" Scenario

Station Number	Station Name	No, of Meshblocks	Year 2011	2016	2021	2026	2031	Shift 2011-2031: Shift 2011-2031	Share of Growth	Cumulative Share of Growth
1434	Papatoetoe	286	45	51	58	70	83	37	22.1%	22.1%
1435	Mangere	372	64	73	81	89	94	30	18.1%	40.2%
1433	Otara	326	46	51	59	65	71	25	15.0%	55.2%
1430	Manurewa	432	82	83	92	97	106	24	14.4%	69.6%
1431	Otahuhu	196	30	34	36	41	43	14	8.1%	77.7%
1432	Howick	446	37	37	41	45	49	12	7.3%	84.9%
1755	Pukekohe	169	17	18	20	22	23	6	3.8%	88.8%
1438	Papakura	295	38	38	44	43	44	6	3.5%	92.2%
1751	Tuakau	60	5	6	7	8	9	4	2.1%	94.4%
1440	Oneroa	41	5	5	6	6	8	3	1.8%	96.1%
1443	Beachlands	39	3	4	3	4	5	2	1.1%	97.3%
1441	Onetangi	27	3	4	4	3	5	2	1.0%	98.2%
1757	Waiuku	94	7	8	9	9	8	1	0.6%	98.8%
1748	Mangatangi	11	1	1	1	1	1	1	0.3%	99.1%
1758	Waiau Pa	12	1	1	1	1	2	0	0.3%	99.4%
1750	Mercer	35	2	2	2	3	3	0	0.3%	99.6%
1756	Patumahoe	33	2	1	2	2	2	0	0.3%	99.9%
1446	Clevedon	27	1	1	1	1	1	0	0.1%	100.0%
1444	Kawakawa Bay	9	0	0	0	0	1	0	0.0%	100.0%
1753	Port Waikato	10	1	1	1	2	1	0	0.0%	100.0%
Total		**2,920**	**391**	**418**	**465**	**512**	**558**	**168**	**100.0%**	

Table 5.3: Modelled Residential Structure Fire Calls by Station First Response Area: "Mass Advertising" Scenario

Station Number	Station Name	No, of Meshblocks	Year 2011	2016	2021	2026	2031	Shift 2011-2031: Shift 2011-2031	Share of Growth	Cumulative Share of Growth
1435	Mangere	372	65	73	84	91	104	39	19.0%	19.0%
1434	Papatoetoe	286	48	56	59	73	85	37	18.0%	36.9%
1433	Otara	326	42	56	59	70	79	37	17.7%	54.7%
1430	Manurewa	432	85	90	96	103	114	29	14.1%	68.7%
1431	Otahuhu	196	30	34	37	42	47	18	8.5%	77.2%
1432	Howick	446	36	37	43	48	50	14	6.7%	83.9%
1438	Papakura	295	39	40	43	49	52	13	6.3%	90.2%
1755	Pukekohe	169	19	18	22	22	25	7	3.2%	93.4%
1751	Tuakau	60	4	7	8	8	10	6	2.7%	96.0%
1443	Beachlands	39	3	3	4	4	5	2	1.0%	97.1%
1757	Waiuku	94	8	8	8	9	9	2	0.9%	97.9%
1440	Oneroa	41	5	5	7	7	6	1	0.7%	98.7%
1756	Patumahoe	33	2	2	2	2	3	1	0.4%	99.1%
1750	Mercer	35	2	2	2	3	3	1	0.4%	99.4%
1758	Waiau Pa	12	1	2	1	1	2	1	0.4%	99.8%
1441	Onetangi	27	4	4	4	4	4	0	0.1%	99.9%
1444	Kawakawa Bay	9	0	1	0	1	1	0	0.1%	100.0%
1753	Port Waikato	10	1	1	1	2	1	0	0.1%	100.1%
1748	Mangatangi	11	1	1	1	1	1	0	0.0%	100.1%
1446	Clevedon	27	1	1	1	1	1	0	-0.1%	100.0%
Total		**2,920**	**395**	**439**	**482**	**540**	**602**	**207**	**100.0%**	

Table 5.4: Modelled Residential Structure Fire Calls by Station First Response Area: "Targeted Education" Scenario

Station Number	Station Name	No, of Meshblocks	Year					Shift 2011-2031		
			2011	2016	2021	2026	2031	Shift 2011-2031	Share of Growth	Cumulative Share of Growth
1434	Papatoetoe	286	47	58	70	80	93	46	18.5%	18.5%
1435	Mangere	372	66	77	91	101	109	43	17.4%	35.9%
1430	Manurewa	432	83	102	108	114	122	38	15.5%	51.3%
1433	Otara	326	47	57	68	76	85	37	15.1%	66.4%
1431	Otahuhu	196	31	37	42	49	51	20	8.2%	74.7%
1432	Howick	446	40	42	48	52	58	18	7.2%	81.9%
1438	Papakura	295	39	44	50	54	56	17	6.8%	88.7%
1755	Pukekohe	169	19	21	22	25	28	9	3.6%	92.3%
1751	Tuakau	60	5	8	8	9	10	5	2.0%	94.3%
1757	Waiuku	94	8	9	11	11	12	4	1.6%	96.0%
1443	Beachlands	39	3	3	4	5	5	3	1.1%	97.0%
1440	Oneroa	41	5	5	7	7	8	2	0.9%	97.9%
1441	Onetangi	27	4	3	4	4	5	2	0.7%	98.6%
1750	Mercer	35	2	2	2	3	3	1	0.5%	99.1%
1758	Waiau Pa	12	1	1	1	2	2	1	0.4%	99.5%
1753	Port Waikato	10	1	1	1	2	2	1	0.4%	99.8%
1748	Mangatangi	11	1	1	1	1	1	0	0.1%	100.0%
1446	Clevedon	27	1	1	1	2	2	0	0.1%	100.1%
1756	Patumahoe	33	2	2	2	2	2	0	0.0%	100.1%
1444	Kawakawa Bay	9	1	1	0	0	0	0	-0.1%	100.0%
Total		**2,920**	**406**	**476**	**542**	**599**	**654**	**248**	**100.0%**	

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5.4 INTERPRETATION

Overall growth in Fire Risk in Counties-Manukau

We have run the Pilot Micro-simulation Model assuming population and households grow in accordance with Statistics NZ's "Medium" Projections, which take into account the Auckland Growth Strategy – Southern Sector Agreement (Auckland Regional Council 2001).

Household growth in the Area is modelled to be so strong (average annual increase of 2.1%[2] p.a. over 2011-2021, and 1.8% p.a. over 2021-2031[3]) that fire and fire calls are modelled to grow under all Fire Service intervention scenarios.

Figure 5.2 illustrates that domestic fire calls increase at higher levels of fire service intervention. This is because households at higher levels of fire safety awareness are more likely to call the Fire Service, as well as dealing with a fire incident themselves if possible. That calls to the Fire Service increase in response to education initiatives is recognised by the Fire Service (McDermott Miller *Strategies* (2011), NZFS Strategic Information Analyst (pers. comm.)).

Figure 5.5 illustrates that there will be some 5% fewer fires (total fires, including those Fire Service not called to) under the "Mass Advertising" scenario than if there is constant

[2] Compared to national growth of 1% p.a.
[3] Compared to national growth of 0.8% p.a.

household fire preparedness, but **Figure 5.6** shows this would lead to 15% more fire calls.

However, under the "Targeted Education" scenario, the pilot simulation model indicates that injuries and fatalities from residential structure fires in the Counties-Manukau area could reduce, in spite of the increase in households.

"Targeted Education" scenario could reduce fatalities by 26-40% compared to what it could be if there is no change in household fire preparedness.

Effect of Home Fire Safety Checks.

We have extended/enhanced the Pilot micro-simulation model to explicitly gauge the benefits of the Home Fire Safety Checks program.

Only in the case of fatalities is there some indication of tangible benefits from the program.

This apparent marginal effectiveness of the HFSC is because of the small number of households checked in relation to total household stock – around 4.5 households/per 1000 households in deprived meshblocks (NZDep 7 and over) per year.

The pilot micro-simulation model could be used to estimate the number of HFSC per year that would be required to generate significant fire risk management benefits.

We are not in a position to judge the effectiveness of the HFSC in targeting the households most at risk.

Spatial Distribution of Growth within Counties-Manukau Area

In accordance with Statistics NZ Area Unit Population Projections, growth will be concentrated in area units that fall within the Manurewa, Mangere, Otara, and Papatoetoe station first response areas.

Tables 5.1 to 5.4 show that modelled growth in fire calls indicates growth is likely to be concentrated in the first response areas of a few stations.

Under all the scenarios, nearly 70% of growth in fire calls is likely to be in the first response areas of four stations (figures are for share of growth under the "Mass Advertising" scenario):

- Mangere (with 19% share of growth)
- Papatoetoe (18% share of growth)

- Otara (18% share of growth)
- Manurewa (14% share of growth).

Within this high-growth group of four first-response areas, the ranking varies between different scenarios. Papatoetoe has the largest share (22%) under the **"No Fire Safety Promotion"** Scenario, but Mangere has the highest share under the "**Mass Advertising**" scenario (at 19%).

Within these station first response areas, the model can help pinpoint area units, and even meshblocks, where growth in fire calls is most likely to arise.

This can help with both resource allocation planning and fire risk management work.

Effectiveness of Fire Service Interventions

The pilot model output suggests that, in a high growth area with many high NZDep households, Fire Service fire risk management interventions will have only a modest impact.

We note that this modelling is based on conservative assumptions of the effect of such interventions on transitions between fire preparedness levels. These assumptions come from the Advisory Panel.

Further survey and incident data is desirable to provide a sounder research base on which to base calculations on the effect of fire service interventions on households' fire safety preparedness.

Caveats

- As the model stands, it indicates future increases in fires and fire calls in Counties-Manukau, due to the increase in households and propensity of "high preparation" households to call the fire service and for a reduction in mortality, at least at high levels of intervention.
- The question is how realistic this is, as there is a trend (nationally at least) for declining fire calls but some indication (not yet statistically significant) of an up-turn in fatalities (Source: NZFS Strategic Information Analyst pers. comm.). The latter may represent the end of previous declining trend and start of an upward trend driven by the ageing of the population. If this not countered by targeted interventions and/or adoption of improved alarm technologies that have been developed specifically to assist elderly people to "age in place", there may be an upward trend in fatalities, even if fire calls reduce.

- Another consideration is that fire calls are lower in new housing stock, due to lower flammability of materials. new wiring, safer heaters and better quality smoke detectors. Higher density neighbourhoods also tend to have fewer fires/100 households than low density neighbourhoods. So new dwellings can be expected to have, all else being equal, lower incidence and consequence of fire.
- These considerations could be met in a future version of the micro-simulation model by introducing:
  - a factor to adjust for age of housing stock
  - another factor to adjust for aging population, ie the fatalities may rise as population ages.
- At the current stage of development, outputs of the Pilot Micro-simulation model indicate the scale of impact a change in household risk could have but should not be regarded as constituting a prediction or projection.

6. DEVELOPMENT OF A "FULL SCALE" MICRO-SIMULATION MODEL

In this section we evaluate the potential for developing a "full scale" national model for household fire risk identification based on the experience of developing the pilot model for Counties-Manukau Fire Area.

6.1 INSIGHTS FROM BUILDING AND RUNNING PILOT MODEL RELEVANT TO A "FULL SCALE" MODEL

- The Pilot micro-simulation model is a successful proof of concept; it demonstrates that micro-simulation can be a useful tool in residential fire risk management and resource allocation.
- At the outset of the project, it was considered that many variables could enter the model, including "socio-economic status, disability, building standards, alcohol consumption, home ownership and home heating systems".
- However, to construct a practical micro-simulation model we have had to be more selective, for reasons including cost (eg of Property IQ records) and Statistics NZ prohibitions against data matching.
- The key challenge of building a household micro-simulation model is to construct realistic synthetic households that combine the above data together with fire preparedness and likelihood of experiencing a fire. The Fire Knowledge and Fire Efficacy survey records come closest to this.
- A key explanatory variable is how households respond to NZFS fire risk management interventions; more research is needed on this.
- The "ageing" of the population is not modelled in the Pilot Micro-simulation model, and analysis of the survey datasets shows no relationship of fire events and age. Yet there is other evidence (eg AFAC (2005)) that rising age increases fire risk, in particular risk of fatalities, and ideally the micro-simulation model would include this in its projections.
- Another factor is that new houses are less fire-prone than older households (CRESA (2009) NZFS Strategic Information Analyst (pers. comm.)) and this should also

enter the model, particularly in a high-growth area such as Counties-Manukau.

6.2 POSSIBLE APPLICATION OF A NATIONAL MODEL

Possible applications of a national for household fire risk micro-simulation model include:

- Fire Risk Management
  - Identify where risk is likely to grow across NZ and where it may reduce;
  - Estimate response to various intervention strategies/instruments.
- Resource Allocation
  - Help indicate where additional resources may have to be allocated in future;
  - Where unused/unnecessary capacity may be freed up for allocation to areas/stations with increasing demand.

Only residential structure fires are modelled in the pilot micro-simulation model but there is potential to apply the micro-simulation approach to other types of fires and other emergency incidents.

6.3 OPTIONS FOR DEVELOPING A NATIONAL MODEL

Two options for developing a national micro-simulation model for household fire risk are as follows:

- **Option 1: Extend Pilot Model methodology to all other Areas:**
  - Build a national level model using identical approach as the Pilot Model, using the same variables;
  - Would make use of 2013 Meshblock Census data when available (March 2014);
  - Every meshblock in the country would be included, and every household represented by a synthetic household, ie a direct scaling up of the Pilot Model;
  - A variant of this, to reduce computation required, would be to have a sampling approach, involving either modelling a sample of synthetic households within each meshblock, or modelling all households within a sample of meshblocks in each fire area.

- **Option 2: Progressively build a suite of fire area models, starting with identified high priority fire areas**.
  - The area level micro-simulation models would be used to address area-level issues.

Advantages and Disadvantages of these Options

- The main **advantage** of **Option 1**, **Extending the Pilot micro-simulation methodology to all Fire Areas,** is that it is the fastest route to a National micro-simulation model.
- There are likely to be cost-effectiveness benefits from simultaneously developing 24 further fire area sub-models within a coherent national model.
- Its **disadvantage** is that it would carry a relatively high cost in the short term.
- The main **advantage** of **Option 2, Progressively build a suite of fire area models,** starting with identified high priority fire areas would be lower cost.
- Development resources could be allocated to Fire Areas designated to be high priority (eg high growth fire areas, or areas which contain large populations of "at risk" communities).
- The main **disadvantage** of **Option 2** would be that no nation-wide strategic analysis of fire risk management interventions could be carried out until a national suite of fire-area models is complete (if ever).
- Nor could model outputs be linked to the National Fire Resource Allocation process.

Scope for Refinement and continuous improvement

Common to both options is scope for refinement and continuous improvement of the micro-simulation model for household fire risk identification. This could involve:

- Bringing in additional explanatory variables that affect household fire risk (refer Sections 6.4 below).
- Improving the synthetic household dataset by making use of 2013 Census CURF (Section 6.5 below).
- Improving estimates of how individual households' fire preparedness affects their fire risk, and how fire preparedness "transition probabilities" are influenced by NZFS fire risk management interventions (Section 6.8 below).

6.4 THE KEY EXPLANATORY VARIABLES: DRIVERS OF RISK

The explanatory (independent) variables in Pilot Micro-simulation Model are:

- Equivalised income (simplified, individual household indicator of deprivation).
- Household size.
- Fire Safety Preparation Level.

Additional explanatory variables which could be considered for an operational model include:

- Average age of house, or perhaps % older than a benchmark age, eg 1970.
- Age of Population, for example percentage of population over age of 70, which impacts on consequence of fire, rather than incidence. Fatalities may rise with growing numbers "ageing in place" unless this risk is managed successfully.
- Housing Density believed to inversely correlate with fire risk is density of housing (NZFS Strategic Information Analyst (pers. comm.)). If other variables such as deprivation/socio-economic status/income, age of housing, distance from fire stations, etc, are equal, the ratio of fires to households is lower in higher than lower density households. This may be because of neighbours reporting fires or higher standards of passive and active fire safety precautions in apartments than in fully detached houses.

6.5 DATA SOURCES FOR A NATIONAL MODEL

Possible additional data sources that could be drawn on for a national micro-simulation model of household fire risk are considered in this sub-section.

Tabulated data

- 2013 Census of Population of Dwellings
  - Household data – household size, household income
  - Age of oldest resident of a household (through available custom tabulation only)
  - Personal data, eg age
  - Meshblock data to be released March 2014
  - Extended availability of up to date microdata (see below).

- Fire Knowledge Survey
  - Assume this survey will continue
  - Upgrades in information collected are suggested (see below).
- Quotable Value/IQ
  - Cost of individual records at 50c/record remains prohibitive for a national model.
  - In any case, these cannot be matched to individual census records as rules in using Statistics NZ microdata prohibit this.
  - However, there is potential for using distribution of houses by decade (numbers or percentages) as outlined below.

2013 Census Microdata

Limitations in Using Datalab microdata:

- Limitation in using is that data matching is not permitted.
- Cross-tabulations at the meshblock level are also not permitted.
- Lack of key data in the Census, in particular age of house and age of people living in households.
- Other restrictions on using Datalab.
- Cost.

However, there is potential for refining construction of synthetic microdata in a set using 2013 CURF – a confidentialised sample of individual household and personal records, to refine the synthetic dataset used in the micro-simulation model.

- It is possible to build a synthetic dataset nationwide using the procedure developed for the pilot simulation model that would match 2013 census data household size and equivalised income, ie all synthetic households are drawn from responses to the Fire Knowledge survey.
- CURF data can also be used to build synthetic datasets at the meshblock level. It may be preferable to refine the Pilot Model procedure by constructing the synthetic dataset from records drawn from the 2013 CURF, rather than from the Fire Knowledge survey dataset.
- Each time a CURF record is selected for inclusion in the synthetic dataset a level of fire safety preparation is required – data that is not collected in the census. In principle, we could link the record to "similar" data records, in terms of Jensen equivalised income and

household size, in the Fire Knowledge survey data set. Estimate probability the CURF record is at "Low", "Medium" or "High" based on this, and randomly generate the preparation level at which the new synthetic household is.

- Would be an initial step of calculating probability distribution for each record in the CURF, then determining preparation level of the synthetic household each time the CURF record is selected.
- It is not possible to confirm this prior to release of information of what variables will be included in the CURF and the number of records likely to be on it.

Property IQ Housing Age Profile

Availability of Housing Age Profiles:

- PropertyIQ can produce housing age profiles, the number or % of houses in a geographic area per decade the houses were built in.
- Information provided by PropertyIQ is that a full set of age profiles can be produced by 2006 Area Unit at a current price of $1800+GST. A full set by 2006 meshblock would be currently $2300+GST (PropertyIQ will change to 2013 meshblocks when 2013 Census data is released).

Using the Housing Age Profiles in National Micro-simulation Model:

- For each synthetic household, it is possible to randomly assign a construction decade based on the PropertyIQ Housing Age Profile.
- Age of house may be more closely linked to property damage or injuries and fatalities than frequency of fires. If a fire starts it is more damaging in an older home.

The question is whether the fire risk in a particular decade's houses stays constant over time, or does it rise over time. In other words:

- is it a fixed function of the materials and construction methods used at the time of building, or
- does it rise over time as the houses age?

6.6 RELATIONSHIP WITH NATIONAL RESOURCE ALLOCATION MODEL

The Purpose of the National Resource Allocation Model (NRAM) is to:

"*allow the Service to improve allocation through strategically considered national deployment of operational resource. Effective allocation requires a modelled approach, which balances actual need against the capacity of the Service. Such a model needs to be based on operational data and a sound assessment of risk for each community"* (NZFS National Resource Allocation Model Process Report 2010).

- Development of NRAM included all types of incident Fire Service responds to, not just residential structure fires.
- Five station groups were generated in the development of NRAM, based on the principal component values, using 'K-Means clustering.'
- The underlying data mining analysis did not distinguish between response (dependent) variables (ie incidents) and explanatory (independent) variables, so in our opinion it provides (at best) only limited insights into the drivers of fire risk.
- A national micro-simulation model would help inform future refinements to the National Resource Allocation process by indicating potential future demand from residential structure fires down to the meshblock level, under a range of fire risk management scenarios.

6.7 WORK PROGRAMME TOWARDS A NATIONAL MICRO-SIMULATION MODEL

In this sub-section we outline a work programme for **Option 1** (refer **Section 6.3**).

Outline Work Programme for Option 1: Extend Pilot Model methodology to all other Areas:

Steps in developing a National Micro-simulation Model:

- Download 2013 census data on households by income and size at meshblock level.
- Purchase 2013 census data on households by household income by number of usual residents by area unit.
- Compile updated Fire Service incident data on fire calls by meshblock.
- Set up synthetic household datasets by meshblock for all fire areas using method developed for Pilot model.

- Project household growth by meshblock, using latest area unit level population and TLA level household projections.
- Calculate probability households will have fire events, using the Transition probabilities presented on **Table 4.1**.
- Run simulations for all fire areas as was done for Counties-Manukau.
- Compile, analyse and interpret results of the simulation runs.

An investigation that could precede building a national model could involve identifying the relative importance of additional explanatory variables.

- This could involve regressing, at the meshblock level, the response variable of numbers of fire calls/per 100 household against the explanatory variables listed in **Section 6.4**.
- While this has some resemblance to the analysis carried out in the National Resource Allocation Model development process (see **Section 6.6**), its purpose is to identify variables that help explain variations in fire calls/per household and therefore help project how this may change over time.
- The insights gained from such a modelling exercise could help refine the Micro-simulation model, either through:
  - helping identify a minimum set of variables to include in synthetic household records in the micro-simulation model; and/or,
  - improving estimates that a particular synthetic household experiences a fire event; or
  - as external weights to be applied, at the meshblock level, to event counts that are calculated via household-level micro-simulation.

6.8 OTHER POSSIBLE INPUT INFORMATION UPGRADES

Development and running of the Pilot micro-simulation model has highlighted some gaps in the information base which should be filled if the putative National micro-simulation model is to be fully robust.

- Household Survey data:
  - The Fire Knowledge survey collected data should include the decade in which respondent's house was built, to provide a link to PropertyIQ Housing Age Profile data.

- The questions on fires experienced should be refined/upgraded along the lines of the questions in the Fire Efficacy survey, provided continuity with the historic series is preserved.

- Incident Statistics: Ideally NZFS Incident statistics should include additional information about the household experiencing a fire incident including:
  - Decade in which the house was built
  - Number of occupants by age group
  - Income
  - Ethnicity, etc.

  We realise that the benefits of collecting some information are already recognised within the Fire Service, and that there are practical and privacy concerns about collecting such information. These should be addressed.

Improved measurement of household fire safety preparation and response of this to intervention strategies requires:

- Refining estimates of risk at each level of household fire safety preparation:
  - Currently, respondents to the Fire Knowledge survey are assigned to "Low", "Medium" and "High" based on responses to the Fire Knowledge Survey to questions on whether they have a smoke alarm, how often they are checked, whether they have an escape plan and, if so, whether they practise it.
  - Estimates of risk faced by "Low", "Medium" and "High" preparation households are based on responses to questions in the Fire Knowledge survey on whether they had a fire in the last five years and whether the Fire Service was called to it.
  - There should be verification that the information collected in the Fire Knowledge Survey accurately measures the fire risk faced by households. Other methods of estimating household fire risk are explored in McDermott Miller (2011), CRESA (2009), and BRANZ (2013).
- Improving estimates of transition probabilities:
  - At present the household transition probabilities are based on the professional judgement of members of the Advisory Panel.
  - Ideally, this would be refined through a longitudinal study of how a panel of households respond to Fire Service fire risk management interventions; the extent to which they adopt improved fire safety practises and for how long they maintain them.

6.9 EXTENDING THE MODEL TO INCLUDE OTHER TYPES OF FIRES AND OTHER TYPES OF INCIDENTS

The micro-simulation approach may be applicable to other types of incident, for example:

- Non-residential fires (commercial premises, etc)
- False alarms
- Motor Vehicle Accidents
- Vegetation Fires
- Floods
- Other emergencies

but these would require different methodologies which we do not address in this report.

But if the Fire Service prefers, it could be a priority to develop pilot micro-simulation models in a specific area (eg Counties-Manukau) before proceeding to a national–level residential fire micro-simulation model.

7. CONCLUSIONS

7.1 KEY INSIGHTS FROM SIMULATIONS USING PILOT MICRO-SIMULATION MODEL IN COUNTIES-MANUKAU

- Household growth in the Area is forecast (by Statistics NZ) to be so strong (average annual increase of 2.1% p.a. over 2011-2021, and 1.8% p.a. over 2021-2031 to 2021), that fires and fire calls are modelled to grow under all Fire Service intervention scenarios.
- **Figure 5.2** illustrates that domestic fire calls increase at higher levels of fire service intervention.
- The "Targeted Education" scenario could reduce fatalities by 26-40% compared to what it could be if there is no change in household fire preparedness (**Section 5.4)**.
- The apparently marginal effectiveness of the HFSC programme in Counties-Manukau is because of the small number of households checked in relation to total household stock – around 4.5 households per 1000 households in deprived meshblocks (NZDep 7 and over) per year.
- The pilot micro-simulation model could be used to estimate the number of HFSC per year that would be required to generate significant fire risk management benefits.
- Under the "Mass Advertising" scenario, nearly 70% of growth in fire calls is likely to be in the first response areas of four stations (Mangere, Papatoetoe, Otara and Manurewa) (**Section 5.4**).
- Within these station first response areas, the model can help pinpoint area units, and even meshblocks, where growth in fire call is most likely to arise.

7.2 BENEFITS OF A NATIONAL MICRO-SIMULATION MODEL FOR FIRE RISK MANAGEMENT

We consider the Pilot Micro-simulation Model to be "proof of concept" for a micro-simulation model for spatial household fire risk modelling and forecasting.

The Pilot model has demonstrated that micro-simulation can be used to explore scenarios of Fire Service fire risk management intervention strategies in terms of residential structure fire calls and the consequences of such fires (injuries and fatalities). This can be input to benefit-cost analyses of fire risk management strategies.

The detailed data that is generated also has utility for Fire Service resource allocation, as it indicates at a fine spatial level (meshblocks), as well as at fire-station first response areas, how residential structure fires calls could grow over time.

7.3 COSTS OF DEVELOPING A NATIONAL MICRO-SIMULATION MODEL

One of the Research Objectives (Refer **Section 1.1**) is:

- *To develop and cost a work programme to develop the micro-simulation model to full-scale.*

Core research and development of the model has been completed by McDermott Miller developing the pilot micro-simulation model. These costs therefore are sunk and we estimate only marginal extra costs of rolling out the pilot model to all fire areas throughout New Zealand. However, our estimated cost of development of an operational national micro-simulation model Household Fire Risk Identification must be qualified due to uncertainty over:

- The software platform the operational national model would run on, and the cost of developing an application on that platform;
- Incorporating model outputs as a layer in the Fire Service's GIS spatial information system;
- The cost of any refinements in the methodology that may be introduced such as utilising the full range of data that will be available from the 2013 Census and other sources.

As an indicative cost, we estimate the average cost before tax per fire area of further models using the same methodology as the Counties-Manukau area would be in the order of $15,000 per fire area.

For 24 further fire areas to achieve a nation-wide set of 25 fire area micro-simulation models of household fire risk models would mean a cost of $360,000. Adding a basic (non GIS) module for running and reporting on nationwide simulations would bring the cost close to $400,000.

Refinements to the existing methodology that may be required following the NZ Fire Service pilot model assessment process (see Recommended Next Steps below) could also accrue additional costs.

These gross costs, of course, need to be set against the potential benefit value of reducing fire risk enabled by application of the micro-simulation models in planning, operations and fire risk management of the New Zealand Fire Service. Estimating the value of such benefits is beyond the scope of McDermott Miller's research, but is fundamental to a decision to move beyond the pilot micro-simulation for household-based fire risk modelling and forecasting.

7.4 RECOMMENDED NEXT STEPS IN NZFS DEVELOPING A NATIONAL MICRO-SIMULATION MODEL

McDermott Miller's pilot micro-simulation model achieves the stated "**Research Purpose**" (see **EXEC 1** above) of demonstrating that micro-simulation can be used to indicate and assess the spatial distribution of household fire risk at geographic areas down to the meshblock level, both at present and over time.

McDermott Miller **recommends** the following "**next steps**" be taken by the New Zealand Fire Service in developing a national micro-simulation model of household fire risk:

1. The pilot Counties-Manukau micro-simulation model of household fire risk be assessed by operational and fire risk management managers in the Counties-Manukau Fire Area, and in Region 1. Their input should be sought on matters such as:
   - Interpretation of the model outputs presented in the **Section 5** of this report;
   - Resource allocation and other operational implications of the Pilot Model's outputs by fire station first response area and meshblock over time;
   - Fire Risk management implications of the Pilot Model's outputs by meshblock over time;
   - Format Area managers would need results to be presented in (ie meshblock level-GIS);
   - Possible applications of the Model in the Counties-Manukau Fire Area;
   - Improvements to model outputs which would be required to enhance the utility of the micro-simulation model for resource allocation or fire risk management purposes.

2. A similar assessment should be carried out by National Headquarters operational and fire risk management managers.

3. The New Zealand Fire Service should further clarify the specific applications that a national micro-simulation model would be put to. Such policy clarification is essential to ensuring cost-effective research and development of a national micro-simulation risk management model. Two areas of opportunity are apparent:

   - Operational applications – in particular helping allocate resources to fire stations as part of the National Resource Allocation process; and,
   - Fire risk management applications – helping to develop, test and evaluate effective fire risk management interventions that focus on communities and geographic areas most "at risk"

   In the process, NZFS needs to identify the relative net benefits to NZFS of each of these.

4. Consideration be given to improving the survey and incident information base (see **Section** 6.8) with the purpose (inter alia) of supporting a national micro-simulation model.

5. A benefit-cost analysis should be carried out for developing a national micro-simulation model of household fire risk, in view of the model applications and refinements identified in steps 1-4 above. A key issue to be examined in the benefit-cost analysis would be whether it would be more cost-effective to develop a full national model consisting of a complete set of fire-area sub-models (which would achieve economies or scale) or to build models for high-priority fire areas only.

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[ENDS]

McDermott Miller *Strategies*
Wellington
30 September 2013

New Zealand Fire Service
Contestable Research Fund 2011/12

Development of a Micro-Simulation Statistical Model for Household Fire Risk Identification

Annex A: Select Bibliography

30 September 2013

ANNEX A SELECTIVE BIBLIOGRAPHY

Micro-simulation References

Ballas, D.; Clarke, G.; Turton, I.; Exploring Micro-simulation Methodologies for the Estimation of Household Attributes. Paper presented at the 4th International conference on GeoComputation, Mary Washington College, Virginia, USA, 25-28 July 1999. 1999

Abstract: Micro-simulation is a rapidly expanding area of spatial modelling, which seems to offer great potential for applied policy analysis. However, currently there is considerable debate on the most appropriate methodology for estimating micro-data. Household or individual attribute data can be represented both as lists and/or as tabulations. It has long been argued (Birkin and Clarke, 1995; Clarke, 1996; Williamson et al, 1998) that the representation of information on households and individuals in the form of lists offers greater efficiency of storage and spatial flexibility as well as an ability to update and forecast. This paper reviews the possibilities and methodologies of building list-based population micro-data for small areas. First, it evaluates the methods, which have been developed and employed so far for the estimation of population micro-data, outlining the advantages and drawbacks of each one of them. Then the paper investigates the comparison of methods for generating conditional probabilities by statistical matching techniques or by using probabilities directly from household data sets such as the Samples of Anonymised Records (SARs) and the Small Area Statistics (SAS) from the UK Census of population. In addition, it explores the combination of these methods in a micro-simulation framework and presents micro-data outputs from a local labour market micro-simulation model for Leeds. Finally, it highlights the difficulties of calibrating this kind of model and of validating the model outputs, given the absence of suitable observed statistics.

Available at http://www.geovista.psu.edu/sites/geocomp99/Gc99/024/gc_024.pdf

Beckman, Richard J,; Baggerly, Keith A,; McKay, Michael D. Creating Synthetic Baseline Populations Transportation Research-A. Vol. 30, No. 6. pp. 415429. 1996

Abstract-To develop activity-based travel models using micro-simulation, individual travellers and households must be considered. Methods for creating baseline synthetic populations of households and persons using 1990 census data are given. Summary tables from the Census Bureau STF-3A are used in conjunction with the Public Use Microdata Sample (PUMS), and Iterative Proportional Fitting (IPF) is applied to estimate the proportion of households in a block group or census tract with a desired combination of demographics. Households are generated by selection of households moving from the associated PUMS according to these proportions. The tables of demographic proportions which are exploited here to make household selections from the PUMS may be used in traditional modelling. The procedures are validated by creating pseudo census tracts from PUMS samples and considering the joint distribution of the size of households and the number of vehicles in the households. It is shown that the joint distributions created by these methods do not differ substantially from the true values. Additionally the effects of small changes in the procedure, such as imputation of additional demographics and adding partial counts to the constructed demographic tables are discussed in the paper.

Birkin, M; Clarke, M.; SYNTHESIS—a synthetic spatial information system for urban and regional analysis: methods and examples. Environment and Planning A, 1988, volume 20, pages 1645-1671 1988

Abstract. There is a growing interest from a wide variety of sources in information pertaining to the characteristics of residents of small geographical areas together with their associated activity patterns. Reliance on the use of conventional aggregate data sources combined with the British Government's reluctance to make available microdata in the form of a public-use data set has restricted the type of questions analysts have been able to ask. The application of a methodology for generating synthetic microdata from a number of different aggregate sources is reported. The resultant information system can be used in a flexible manner to produce distributions not currently available from aggregate sources. Additionally, the microdata form direct inputs into micro-simulation models. The application described has been undertaken with Leeds Metropolitan District as the system of interest and a wide range of outputs is produced to illustrate the method.

Birkin, M., Allan, R., Beckhofer, S., Buchan, I., Finch, J., Goble, C., Hudson-Smith, A., Lambert, P., Procter, R., de Roure, D. and Sinnott, R.O. (2010) The elements of a computational infrastructure for social simulation. Royal Society of London Philosophical Transactions A: Mathematical, Physical and Engineering Sciences, 368 (1925). pp. 3797- 3812. ISSN 1364-503X. 2010

Brown, Laurie; Harding, Ann. Social Modelling and Public Policy: Application of Micro-simulation Modelling in Australia Journal of Artificial Societies and Social Simulation vol. 5, no. 42002 <http://jasss.soc.surrey.ac.uk/5/4/6.html>

This paper provides an overview of social modelling and in particular a general introduction to and insight into the potential role and usefulness of micro-simulation in contributing to public policy. Despite having made a major contribution to the development of tax and cash transfer policies, there are many important areas of government policy

to which micro-simulation has not yet been applied or only slow progress has been made. The paper starts with a brief review of some of the main distinguishing characteristics of social models. This provides a contextual background to the main discussion on recent micro-simulation modelling developments at the National Centre for Social and Economic Modelling (NATSEM) in Canberra, Australia, and how these models are being used to inform social and economic policy in Australia. Examples include: NATSEM's static tax and cash transfer model (STINMOD); modelling the Australian Pharmaceutical Benefits Scheme; application of dynamic modelling for assessing future superannuation and retirement incomes; and the development of a regional micro-simulation model (SYNAGI). Various technical aspects of the modelling are highlighted in order to illustrate how these types of socio-economic models are constructed and implemented. The key to effective social modelling is to recognise what type of model is required for a given task and to build a model that will meet the purposes for which it is intended. The potential of micro-simulation models in the social security, welfare and health fields is very significant. However, it is important to recognise that policy decisions are going to involve value judgements - policies are created and implemented within a political environment. The aim is for social modelling, and in particular policy simulations, to contribute to a more rational analysis and informed debate. In this context, micro-simulation models can make a significant contribution to the evaluation and implementation of 'just and fair' public policy.

Charatdao Kongmuang, Graham P Clarke, Andrew J Evans and Jianhui Jin. SimCrime: A Spatial Micro-simulation Model for the Analysing of Crime in Leeds. Working Paper, School of Geography, University of Leeds 2006

Abstract: This Working Paper is a part of PhD thesis ‘Modelling Crime: A Spatial Micro-simulation Approach’ which aims to investigate the potential of spatial micro-simulation for modelling crime. This Working Paper presents SimCrime, a static spatial micro-simulation model for crime in Leeds. It is designed to estimate the likelihood of being a victim of crime and crime rates at the small area level in Leeds and to answer what-if questions about the effects of changes in the demographic and socio-economic characteristics of the future population. The model is based on individual microdata. Specifically, SimCrime combines individual microdata from the British Crime Survey (BCS) for which location data is only at the scale of large areas, with census statistics for smaller areas to create synthetic microdata estimates for output areas (OAs) in Leeds using a simulated annealing method. The new microdata dataset includes all the attributes from the original datasets. This allows variables such as crime victimisation from the BCS to be directly estimated for OAs.

Day, Susan; Dwyer, Anita, How vulnerable is your community to a natural hazard? Using Synthetic estimation to produce spatial estimates of vulnerability. Australasian Journal of Regional Studies, Vol. 9, No. 3, 2003

ABSTRACT: Geoscience Australia and NATSEM have recently collaborated to produce experimental estimates of the geographic distribution of vulnerability to a natural hazard. Geoscience Australia (GA) has devised a methodology to quantify community impacts of natural hazards. NATSEM has used its synthetic estimation techniques to produce estimates of vulnerability to flood in 224 Census Collection Districts in Perth. GA’s methodology comprises four stages: indicator selection, a risk perception questionnaire, a decision tree analysis and a case study. This paper is about the fourth step, in which NATSEM was involved. An assessment of the estimates of vulnerability and the role of synthetic estimation must be done in the context of the preceding steps in the four-stage methodology. Due to the issues identified, we see the synthetic vulnerability outputs as powerful examples of the kind of small area data that can be produced using synthetic estimation rather than as authoritative final estimates of vulnerability in their own right.

Harland, Kirk; Heppenstall, Alison; Smith, Dianna; Birkin, Mark; Creating Realistic Synthetic Populations at Varying Spatial Scales: A Comparative Critique of Population Synthesis Techniques (2012) Journal of Artificial Societies and Social Simulation 15 (1) 1<http://jasss.soc.surrey.ac.uk/15/1/1.html>2012

Abstract There are several established methodologies for generating synthetic populations. These include deterministic reweighting, conditional probability (Monte Carlo simulation) and simulated annealing. However, each of these approaches is limited by, for example, the level of geography to which it can be applied, or number of characteristics of the real population that can be replicated. The research examines and critiques the performance of each of these methods over varying spatial scales. Results show that the most consistent and accurate populations generated over all the spatial scales are produced from the simulated annealing algorithm. The relative merits and limitations of each method are evaluated in the discussion.

Kurban, Haydar; Gallagher, Ryan; Kurban, Gulriz Aytekin; Persky, Joseph; A Beginner’s Guide To Creating Small-Area Cross-Tabulations. Cityscape: A Journal of Policy Development and Research. Volume 13, Number 3. U.S. Department of Housing and Urban Development • Office of Policy Development and Research 2011

Abstract: This short article introduces two techniques of generating cross-tabulations in small areas (for example, block groups or tracts) for which only univariate distributions are available. These techniques require either a microsample or a cross-tabulation from a larger geographic area (for example, a Public Use Microdata Area). One technique uses hill-climbing algorithms, and the other is based on iterated proportional fitting. In this article, we identify the general characteristics of both techniques. We present and evaluate an example (generating cross-tabulations of households by housing value and number of children enrolled in public school), briefly discuss extensions of both techniques to synthetic population construction, and test the synthetic populations by comparing the estimated microsamples with the actual population

Mahdavi, B; O'Sullivan, D.; Davis P. An Agent-based Micro-simulation Framework For Investigating Residential Segregation (2007)

Abstract Using Census Data Social and urban structures are inherently complex and multidimensional. They do not arise from a single process, but from the multifaceted interplay of different social and economic processes. This is true for racial and residential/neighbourhood segregation which is the result of many factors, and its causes are not well understood. Over years, researchers have studied and measured the role and influence of different factors implicated in residential segregation, using traditional techniques and tools, mostly in social science. These include empirical studies and statistical analyses of survey and census data. Such complex and nonlinear systems are difficult to study analytically. To better understand the complexity of the social world, building a model – a smaller, less detailed and less complex version of the real world (structure, system) – is recognized as an indispensable tool. Simulation is an excellent way of modelling which results to a better understanding of social processes and features of the social world. Simulation can be used to test theories and the result of simulation will often be the development of further theory.

Mannion, Oliver; Roy Lay-Yee, Wendy Wrapson, Peter Davis and Janet Pearson. JAMSIM: a Micro-simulation Modelling Policy Tool. Journal of Artificial Societies and Social Simulation 15 (1) 8 http://jasss.soc.surrey.ac.uk/15/1/8.html 2012

Abstract: JAMSIM (Java Micro-simulation) is an innovative synthesis of open source packages that provides an environment and set of features for the creation of dynamic discrete-time micro-simulation models that are to be executed, manipulated and interrogated by non-technical, policy-oriented users. Combining the leading open source statistical package R and one of the foremost agent-based modelling (ABM) graphical tools Ascape, JAMSIM is available as an open source tool, for public reuse and modification. Here we describe micro-simulation, our functional requirements, a review of tools used by other micro-simulators and an evaluation of existing software, followed by the architecture, features and use of JAMSIM.

Ota, Rissa; Stott, Helen P; A New New Zealand Static Micro-simulation Model - Challenges With Data. Forecasting and Modelling Unit, Ministry for Social Development Wellington. 2007

Abstract: The New Zealand Ministry of Social Development has been developing a new static micro-simulation model of the national tax and transfer system. The survey data used for the simulation is the Survey of Family, Income and Employment (SoFIE), which is a rich source of information about income, employment, benefits and family structure changes along the interview year. The 2002/3 survey is the first wave of a longitudinal survey which will be carried out for eight years. As the primary use of the database will be modelling changes to the income support system, the primary focus is on benefit recipients and low income families.

This paper gives an overview of the development of the database, with emphasis on the data synthesis, imputation and calibration of the beneficiary population. Calibration using generalised regression estimators has enabled a wide range of benchmarks to be used. However, there have been a range of challenges encountered along the way, including issues around updating the data as the benefit system has been undergoing major changes, and the representativeness of the data as the number of unemployed has dropped significantly since the first wave was collected.

Pearson, Janet; Lay-Yee, Roy; Davis, Peter et al. Primary care in an ageing society - Building a micro-simulation model for policy purposes. Centre of Methods and Policy Application in the Social Sciences (COMPASS), University of Auckland. 2006

Aims:
To develop a micro-simulation model of primary medical care in New Zealand and to test the impact of demographic ageing.
Methods:
Micro-level data from multiple sources - the New Zealand Health Survey (1996/7 and 2002/3) and the National Primary Medical Care Survey (NatMedCa, 2001/2) - were statistically matched to create a representative synthetic base-file of over 13,000 individuals. Probabilities of health experiences and general practitioner (GP) use from the Australian National Health Survey (1995), and of GP activity from NatMedCa respectively were derived. A micro-simulation model was developed that applied these probabilities via a random allocation process to individuals in the base-file. Iterative verification and validation were undertaken to continuously improve the model. Final outcomes simulated were: the number of visits in a year, the distribution of health conditions, and GP levels of investigation, prescription, non-drug treatment, follow up and referral. Scenarios of demographic ageing, community support and practitioner repertoire were tested by changing characteristics of the synthetic population.
Results:
The model imputed a health history over a year to each synthetic individual. Verification showed that the model was able to reproduce expected results and was operating according to design specifications.
The final outcomes produced by simulation were validated against actual data within acceptable error.
Various scenarios, assuming moderate demographic ageing, were tested by a forward projection to 2021 which showed little change in the final outcomes.

Conclusions:
Using a novel micro-simulation approach, a working model of primary medical care in New Zealand 2002 was constructed which produced plausible results. Furthermore, the model was able to be used to test the impact of demographic ageing, community support and practitioner repertoire. There is potential for an enhanced model to become a useful tool for policy purposes.

Spielauer, Martin; Neuwirth, Norbert. Family Micro-simulation. Working Paper, Austrian Institute for Family Studies. (2001)
Abstract The FAMSIM model is based on history event data collected in the Family and Fertility Survey (FFS). In this model, events belong to four distinguished careers: education, work, partnerships and births. While the FFS data allow the generation of individual biographies or event-histories in a series of important family-related events, FAMSIM—and micro-simulation models in general—can be viewed as a way to predict the future course of individual biographies. .

Williamson, P., Birkin, M., Rees, P. The estimation of population microdata by using data from small area statistics and samples of anonymised records,
Environment and Planning A, 30, pp. 785-816.1998
Abstract. Census data can be represented both as lists and as tabulations of household/individual attributes. List representation of Census data offers greater flexibility, as the exploration of interrelationships between population characteristics is limited only by the quality and scope of the data collected. Unfortunately, the released lists of household/individual attributes (Samples of Anonymised Records, SARs) are spatially referenced only to areas (single or merged districts) with populations of 120 000 or more, whereas released tabulations are available for units as small as single enumeration districts (Small Area Statistics, SAS). Intuitively, it should be possible to derive list-based estimates of enumeration district populations by combining information contained in the SAR and the SAS. In this paper we explore the range of solutions that could be adapted to this problem which, ultimately, is presented as a complex combinatorial optimisation problem. Various techniques of combinatorial optimisation are tested, and preliminary results from the best performing algorithm are evaluated. Through this process, the lack of suitable test statistics for the comparison of observed and expected tabulations of population data is highlighted.

Other References

AFAC. Accidental fire fatalities in residential structures: who's at risk?. 2005
Abstract: The 'Accidental Fire Fatalities in Residential Structures: Who's at Risk?' project is a research initiative of the Australasian Fire Authorities Council (AFAC). The project was conducted with the cooperation of Australian Fire Services and the New Zealand Fire Service. The 'Accidental Fire Fatalities in Residential Structures: Who's at Risk?' project builds on the 1998 'Fire Fatalities: Who's at Risk?" Research Report and provides further insight into the identification of 'at risk' groups, time periods of elevated risk, and major causes of fatal fires. Armed with this information, Australasian Fire Services and other associated bodies are placed in the advantageous position of being able to develop enhanced strategies aimed at reducing the total number of fire fatalities in Australia and New Zealand

AFAC. Accidental fire injuries in residential structures: who is at risk? Australasian Fire and Emergency Service Authorities Council. 2009
Abstract: The 'Accidental Fire Injuries in Residential Structures: Who's at Risk?' project is a research initiative of the Australasian Fire and Emergency Service Authorities Council. The project was conducted with the cooperation of Australian Fire Services and the New Zealand Fire Service. Data from rural South Australia was not available at the time this report was produced and therefore could not be included in this report. The 'Accidental Fire Injuries in Residential Structures: Who's at Risk?' project complements the October 2005 'Accidental Fire Fatalities in Residential Structures: Who's at Risk?' report providing further insight into the consequences of residential fires on people in terms of fire injuries. The report includes the identification of 'at risk' groups, time periods of elevated risk, and major causes of fires that cause injury to people. This information will assist Australasian Fire Services and other associated bodies to develop targeted strategies aimed at reducing the total number of fire injuries in Australia and New Zealand

BRANZ Fire design for aging residential occupancies New Zealand Fire Service Commission Research Report Number 115. 2011
Abstract: The main focus of this report is discussion of what differences there would be in residential fire safety design to account buildings that are targeted to older segments of our community compared to general residential buildings, where there is a wider distribution of ages of the intended occupancy.

BRANZ Limited. Fire Safety Features in Housing. New Zealand Fire Service Commission Research Report Number 128 .2013

Abstract: The research studied trends in fire safety features in the housing stock and the costs associated with mitigating fire hazards The research extracts information from several surveys and research reports on fire safety and fire safety features in houses. This information adds to our knowledge of risk factors and our ability to better target interventions to educate and also influence people's behaviours and attitudes to fire safety.

CRESA. A Review of Existing Fire Safety in Homes. New Zealand Fire Service Commission Research Report Number 88. 2009

Abstract: This research aimed to contribute to a reduction in the incidence and consequences of unintended fires in New Zealand households by estimating the prevalence and characteristics of risk factors across a range of dwellings and household types. These findings provided a basis for developing practical risk assessment tools and delivery mechanisms for typical and hard-to-access households.

Duncanson, Mavis; Woodward, Alister; Reid, Paparangi. Social & economic deprivation and fatal unintentional domestic fires in NZ 1988 – 1998. New Zealand Fire Service Commission Research Report Number 5. 2000

Abstract: The first report to establish a spatial correlation between social and economic deprivation and fire fatalities.

FEMA Fire Risks for Older Adults United States Fire Administration. 1999

Abstract: Older adults represent one of the highest fire risk populations in the United States. As a result of progressive degeneration in physical, cognitive, and emotional capabilities, older adults present unique challenges in the fields of fire protection, prevention, and safety. Complications associated with aging increase the likelihood that an elderly person will accidentally start a fire and at the same time reduce his or her chances of surviving it. As the nation's elderly population grows, the fire death toll will likely rise in direct proportion to that growth unless measures are taken to ameliorate the risks associated with this group. The fire safety community must address the fire safety needs of older adults or be faced with the potential for a severe public health problem.
http://www.usfa.fema.gov/downloads/pdf/publications/older.pdf

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