FIRE EMERGENCY NEW ZEALAND

WHAKARATONGA IWI

UNDERSTANDING NON-FATAL FIRE RELATED INJURIES IN NEW ZEALAND: 2013-2017

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Understanding Non-Fatal Fire Related Injuries

In New Zealand: 2013-2017

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List of abbreviations

ACC – Accident Compensation Corporation

Fire and Emergency – Fire and Emergency New Zealand

FIRS – Fire and Emergency's Fire Incident Recording System

ICISS – ICD-based injury severity score

NMDS – Ministry of Health's National Minimum Dataset

NFFRI – Non-fatal fire-related injury

UDF – Unintentional dwelling fire

UK – United Kingdom

2. Executive Summary

This descriptive study utilised data from three national administrative datasets to provide a comprehensive account of non-fatal fire-related injuries (NFFRI) in New Zealand for the period 2013-2017. The three datasets included the Ministry of Health's National Minimum Dataset (NMDS) of hospital discharges, Accident Compensation Corporation's (ACC) Claims Management database, and Fire and Emergency's Fire Incident Recording System (FIRS). Both intentional and unintentional NFFRI were collected, as well as information on injuries that occurred as a result of residential and non-residential fires.

While all three data sets identified different sized samples capturing different NFFRI events (ACC claims 10,368, NMDS hospital discharges 2,257 , Fire and Emergency attended incidents 1,716) all three data sets identified a higher rate of NFFRI among males, individuals aged between 20-29 years of age, and among those who were Māori. The same pattern of risk was observed in an earlier review of hospitalisations for unintentional domestic injury from fire and flame occurring in New Zealand during 1996-2000 (Duncanson, Reid, Langley, & Woodward, 2002).

The common causes and circumstances of NFFRI are more difficult to determine as this information differed according to the dataset examined, with each dataset capturing different NFFRI events.

Within the NMDS hospital discharge data, it was common for injuries to be sustained due to exposure to flammable materials and explosions, with differences in fire type exposures by age, sex and ethnicity. The average (mean) stay in hospital was 5.5 nights, with those aged over 70 years old more likely to spend 10, or more, nights in hospital. One in five with a NFFRI resulting in hospitalisation were readmitted for reasons related to the original hospitalisation at least once in the following 12 months. Using the ICD-based injury severity score (ICISS) recorded within the NMDS as an estimate of injury severity, 88% of injuries were minor/moderate and 12% presented a serious threat-to-life.

The majority of ACC claims were for NFFRI occurring within the home, with the majority of claims from the Auckland, Canterbury and Waikato regions. Significant costs associated with NFFRI were identified using the ACC dataset. The average (median) total claims cost within 3 years after a NFFRI was $209 (mean = $1,779, std. dev. = $11,190). Entitlement claims were associated with the greatest cost per claim (median = $3,052). Males had a higher number of both entitlement and medical fee claims than females, and average entitlement and medical fee claims were highest for a small number of older adults (aged 80 and above).

Fire and Emergency's Fire Incident Recording System identified those aged 30-39 years and 60-69 years had higher rates of NFFRI, in addition to individuals aged between 20-29 years. Fire and Emergency attended NFFRI were found to occur most frequently due to fire in a

single house, and from fires originating in the kitchen, with the most common cause due to unattended cooking. Cooking materials or food were identified as the most frequently ignited objects. The majority of injuries were classified by Fire and Emergency staff as moderate or minor (95%), with smoke inhalation the most common injury.

Significant differences in the number of NFFRI were identified across the datasets, with a far larger number of claims for NFFRI detected within the ACC claims dataset than the number recorded in the NMDS hospital discharge data, or the number of incidents documented as attended by Fire and Emergency services. Despite these differences, the general pattern of high risk was similar across datasets. Differences in age distribution were found across the datasets, indicating that each dataset is capturing different populations of individuals with NFFRI. For example, within the ACC database, more injuries in young people and fewer in older age groups were identified compared to other datasets potentially reflecting claim behaviour of the working age population. While a decrease in the number and rates of NNFRI each year was detected in the Fire and Emergency data, this trend was not observed in the other datasets.

Linking of FIRS data to NMDS hospital discharge and ACC claims data was minimal, primarily because of the lack of common data fields. Other data issues identified in this study include the lack of specificity of NFFRI data available in the ACC claims management system for case selection, missing cases especially in multiple casualty events, and data quality issues such as substantial amounts of missing or incorrect personal data, for variables including age and ethnicity. Due to these data quality issues, it is difficult to obtain accurate estimates for NFFRI attended by Fire and Emergency that result in hospitalisation (i.e. in-patients) or ACC compensation claims or, conversely, the recorded Fire and Emergency attended NFFRI that do not result in admission to hospital or in an ACC compensation claim.

This study provides limited information to inform the development and evaluation of national and local fire safety strategies and to target interventions at vulnerable populations. It is clear that patterns of risk for NFFRI are persistent over time and require improved inter-sectoral and cross-cultural collaboration and partnership to address non-fatal injuries from smoke, flame and fire.

Recommendations:

Recommendation 1: Efforts to reduce ethnic disparities should be a focus of fire safety activities. Fire and Emergency New Zealand should continue supporting and developing 1) bicultural policy and culturally appropriate services and networks to promote fire safety to Māori; and 2) effective fire safety strategies for Pacific peoples and other ethnic minorities. Culturally appropriate programmes should be adequately supported by Māori liaison staff in each fire region and ongoing training in cultural awareness should be provided to all fire-fighters. Establishing active community partnerships to support Fire and Emergency fire

safety programmes may produce more effective means of accessing and educating at risk communities.

Recommendation 2: Fire and Emergency New Zealand should continue and expand fire safety campaigns specifically addressing the risks of NFFRI from cooking/kitchen fires.

Recommendation 3: That Fire and Emergency New Zealand considers, develops, and adopts appropriate strategies to improve the collection of fire safety information in residential fire incidents, particularly the collection of person level details (i.e. name, actual age, date of birth, residential address) in order to allow for future assessments of at risk populations and outcomes following NRFFI.

Recommendation 4: That Fire and Emergency New Zealand considers undertaking formal fire investigations (as conducted for fatal fire incidents) in selected events resulting in NFFRI to gain a more comprehensive picture of the circumstances associated with such injury. At an absolute minimum, this should be undertaken for Fire and Emergency attended cases with serious and critical injuries requiring hospitalisation.

Recommendation 5: That Fire and Emergency New Zealand investigate and address the current limited ability of attending staff to accurately complete current data fields in the Fire Incident Reporting System in fire incidents resulting in a NFFRI, particularly the injury severity field.

Recommendation 6: That Fire and Emergency New Zealand considers adopting annual NFFRI incidence monitoring of serious non-fatal cases identified from NMDS hospital discharge data with derived ICISS.

3. Purpose

This report was commissioned by Fire and Emergency New Zealand (Fire and Emergency) to describe non-fatal fire-related injuries in New Zealand for the period 2013-2017. The findings build upon a previous examination of unintentional domestic non-fatal fire-related injuries occurring between 1996-2000 which linked Fire and Emergency Incident Reporting System data to hospital discharges that had a primary diagnosis of burn injury or smoke inhalation (Duncanson et al., 2002).

The aim of this research was to accurately inform directions for non-fatal fire-related injury (NFFRI) prevention efforts by using data derived from administrative datasets to identify current high-risk groups, causes and circumstances related to NFFRI. This information can be used to effectively prioritise and target preventive action to reduce NFFRI through fire safety strategy and prevention programmes.

Through epidemiological analyses of linked administrative data on NFFRI, the project endeavoured to address the following key research questions:

RQ-1: Who is at highest risk of NFFRI?

RQ-2: What are the common causes and circumstances of NFFRI?

4. Acknowledgements

This research was funded by Fire and Emergency New Zealand's contestable research fund.

5. Background

5.1 Introduction

This section describes the scientific evidence regarding at-risk populations and risk factors for NFFRI relevant to the New Zealand context.

Duncanson et al. have conducted the most comprehensive examination of non-fatal injuries resulting from unintentional domestic fires in New Zealand to date (Duncanson et al., 2002). This investigation attempted to link New Zealand Fire Service Fire Incident Reporting System data on NFFRI with hospital admissions for a primary diagnosis of burn injury or smoke inhalation from 1996-2000 (n = 862). However, very few linked cases were identified (n = 179; 21%), illustrating the combined dataset is of limited utility for surveillance of trends.

Additional detail and analysis of this non-fatal injury data collated from the New Zealand Fire Service, the New Zealand Health Information Service (now the Information Directorate of the Ministry of Health), and the New Zealand Coroners' Courts is available in Duncanson (2011).

Internationally, evidence on the epidemiological risk factors for NFFRI is limited and may not be directly relevant to New Zealand's housing and social context. The most recent systematic review in this area identified 11 studies examining risk factors for unintentional fatal and non-fatal house fire injuries (Turner et al., 2017). A quality assessment was conducted for each study which revealed no high-quality studies; all studies ranged from medium to low quality.

Few international studies have investigated the prevalence and risk factors associated with all types of NFFRI (i.e. not only residential house fires but those occurring outside the home), and none have done so in New Zealand. One analysis of a broad range of NFFRI occurring in England between 1995 and 2004 identified reductions in the total number of these injuries over time (Mulvaney et al., 2009). However, injury rates were found to increase over time for those living in areas of high deprivation, and rates of deprivation did not change across the years that NFFRI were examined.

5.2 Risk Factors

5.2.1 At-risk populations

Risk of hospitalisation following a NFFRI in New Zealand was found to be elevated in a number of age groups, including children under five years of age, young adults between 15 and 34 years, and older people over the age of 74 (Duncanson et al., 2002). Rates of hospitalisation were higher among Māori compared to other ethnic groups, with the rate for Māori two and a half times greater than that for non-Māori. Males were also at increased risk, with available evidence indicating that they were hospitalised for NFFRI at twice the rate of females (Duncanson et al., 2002).

Findings from international studies suggest that males and people over the age of 65 years are at greater risk of experiencing a residential NFFRI (Turner et al., 2017). Individuals with physical or cognitive disabilities, and those with low income or low property value, are also at increased risk (Mulvaney et al., 2009).

5.2.2 Risk factors

A number of common circumstances associated with hospitalisation for a residential NFFRI in New Zealand have been identified. Heat sources that most frequently lead to injury were documented using data from a sample of 383 individuals hospitalised between 1996-2000 (Duncanson et al., 2002). Heating appliances (including electric heaters, gas heaters, solid fuel burners, and open fires), stove tops or ovens, lighters or matches, and other electric appliances (such as electric blankets, toasters or lamps) were the most common sources of ignition. Outdoor fires, including those used for cooking, also contributed to a number of domestic NFFRI. Similar to the common sources of ignition identified in New Zealand, internationally injury risk is increased for fires ignited by smoking materials, heating units, and combustibles too close to heat (Turner et al., 2017). The precise ignition location is yet to be examined in the New Zealand context. However, international evidence has found an increased risk of NFFRI from fires ignited in the living room or bedroom, or fires in which the injured individual was located in the room of ignition (Turner et al., 2017).

Duncanson et al. (2002) identified the most commonly ignited item that resulted in an individual being hospitalised for domestic NFFRI in New Zealand was clothing. Direct contact with a heat source was also a key contributor to these injuries, in addition to ignition of flammable gas or liquid, cooking materials, bedding materials, and interior furnishings.

The role of domestic smoke alarms in relation to NFFRI has not been determined in New Zealand, due to limited data available regarding the presence or absence of smoke alarms in investigations conducted to date (Duncanson, 2011; Duncanson et al., 2002). However, international evidence demonstrates a clear relationship between the absence of working smoke alarms and increased NFFRI risk (Turner et al., 2017). Other property related factors that have been associated with increased risk of fire related injury in the international literature include residing in rented/public housing properties, municipality owned, and social housing properties compared with privately owned properties (Turner et al., 2017).

A characteristic of the physical environment identified as a risk factor for NFFRI resulting in hospitalisation in New Zealand is season, with inpatient admissions found to be more common in the winter months (June-August) (Duncanson et al., 2002). International studies also suggest that NFFRI are more likely to occur during winter (Turner et al., 2017).

Social factors are likely to play a role in the occurrence of hospitalisations due to NFFRI in New Zealand. Such injuries were more likely to occur on the weekend or in the evening

(Duncanson et al., 2002), a trend that has been observed internationally. Fires occurring in homes where an individual is alone are also associated with increased risk of NFFRI (Turner et al., 2017).

Little information is available regarding alcohol misuse and NFFRI in New Zealand. Cigarettes have previously been identified as the heat source contributing to 4% of hospitalisations for NFFRI during 1996-2000. Furthermore, 11% of individuals hospitalised for NFFRI during this period were identified as tobacco users, increasing the availability of matches and cigarette lighters within their households. Matches and lighters were identified as a principle heat source in domestic NFFRI among children under the age of 15 (Duncanson et al., 2002). International studies have found smoking to be associated with increased risk of experiencing NFFRI (Turner et al., 2017). The only available study suggests that the relationship between alcohol consumption and injury risk is less clear, with risk conferred by alcohol partly because drinkers tend to live in households with higher levels of smoking (Ballard, Koepsell, & Rivara, 1992).

While no NZ-specific information on risk factors for all types of NFFRI (including intentional injuries and those occurring outside the home) is available, analyses of data from England for the period 1995-2004 found cooking appliances to be the primary cause of a broad range of NFFRI (Mulvaney et al., 2009). This was evident in both males and females and for all age groups. Other common sources of ignition leading to NFFRI included smokers' materials, matches, space heaters, and cigarette lighters.

6. Methodology

6.1 Data sources

Potential NFFRI cases with a date of injury between 1/1/2013 and 31/12/2017 were identified using data from three sources: 1) Ministry of Health National Minimum Dataset (NMDS) of hospital discharges; 2) Accident Compensation Corporation (ACC) Claims database; and 3) Fire and Emergency Fire Incident Recording System.

Relevant variables available from within each dataset are presented in Table 1 below.

Table 1. Variables obtained from each dataset to examine patterns of NFFRI

Dataset	Relevant Variables Available
NMDS	Record ID; event ID; ICD 10 diagnosis; external cause of injury code (ICD 10); description of event leading to hospitalisation; description of diagnosis; injury date; admission date; discharge date; number of readmissions occurring in the 12 months after injury (linked to the first admission); number of days in hospital for first admission; total number of days in hospital for all admissions in the 12 months after injury; intent; hospital department; hospital; date of birth; age; sex; prioritised ethnicity; birth country; ACC involvement.
ACC	Person ID; event ID; region; injury date; work-related injury; cause; contact (e.g. exposure to flame); claim acceptance decision; date of birth; injury diagnosis; read code description; injury site; occupation; scene; accident description; resident indicator; residential address; total claims cost within 3 years after injury; sex; age at time of injury.
Fire and Emergency	Computer-aided dispatch (CAD) number; incident type; address; injury date; property type; building owner; fire origin location; object ignited; material ignited; equipment involved; cause of fire; heat source; fire detector type; fire detector performance; reason for detector failure; flame damage; number of casualties per incident; injury severity; injury type; age; sex; ethnicity; action taken.

Note. Prioritised ethnicity involves each person being allocated to a single ethnic group, based on the ethnicities they have identified with, in the prioritised order of Māori, Pacific, Asian and European/Other.

6.2 Ethical considerations

Ethical approval was obtained from the: University of Otago Human Research Ethics Committee Ref # HD18/086), Accident Compensation Corporation (ACC; for use and linkage of ACC fire-related injury claims from ACC data – ref #369), and Ministry of Health (for use and linkage of hospital discharges from the National Minimum Dataset; OTA/99/02/008/AM09). These approvals include permission for the provision of de-identified data to Fire and Emergency for restricted staff access for research purposes at the completion of the project. To protect individual privacy, response categories have been

combined within the report to ensure that there are at least three individuals, or incidents, in each cell of a table for the socio-demographic characteristics.

6.3 Data collection methodology

6.3.1 Inclusion/Exclusion criteria

Potential NFFRI cases were defined as injuries due to exposure to smoke, fire or flame. The following inclusion/exclusion criteria were applied when identifying cases.

Inclusion criteria

- Residential and non-residential fires (including fires in commercial premises or workplaces; communal residences – such as residential facilities (e.g. rest-homes), hostels and hotels; garden and outdoor areas; and roads and vehicles)
- Unintentional and intentional fires (including fires resulting in self-inflicted injury and homicide by fire)
- Cause of injury is fire or the effects of fire which includes: clothing that caught fire but did not result in more extensive structural conflagration (even when Fire & Emergency not called), injury resulting from falling into fires
- Fires due to explosion, including explosion of flammable materials

Exclusion criteria

- Fire occurred outside New Zealand

6.3.2 NMDS data

Cases of NFFRI were identified from within the NMDS on the basis of International Classification of Disease (ICD-10) external cause of injury codes (E-codes) (see Table 2).

Table 2. Identification of cases from the NMDS

External cause of injury	**ICD10 E-code**
Explosion and rupture of boiler/ gas cylinder	W35, W36
Exposure to smoke, fire and flames – unintentional	X00-X09
Contact with explosive material – undetermined	Y25
Exposure to smoke, fire and flames - undetermined	Y26

We obtained demographic information on the injured person and information about the type of fire for each case identified within the NMDS. These data also include Emergency Department (ED) admissions, where a patient has stayed in for 3 hours or more, and has been a day-stay patient.

6.3.3 Fire and Emergency data

Cases of Fire and Emergency attended incidents with a resulting NFFRI were obtained from the Fire and Emergency Fire Incident Recording System which classifies injuries as Critical (Status 1), Serious (Status 2), Moderate (Status 3), or Minor (Status 4).

6.3.4 ACC data

ACC provided data on 122,069 “fire-related” claims for the period 2013-2017 based on keywords specified below. Of these, ACC identified 26,124 (15.2%) as “refined-fire” claims (see Table 3 below).

Table 3. Key words used to describe 'fire-related' claims identified by ACC and 'refined-fire' claims likely to be of interest to Fire and Emergency

Claim category	**Includes all claims where:**
“Fire-related” claims	- injury diagnosis is "Burns (Burn, Corrosive Injury, Scald)" OR - injury cause is "Fire", "Unclear Fire or Explosion" or "Explosion/Blasting/Implosion" OR - contact is "Exposed to Flame/Noise/Elect" OR - external agency is "Fire, Flame etc" OR - read code contains "smoke"
“Refined-fire” claims	- the accident description contains "smoke" or "fire" or "flame" or "candle" or "lighter" or "match" or "lit" or "ignite" or "igniting" or "ignition" or contains "flash", but does not contain "weld" - excludes claims where accident description contains "firework", but does not contain the word "fire", "flame" or "smoke"

Manual review of claims flagged by as ACC as “refined-fire” indicated further refinement was required to select a subset of eligible cases due to exposure to smoke, flames and fire of direct interest to Fire and Emergency. A machine learning approach was used to do this. Machine learning develops algorithms and statistical models that computer systems use to effectively perform a specific task without using explicit instructions, relying on patterns and inference instead.

To obtain the 'gold-standard' training dataset, a stratified random sample of 1000 ACC claims were selected such that 900 records were 'refined-fire' claims and 100 not 'refined-fire'. Of these, Fire and Emergency manually reviewed the accident description field and classified 312 claims as in-scope. Extrapolation of the results from the manual review of 1000 claims suggested around 7% of the larger fire-related claims dataset were likely to be relevant.

In order to balance the training dataset, another random sample of 330 claims identified as not 'refined-fire' were selected and manually classified. Only one claim was considered to be in-scope and was therefore excluded. The first 312 of these out-of-scope claims were added to the previous 312 in-scope claims already identified. A Naïve Bayes machine learning algorithm was trained with this initial set of 624 claims and was used to predict the relevance of all 122,069 claims. The initial training dataset was boosted by selecting another 1,252 claims, such that 626 were predicted and manually verified to be in-scope and 626 were out-of-scope. These claims were combined with the initial 624 training claims to create a training set of 1876 records. This was used to train a second Naïve Bayes text classifier, which was found to have a classification accuracy (percentage of correct predictions) estimated to be 83%.

Manual review of the agreement between ACC's refined-fire flag and the Naïve Bayes algorithm indicated that using both together would result in the most accurate classification for this purpose. Doing so resulted in 10,385 claims (6% of the original sample) identified by both the algorithm and ACC's refined-fire flag. The READ code diagnosis categories associated with the 10,385 claims were examined and obvious exclusions were identified e.g. mesothelioma. This further reduced the ACC sample to 10,268 claims.

We determined that of all the variables provided by ACC, accident description (free text variable) was the best to determine cases meeting our inclusion criteria. A random sample of 10% of these descriptions (n = 1027) was manually reviewed to identify the likely over-estimation of burn injuries within this data set. This revealed that approximately 677 (66%) of cases met Fire and Emergency criteria. This contrasts with the number of cases meeting Fire and Emergency criteria within the set of 26,124 ACC had initially flagged as highly likely to be fire-related, where only 349 (34%) were classified as meeting Fire and Emergency criteria after a review of a random sample of 1027 cases.

6.4 Data analysis

All quantitative analyses were undertaken using STATA statistical software (StataCorp, 2017). This included calculation of rates, confidence intervals and chi-square tests.

6.4.1 Identification of high risk groups

To determine groups with high rates of NFFRI, rates per 100,000 person years were

calculated by age groups, sex and ethnicity using denominator data obtained from census population data and inter-censal population estimates available from Statistics New Zealand. Comparison of rates and patterns of risk were undertaken across the three datasets to ascertain differences in the populations represented in each dataset.

The impact of injuries in the year following NFFRI was assessed using length of hospital stay (from NMDS data, including readmissions), time off work and total costs of treatment and compensation (from ACC data).

6.4.2 Identification of common causes and circumstances

The common causes and circumstances of NFFRI, including the distribution of the personal, lifestyle, health, housing, and behavioural characteristics, were examined using both frequencies and proportions. Chi-square tests were used to compare frequencies and proportions as appropriate.

6.4.3 Linkage of datasets

In order to establish the injury outcomes and costs of fire-related injury cases attended by Fire and Emergency, linkage of 5 “critical” and 78 “severe” injury cases (cases most likely to result in a hospital discharge or an ACC claim) identified from Fire and Emergency data to NMDS and ACC records was attempted using manual linkage. Linkage was attempted first on date of injury, followed by age, sex, ethnicity and region of incident for individuals captured across datasets. A further variable available for linkage included the address of incident available in Fire and Emergency data to residential address data available in ACC records. We attempted to link data across all datasets (i.e. Fire and Emergency, ACC and NMDS) by using name, age, date of birth and date of injury.

7. Results

7.1 Hospitalisations (National Minimum Dataset - NMDS)

A total of 2257 cases of NFFRI occurring in the period 2013 - 2017 were identified from the NMDS (Table 4). There was no clear trend in the number and rates of NNFRI cases occurring each year over this time. There were between 427 and 480 NFFRI hospitalisations per year, with an average of 451 NFFRI hospitalisations per year across the 5 year study period.

Table 4. Number of NFFRI with hospital discharges by year, 2013-2017

	Year of injury, n (%)					
	2013	**2014**	**2015**	**2016**	**2017**	**Total**
Number of injuries	458 (20)	427 (19)	455 (20)	437 (19)	480 (22)	2257
Rate per 100,000 person years	10.3	9.5	9.9	9.3	10.1	9.8
95% confidence interval	9.4, 11.3	8.6, 10.4	9.0, 10.9	8.5, 10.3	9.2, 11.1	9.4, 10.2

7.1.1 Personal Characteristics

A higher rate of hospitalisation due to NFFRI was observed among males compared to females with males nearly three times as likely to have a NFFRI resulting in a hospital discharge (Table 5). Individuals aged between 20-29 years had the highest rate of NFFRI when compared to other age groups, and a higher rate of NFFRI hospitalisation was evident for Māori compared to other ethnic groups (close to double the rate of individuals of Pacific Island ethnicity and four times the rate of individuals of Asian ethnicity).

Table 5. Sex, age and ethnicity of individuals with hospital discharges due to NFFRI, 2013-2017

Characteristics	Count n (%)	Rate per 100,000 person years (95% CI)
Sex		
Male	1642 (73)	14.6 (13.9, 15.3)
Female	615 (27)	5.3 (4.8, 5.7)
Age (years)		
0-9	208 (9)	6.7 (5.8, 7.7)
10-19	267 (12)	8.7 (7.7, 9.8)
20-29	515 (23)	16.1 (14.8, 17.6)
30-39	311 (14)	11.0 (9.9, 12.3)
40-49	332 (15)	10.6 (9.5, 11.9)
50-59	265 (12)	8.8 (7.7, 9.9)
60-69	157 (7)	6.6 (5.6, 7.7)
70-79	121 (5)	8.4 (7.0, 10.0)
80+	81 (3)	9.8 (7.8, 12.2)
Ethnicity (prioritised)		
Māori	576 (25)	15.9 (14.7, 17.3)
Pacific Island	128 (6)	8.6 (7.2, 10.3)
Asian	110 (5)	3.7 (3.1, 4.5)
NZ European and Other	1443 (64)	9.7 (9.2, 10.2)

7.1.2 Exposures

The majority of hospital discharges due to NFFRI between 2013 and 2017 were unintentional (94%), with 4% of undetermined intent and less than 1% of cases intentional.

The different types of fire exposures leading to NFFRI resulting in hospital discharge are shown in Figure 1. Exposure to ignited highly flammable material was the most common exposure, responsible for 382 (17%) of all NFFRI with a hospital discharge over the study period. This was followed by 363 (16%) NFFRI due to other specified smoke, fire and flames. Examples of scenarios with this fire code are varied and include ‘exposure to flames from open fire’, ‘escaped from house fire’, and ‘burnt while lighting sparklers’. Exposure to controlled and uncontrolled fires within a building or structure were also key exposures leading to NFFRI, contributing to 335 (15%) and 257 (11%) of these hospitalised injuries respectively. Exposure to unspecified forms of smoke, fire and flames, when the exact type of exposure was unknown, was also commonly recorded in the NMDS, accounting for 286 (13%) of all hospitalisations.

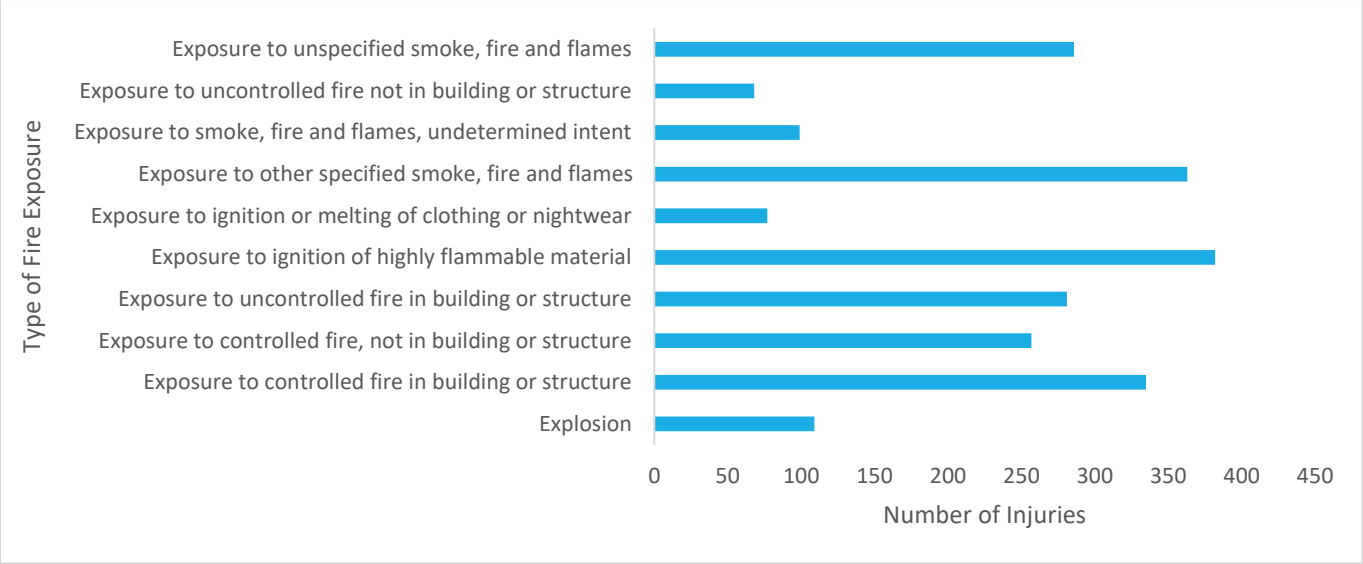

Figure 1. Number of NFFRI with hospital discharges by type of fire exposure, 2013-2017

Statistically significant relationships were observed between age (Chi^2= 285.2, $p < 0.001$), sex (Chi^2= 146.4, $p < 0.001$) and ethnicity (Chi^2 = 42.6, $p = 0.03$) with type of fire exposure (Table 6). For injuries from fires occurring outside of a building (controlled or uncontrolled) (COL 84%) and for those resulting from highly flammable material (COL 88%) or an explosion (COL 89%), males were more frequently hospitalised than females.

Type of fire exposure resulting in hospitalisation differed by age group. For injuries from controlled fires within a building, those aged 0-9 years (COL 16%), 20-29 years (COL 15%) and 40-49 years (COL 18%) were the most frequently hospitalised. For uncontrolled fires within a building, individuals aged 20-29 (COL 21%) and 40-49 (COL 18%) were hospitalised most frequently. For injuries from fires occurring outside of a building (controlled or uncontrolled), those in the 20-29-year age group were again most frequently hospitalised (COL 33%). This age group was also most frequently hospitalised for injuries from explosions (COL 25%) and for injuries resulting from ignition of flammable materials (COL 29%). For injuries due to ignition of clothing, children aged 0-9 years (COL 17%) were most frequently hospitalised in addition to those in the 20-29 years age group (COL 16%).

For injuries due to ignition of clothing, Māori (COL 34%) and NZ European/other (COL 60%) ethnic groups were most frequently hospitalised. NZ European/other ethnic groups were more frequently hospitalised as a result of controlled fires outside of a building (COL 72%), and because of ignition of flammable material (COL 69%) compared to other ethnic groups.

Table 6. Type of exposure leading to hospital discharge for NFFRI according to sex, age and ethnicity, 2013-2017

	Smoke, Fire & Flames in Building*		Smoke, Fire & Flames not in Building*		Ignition		Smoke, Fire & Flames			Explosion
	Controlled	Uncontrolled	Controlled	Uncontrolled	Clothing	Flammable Material	Unspecified	Other	Undetermined Intent	
Sex										
Male	209 (62)	165 (59)	216 (84)	57 (84)	51 (66)	338 (88)	188 (66)	262 (73)	59 (60)	97 (89)
Female	126 (38)	116 (41)	41 (16)	11 (16)	26 (34)	44 (12)	98 (34)	101 (28)	40 (40)	12 (11)
Age										
0-9	54 (16)	22 (8)	19 (7)	4 (6)	13 (17)	7 (2)	44 (15)	32 (9)	10 (10)	3 (3)
10-19	23 (7)	27 (10)	39 (15)	9 (13)	10 (13)	50 (13)	24 (8)	55 (15)	12 (12)	18 (16)
20-29	49 (15)	59 (21)	83 (33)	17 (25)	12 (16)	109 (29)	54 (19)	83 (23)	22 (23)	27 (25)
30-39	37 (11)	30 (11)	40 (16)	9 (13)	7 (9)	75 (20)	23 (8)	48 (13)	19 (19)	23 (21)
40-49	60 (18)	50 (18)	31 (12)	10 (15)	5 (6)	66 (17)	28 (10)	50 (14)	8 (8)	24 (22)
50-59	45 (13)	35 (12)	19 (7)	12 (18)	8 (10)	47 (12)	33 (12)	43 (12)	16 (16)	7 (6)
60-69	22 (6)	22 (8)	16 (6)	3 (4)	10 (13)	17 (4)	28 (10)	28 (8)	7 (7)	4 (4)
70-79	26 (8)	25 (9)	10 (4)	3 (4)	3 (4)	9 (2)	28 (10)	12 (3)	4 (4)	1 (1)
80+	19 (6)	11 (4)	0 (0)	1 (2)	9 (12)	2 (1)	24 (8)	12 (3)	1 (1)	2 (2)
Ethnicity										
Māori	100 (30)	72 (26)	57 (22)	15 (22)	26 (34)	89 (23)	79 (28)	87 (24)	24 (24)	27 (25)
Pacific Island	22 (6)	22 (8)	9 (4)	2 (3)	4 (5)	13 (3)	13 (4)	29 (8)	7 (7)	7 (6)
Asian	20 (6)	17 (6)	6 (2)	1 (1)	1 (1)	18 (5)	15 (5)	16 (4)	9 (9)	7 (6)
Other Ethnicity	193 (58)	170 (61)	185 (72)	50 (74)	46 (60)	262 (69)	179 (63)	231 (64)	59 (60)	68 (63)

Note. *Building or structure; % reflects column percentage

7.1.3 Outcomes

The majority of NFFRI identified within the NMDS were external burns and corrosions (75%), and nearly 20% were classified as cases of carbon monoxide poisoning/smoke inhalation and toxic effects of petroleum (Table 7).

Table 7. Characteristics of NFFRI with hospital discharges, 2013-2017

Characteristics	n (%)
Complications of medical care	5 (0)
Early complications of trauma	7 (0)
External burns and corrosions	1515 (75)
Head injuries	20 (1)
Internal organ burns	43 (2)
Lower extremity injuries	25 (1)
Multiple body region burns	8 (0)
Other effects	16 (1)
Torso injuries	10 (1)
Toxic effects of substances*	355 (18)
Upper extremity injuries	18 (1)

Note. *Carbon monoxide poisoning/smoke inhalation and toxic effects of petroleum

Almost 20% of individuals hospitalised for NFFRI between 2013 and 2017 were readmitted to hospital at least once after their initial injury, as indicated in Table 5. The number of readmissions per person ranged from 0 only hospitalised once for the injury) up to 9 readmissions for the original injury event.

Table 8. Number of hospital readmissions in the first 12 months after NFFRI with hospital discharge, 2013-2017

Number of Readmissions in 12 Months	n (%)
0	1860 (82)
1	310 (14)
2 or more	87 (4)

Figure 2 illustrates the pattern of readmissions by age. Although no statistically significant differences in readmissions by age were found (Chi^2= 21.32, p = 0.17), there was a tendency for those aged between 40-49 years and those over the age of 80 years to be more likely to experience a readmission than other age groups.

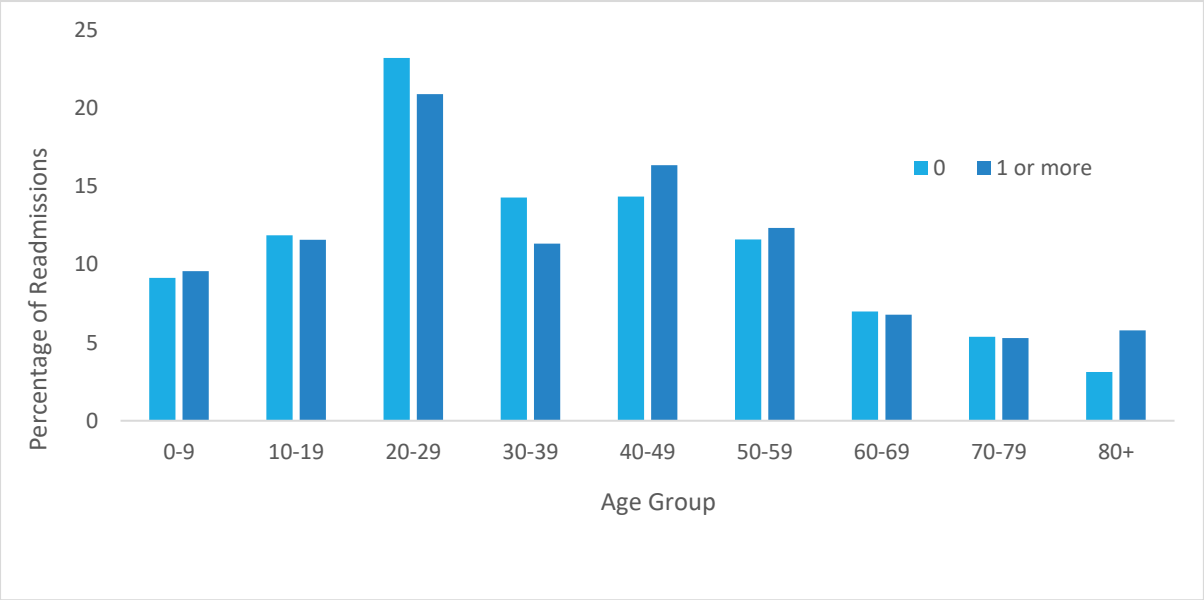

Figure 2. Percentage of hospital readmissions in the first 12 months after NFFRI with hospital discharge by age group, 2013-2017

Figure 3 below shows that more than half of people who were hospitalised for NFFRI between 2013 and 2017 required one night (in hospital over midnight), or more, in hospital for their first admission. Length of stay for first admission ranged from no nights (i.e. short-term day stay Emergency Department patients) to 8.5 months. The average (mean) length of stay for first admission was 3 nights.

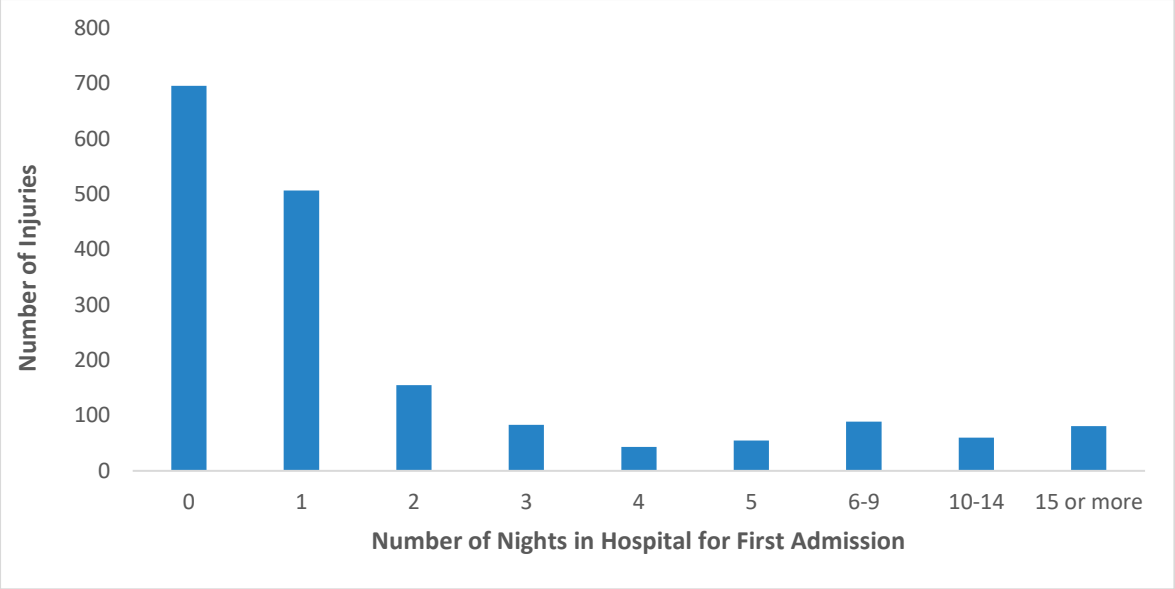

Figure 3. Number of nights spent in hospital for first admission for NFFRI, 2013-2017

Figure 4 demonstrates the total number of nights (across original admission and readmissions, if relevant) that each person experiencing a NFFRI between 2013 and 2017 spent in hospital in the first 12 months following the initial injury event. Total length of hospital stay ranged from 0 to almost 11 months. The average (mean) total length of stay was 5.5 nights.

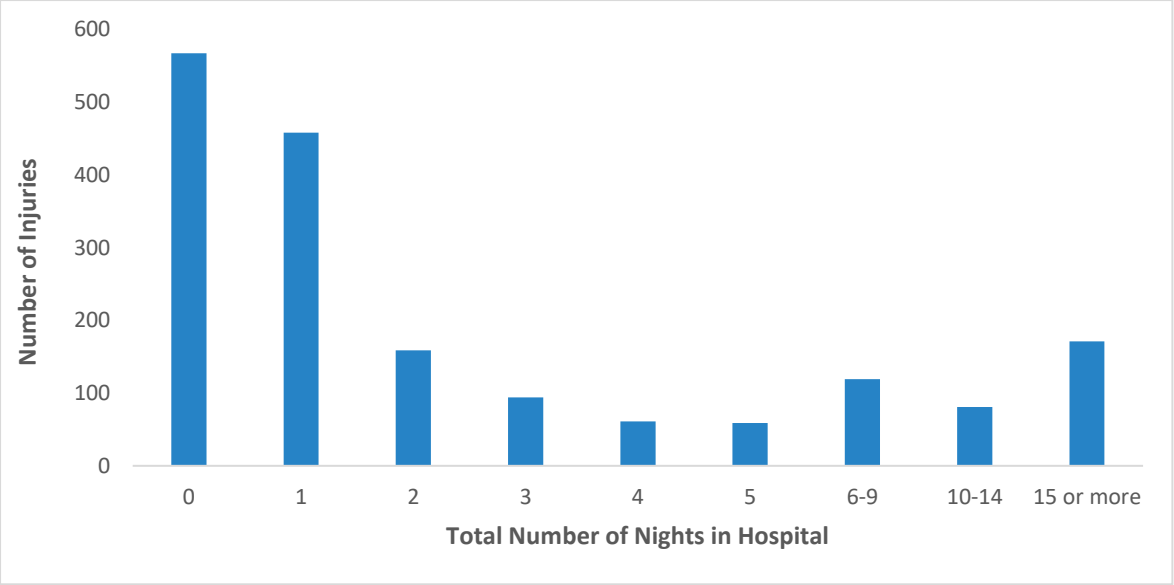

Figure 4. Total number of nights spent in hospital in the first 12 months after NFFRI, 2013-2017

Table 9 highlights that there is a significant relationship between total number of nights spent in hospital due to NFFRI and sex (Chi^2 = 19.05, p = 0.02). Of those spending more than 2 weeks in hospital, 76% were male. No significant relationship was evident between total number of nights spent in hospital for NFFRI and ethnicity (Chi^2 = 18.87, p = 0.7).

Table 9. Total number of nights spent in hospital in the first 12 months after NFFRI by sex, age and ethnicity, 2013-2017

	Total Number of Nights in Hospital								
	0	1	2	3	4	5	6-9	10-14	15 or more
Sex									
Male	513 (68)	423 (74)	149 (75)	89 (79)	54 (74)	46 (65)	118 (78)	81 (79)	169 (76)
Female	241 (32)	147 (26)	50 (25)	24 (21)	19 (26)	25 (35)	34 (22)	21 (21)	54 (24)
Age									
0-9	67 (9)	62 (11)	25 (13)	9 (8)	4 (5)	5 (7)	14 (9)	8 (8)	14 (6)
10-19	96 (13)	82 (14)	22 (11)	9 (8)	7 (10)	6 (8)	18 (12)	10 (10)	17 (8)
20-29	194 (26)	119 (21)	54 (27)	32 (28)	19 (26)	15 (21)	32 (21)	17 (16)	33 (15)
30-39	110 (14)	82 (14)	23 (12)	14 (13)	8 (11)	8 (11)	15 (10)	14 (13)	37 (17)
40-49	120 (16)	71 (13)	36 (18)	19 (17)	11 (15)	11 (16)	23 (15)	13 (13)	28 (13)
50-59	81 (11)	64 (11)	20 (10)	15 (13)	10 (14)	11 (16)	19 (12)	11 (11)	34 (15)
60-69	43 (5)	37 (7)	8 (4)	8 (7)	7 (10)	10 (14)	11 (7)	8 (8)	25 (11)
70-79	28 (4)	31 (5)	10 (5)	1 (1)	4 (5)	4 (6)	13 (9)	11 (11)	19 (8)
80+	15 (2)	22 (4)	1 (0)	6 (5)	3 (4)	1 (1)	7 (5)	10 (10)	16 (7)
Ethnicity									
Māori	186 (25)	134 (24)	55 (28)	27 (24)	26 (36)	18 (25)	43 (28)	25 (24)	62 (28)
Pacific Island	40 (5)	33 (6)	12 (6)	7 (6)	1 (1)	4 (6)	12 (8)	5 (5)	14 (6)
Asian	45 (6)	31 (5)	6 (3)	4 (4)	3 (4)	3 (4)	4 (3)	2 (2)	12 (5)
NZ European/Other	483 (64)	372 (65)	126 (63)	75 (66)	43 (59)	46 (65)	93 (61)	70 (69)	135 (61)

Note. % reflects column percentage.

There was a significant relationship between total number of nights in hospital and age group, Chi^2 = 118.34, p < .001. Adults aged 70-79 and those aged over 80 were more likely to spend 10 or more nights in hospital as a result of their NFFRI compared to other age groups. Figure 5 demonstrates this graphically by presenting the row % of injuries and total number of nights in hospital by age group.

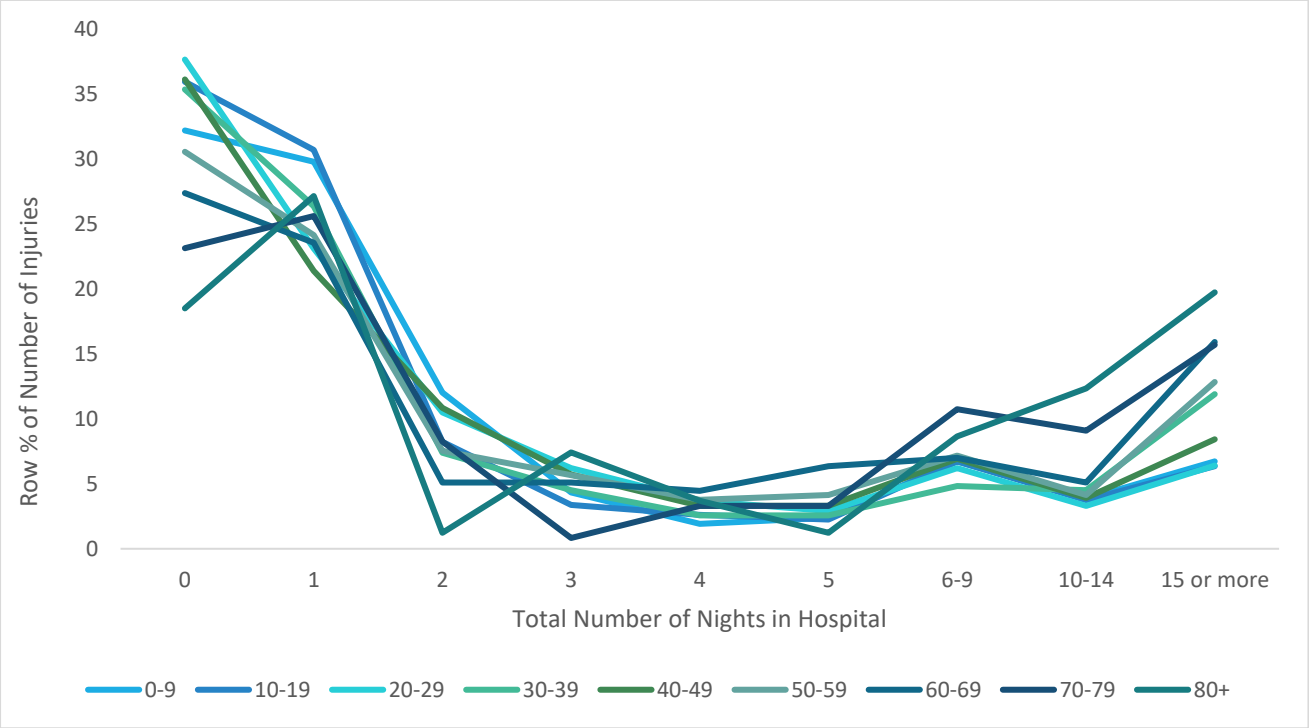

Figure 5. Row % of NFFRI and total number of nights in hospital by age group

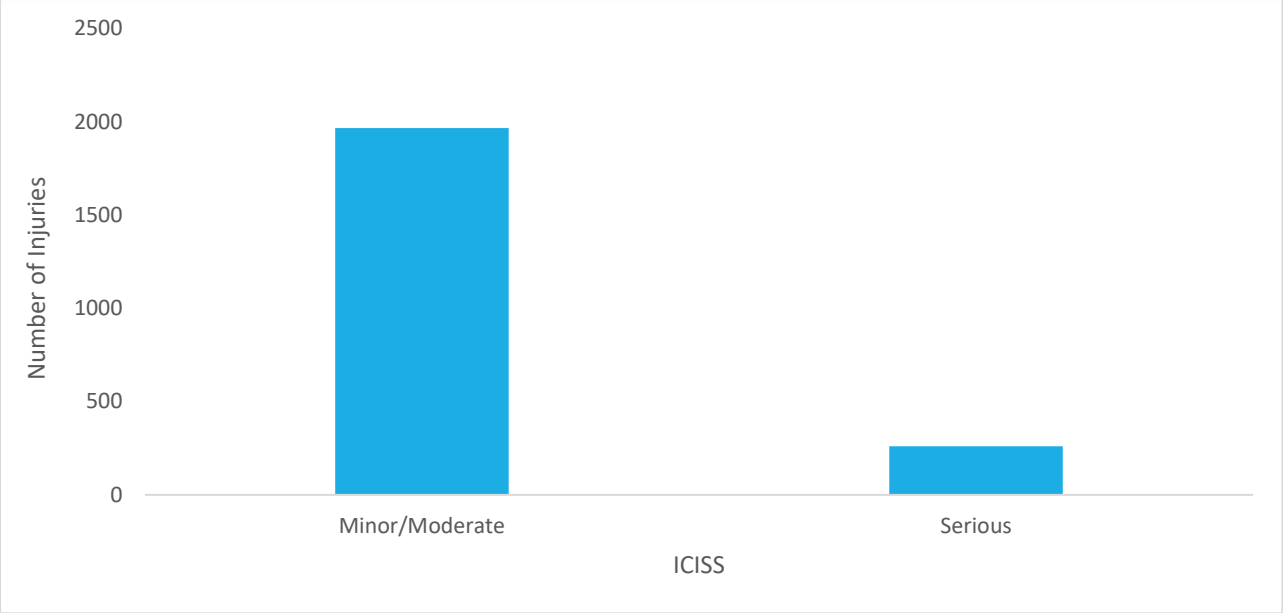

Figure 6. Number of hospital discharges for NFFRI by injury severity (ICISS)

The ICD-based injury severity score (ICISS) recorded within the NMDS can be used to estimate injury severity. Scores are calculated by estimating probability of death directly from ICD injury diagnoses by examining a large set of cases for which survival status in hospital is known. Determining which injuries are "serious" by the ICISS method involves calculating a Survival Risk Ratio (SRR) for each individual injury diagnosis code. A given SRR represents the likelihood that a patient will survive that particular injury diagnosis (Davie, Cryer, & Langley, 2008). The ICISS score for an individual is the product of all SRRs associated with a patient's ICD codes.

ICISS was missing for 32 patients. For the remaining 2225 patients who were hospitalised for NFFRI over the study period, 1965 (88%) were classified as having a minor/moderate injury and 260 (12%) were classified as having a serious threat-to-life injury.

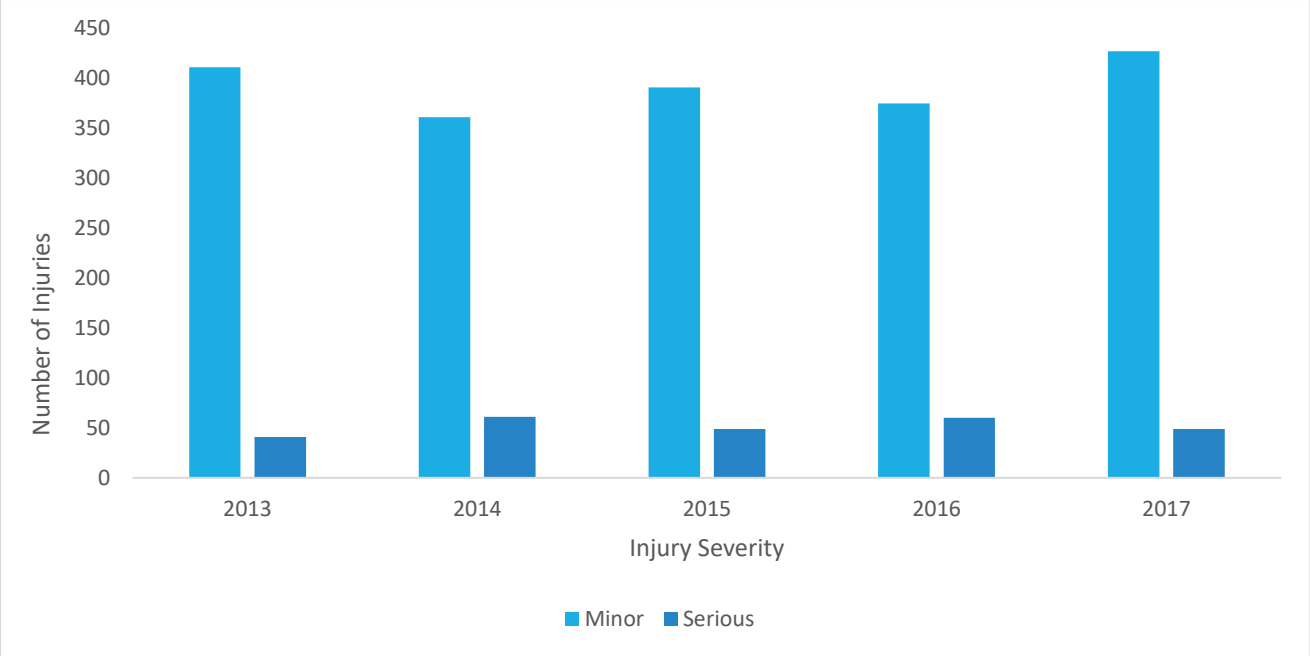

Figure 7. Number of hospital discharges for NFFRI per year by injury severity

Figure 7 demonstrates the number of minor and serious injuries occurring per year across the study period. While the relationship between number of serious injuries and year of injury was of borderline statistical significance, (Chi^2 = 9.03, p = 0.06), a slightly higher proportion of serious injuries was observed in 2014 and 2016 relative to other years. The lowest proportion of serious injuries occurred in 2013 (n = 41, 9%).

Table 10. Sex, age and ethnicity by injury severity (ICISS), 2013-2017

Characteristics	Minor Injury	Serious Injury
Sex		
Male	1443 (73)	184 (71)
Female	522 (27)	76 (29)
Age (years)		
0-9	169 (9)	31 (12)
10-19	234 (12)	29 (11)
20-29	454 (23)	53 (21)
30-39	267 (13)	42 (16)
40-49	298 (15)	31 (12)
50-59	235 (12)	27 (10)
60-69	136 (7)	19 (7)
70-79	100 (5)	19 (7)
80+	72 (4)	9 (4)
Ethnicity (prioritised)		
Māori	485 (25)	76 (29)
Pacific Island	102 (5)	21 (8)
Asian	98 (5)	10 (4)
NZ European and Other	1280 (65)	153 (59)

Note. % reflects column percentage.

Table 10 shows that the distribution of injury severity was similar across both sexes, Chi^2 = 0.83, p = 0.36. No significant relationship was found between injury severity and age (Chi^2 = 9.07, p = 0.34), although individuals aged 0-9 (ROW 16%) and those aged 70-79 (ROW 16%) experienced a slightly higher proportion of serious injuries relative to other age groups.

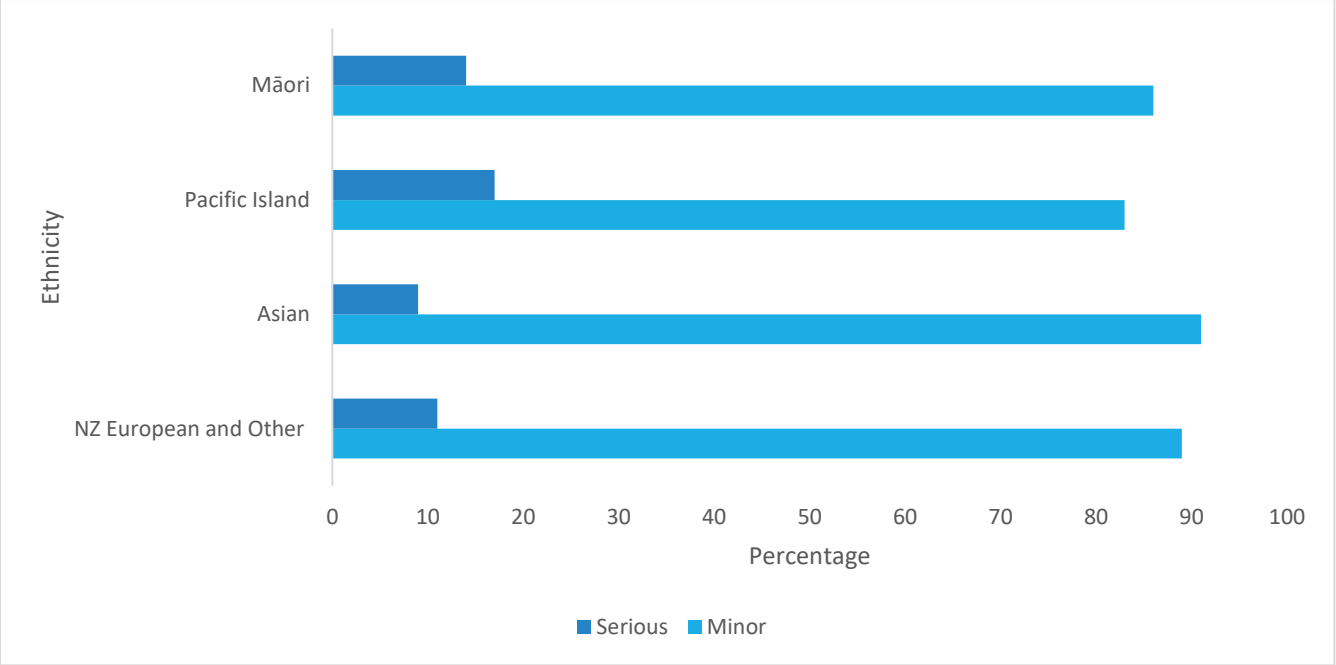

Figure 8. Row percentage of individuals experiencing minor and severe injuries by ethnicity.

While the relationship between injury severity and ethnicity was of borderline statistical significance (Chi^2 = 7.37, p = 0.06), Māori were more likely to experience a serious injury (ROW 14%) than Asian and NZ European/other ethnic groups, and individuals of Pacific Island ethnicity were at increased risk of experiencing serious injury (ROW 17%) compared to all other ethnic groups.

7.2 ACC

Following machine learning to refine the original dataset provided by ACC (described above), a final sample of 10,268 cases of NFFRI occurring in the period 2013 – 2017 were identified as being relevant based on the NFFRI inclusion criteria. There were between 1963 and 2087 NFFRI claims made per year, with an average of 2054 NFFRI claims per year across the 5-year study period (Table 11).

Table 11. Number of ACC claims for NFFRI by year as identified by ACC, 2013-2017

	Year of injury, n (%)					
	2013	**2014**	**2015**	**2016**	**2017**	**Total**
Number of claims	1963 (19)	2150 (21)	2009 (21)	2059 (20)	2087 (20)	10268
Rate per 100,000 person years	44.2	47.7	43.7	44.0	43.9	44.7
95% confidence interval	42.3, 46.2	45.7, 49.7	41.8, 45.7	42.1, 45.9	42.1, 45.9	43.8, 45.6

7.2.1 Personal Characteristics

A higher rate of ACC claims for NFFRI was observed among males compared to females (Table 12). Similar to findings using data within the NMDS, individuals aged between 20-29 years had the highest rate of ACC claims for NFFRI when compared to other age groups, and a higher rate of NFFRI claims was evident for Māori compared to other ethnic groups. Approximately 45% of claimants were employed at the time of their NFFRI.

Table 12. Sex, age, ethnicity and employment status of individuals making a claim to ACC for NFFRI, 2013-2017

Characteristics	n (%)	Rate per 100,000 person years (CI)
Sex		
Male	6791 (66)	60.3 (58.8, 61.7)
Female	3477 (34)	29.7 (28.7, 30.7)
Age (years)		
0-9	1531 (15)	49.3 (46.8, 51.8)
10-19	1630 (16)	53.3 (50.7, 55.9)
20-29	2075 (20)	65.0 (62.2, 67.8)
30-39	1349 (13)	47.9 (45.4, 50.5)
40-49	1327 (13)	42.5 (40.3, 44.9)
50-59	1136 (11)	37.5 (35.4, 39.8)
60-69	712 (7)	29.9 (27.7, 32.2)
70-79	334 (3)	23.1 (20.7, 25.8)
80+	174 (2)	21.0 (18.0, 24.4)
Ethnicity (prioritised)		
Māori	2352 (23)	65.1 (62.5, 67.8)
Pacific Island	587 (6)	39.6 (36.5, 42.9)
Asian	502 (5)	16.9 (15.5, 18.5)
NZ European and Other	6827 (66)	45.8 (44.7, 46.9)
Employment Status		
Employed	4117 (40)	
Self-employed	562 (5)	
Unemployed	8 (0)	
Non-earner	5570 (55)	
Other	11 (0)	

Table 13 demonstrates that the largest number of NFFRI identified by ACC occurred in the most densely populated regions of New Zealand with one in five claims originating from the Auckland region. Other regions with a high frequency of claims include Waikato (12%) and Canterbury (13%).

Table 13. Region in which NFFRI resulting in an ACC claim occurred, 2013-2017

Region	n (%)
Northland	531 (5)
Auckland	2195 (21)
Waikato	1275 (12)
Bay of Plenty	855 (8)
Gisborne	189 (2)
Hawkes Bay	481 (5)
Taranaki	325 (3)
Manawatu-Wanganui	620 (6)
Wellington	762 (7)
Tasman	113 (1)
Nelson	142 (2)
Marlborough	163 (2)
Canterbury	1339 (13)
West Coast	172 (2)
Otago	639 (6)
Southland	407 (4)
Other	40 (1)
Unknown	12 (0)

7.2.2 Exposures

The vast majority of ACC claims were for NFFRI occurring within the home (see Table 14).

Table 14. Scene of NFFRI resulting in an ACC claim, 2013-2017

Scene	n (%)
Commercial/service location	586 (6)
Farm	143 (1)
Home	7616 (74)
Industrial place	201 (2)
Place of medical treatment	21 (0)
Place of recreation or sports	308 (3)
Road or street	171 (2)
School	124 (1)
Other	1084 (11)
Unknown	14 (0)

Table 15 shows that exposure to flame, noise or electricity was the primary cause of NFFRI identified within the ACC dataset. Impact with an object resulted in more than a quarter of claims for NFFRI (for example, loss of balance near fire) and a significant number were due to an inhaled/swallowed substance or object (likely reflective of cases of carbon monoxide poisoning/smoke inhalation).

Table 15. Type of contact resulting in an ACC claim for NFFRI, 2013-2017

Contact	n (%)
Contact while handling/carrying	332 (3)
Environmental elements	73 (1)
Exposed to flame/noise/electricity	5506 (54)
Flowing liquid or gas	125 (1)
Flying objects/spatter/fragments	215 (2)
Impact with object	2650 (26)
Impact with ground/floor	101 (1)
Inhaled/swallowed substance or object	858 (8)
Other or unclear contact	408 (4)

7.2.3 Costs

Of the 10,268 claims for NFFRI identified within the ACC dataset, approximately 2,019 were for hospitalised injuries that are bulk-funded. Therefore, no cost information is available for these cases. However, information on the costs associated with other entitlement and medical fee only claims is reported below. Note that estimated costs based on this data will be underestimates as complete costs within 3 years after injury will only be available for those who made claims in 2013 and 2014.

Of the claims that were not bulk funded, 1,198 claims (15%) were entitlement claims, 7,047 claims (85%) were medical fee claims, and 4 claims were categorised as ‘other’ (0%). Total claims cost information was missing for 2 claims. The average (median) total claims cost within 3 years after a NFFRI was $209 (mean = $1779, std. dev. = $11190).

Earnings-related compensation is covered under an entitlement claim. Entitlement claims were associated with the greatest cost within 3 years after NFFRI (median = $3052), ranging from $34 to $359,915. Medical fee claims were associated with substantially lower costs (median = $154), ranging from $13 to $8,732 (see Figure 8 below).

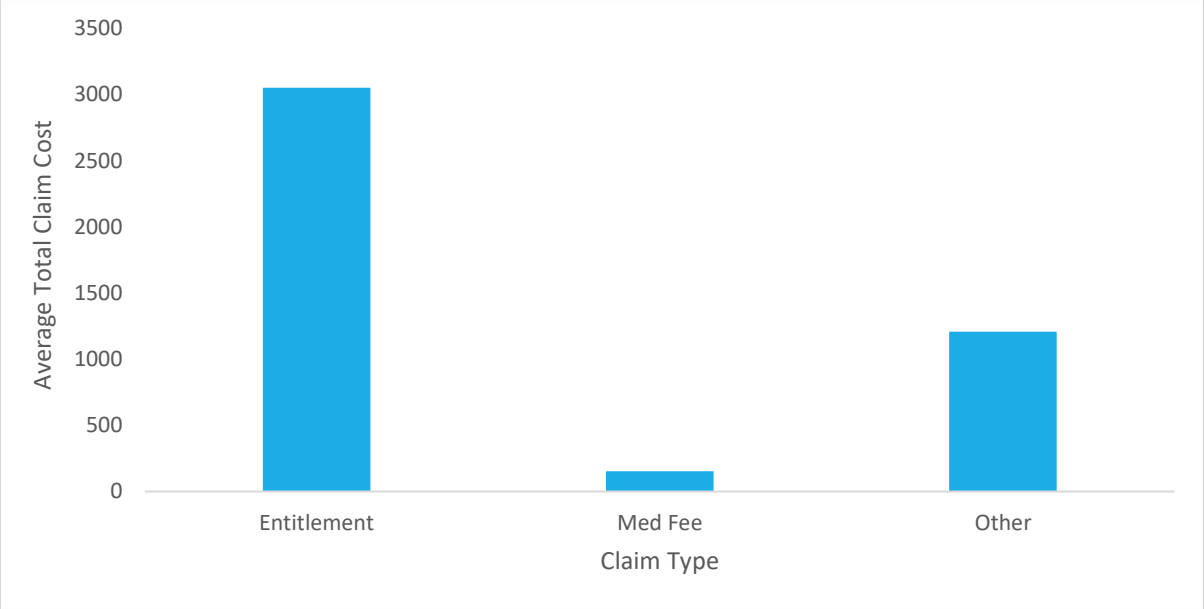

Figure 8. Claim type and average (median) total claims cost within 3 years after NFFRI, 2013-2017

Table 16 shows the number of entitlement and medical fee claims by sex, age, and ethnicity. Males had a higher number of both entitlement and medical fee claims than females. The highest number of entitlement claims were observed for the 20-29-year-old age group, while the fewest were observed for those aged 0-9, and those over the age of 60. With respect to medical fee only claims, these were higher for individuals in younger age categories compared to older groups. The majority of both entitlement and medical fee claims were for European/other and Māori ethnic groups.

Table 16. Number of claims for NFFRI by sex, age and ethnicity, 2013-2017

	Claim Type	
	Entitlement Claims, n (%)	Medical Fee Only Claims, n (%)
Sex		
Male	944 (79)	4548 (65)
Female	254 (21)	2499 (35)
Age		
0-9	67 (6)	1175 (17)
10-19	142 (12)	1136 (16)
20-29	312 (26)	1292 (18)
30-39	201 (17)	865 (12)
40-49	199 (17)	862 (12)
50-59	157 (13)	786 (11)
60-69	83 (7)	545 (8)
70-79	27 (2)	257 (4)
80+	10 (1)	129 (2)
Ethnicity		
Māori	260 (22)	1553 (22)
Pacific Island	67 (6)	414 (6)
Asian	72 (6)	341 (5)
NZ European and Other	799 (67)	4739 (67)

Table 17 shows differences in average total claim costs with respect to sex, age, and ethnicity. Although, males and females had entitlement claims of similar average cost males had significantly higher average medical fee only claims than females.

Average costs of entitlement claims were highest for claimants aged 40-49, 50-59, and 60-69 years relative to other age groups. While the highest average claim cost was observed for those aged 80 and over, it is important to note that the confidence interval associated with this average is wide due to the small number of individuals in this age category. The lowest average entitlement claim cost was observed for individuals 10-19 years of age. These patterns probably reflect higher levels of wage replacement needed as earning potential peaks during later working life.

Table 17. Average (median) total claims cost within 3 years after NFFRI by sex, age and ethnicity and claim type, 2013-2017

	Claim Type			
	Average Entitlement Claim (NZD)	95% Confidence Interval	Average Medical Fee Claim (NZD)	95% Confidence Interval
Sex				
Male	$3031	$2696, $3289	$172	$162, $185
Female	$3158	$2504, $4164	$130	$120, $141
Age				
0-9	$2247	$1264, $3267	$134	$120, $145
10-19	$1968	$1734, $2719	$147	$130, $159
20-29	$2672	$2291, $3132	$160	$143, $184
30-39	$2973	$2422, $4036	$167	$149, $192
40-49	$3888	$3140, $4710	$164	$148, $188
50-59	$3768	$3136, $4608	$148	$123, $171
60-69	$4001	$2430, $5162	$181	$143, $210
70-79	$2627	$1896, $3737	$182	$148, $250
80+	$9217	$2848, $52667	$364	$227, $510
Ethnicity				
Māori	$3392	$2910, $3810	$144	$124, $160
Pacific Island	$4290	$2767, $4780	$149	$128, $182
Asian	$2359	$1795, $3304	$181	$146, $236
NZ European and Other	$2940	$2561, $3202	$158	$148, $165

For medical fee claims, there was a tendency for costs to increase incrementally with age, with the lowest average cost evident for those aged 0-9 years and the highest average cost for the 80+ age group (see Figure 9 below).

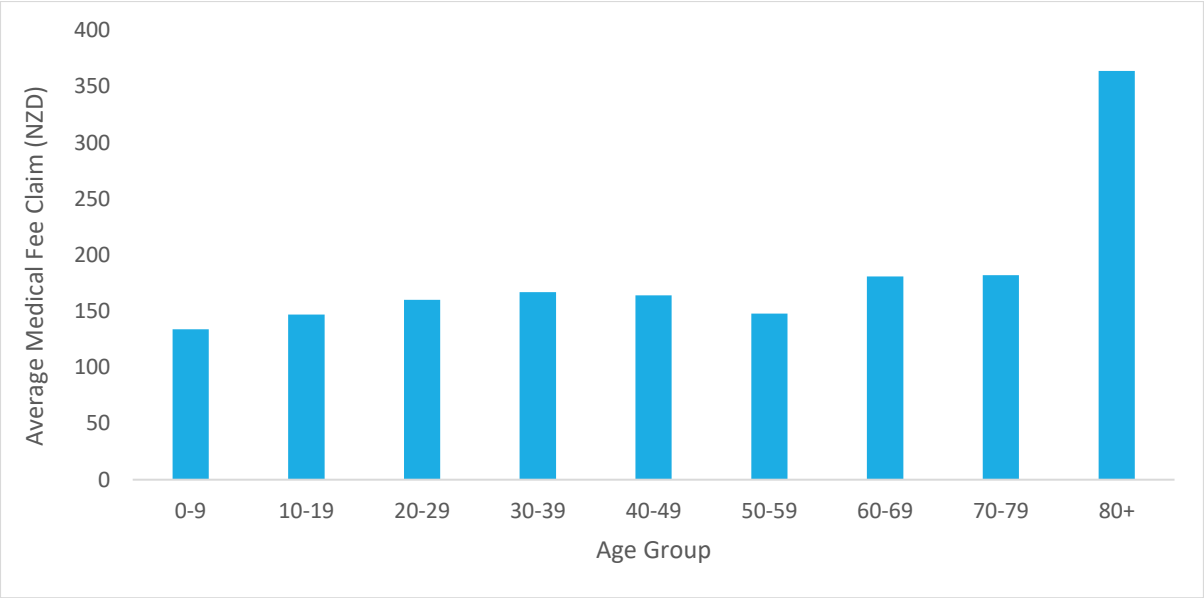

Figure 9. Average (median) medical fee claim for NFFRI by age group, 2013-2017

Higher average entitlement claim costs were observed for Māori and Pacific Island ethnic groups. Interestingly, Asians had the highest average medical fee claim cost, while Māori had the lowest.

7.2.4 Lost Work Days

731 individuals within the ACC dataset (8% of those with claims information available) received compensation for loss of wages or salary due to their NFFRI. The number of work days compensated ranged from 0 to 1088, with a median compensation period of 23 days (mean = 53, std. dev. = 114).

A far greater number of males received compensation for lost work days than females. Individuals aged 20-29 were the age group most frequently compensated for lost work days. The distribution of lost work days by age reflects the working age population.

Table 18. Number of individuals receiving compensated work days for NFFRI by sex, age and ethnicity, 2013-2017

	Days Compensated, n (%)
Sex	
Male	624 (85)
Female	107 (15)
Age	
0-9	0 (0)
10-19	58 (8)
20-29	255 (35)
30-39	130 (18)
40-49	138 (19)
50-59	103 (14)
60-69	46 (6)
70-79	1 (0)
80+	0 (0)
Ethnicity	
Māori	123 (17)
Pacific Island	38 (5)
Asian	47 (6)
NZ European and Other	523 (72)

Average number of work days compensated was similar for men and women (see Table 19 below). Although individuals aged 60 and over tended to have a greater number of work days compensated on average, certainty about these estimates is less as there were small numbers in these age groups. Māori tended to have more work days compensated than individuals in other ethnic groups.

Table 19. Average (median) number of work days compensated for NFFRI by sex, age and ethnicity, 2013-2017

	Days Compensated (Median)	95% Confidence Interval
Sex		
Male	23	20, 34
Female	25	20, 25
Age		
10-19	22	14, 28
20-29	20	17, 24
30-39	20	16, 27
40-49	29	22, 33
50-59	22	17, 33
60-69	39	31, 68
70-79	79*	79, 79
Ethnicity		
Māori	33	21, 39
Pacific Island	22	17, 35
Asian	20	11, 37
NZ European and Other	22	19, 24

Note. * = 1 observation only

7.3 Fire and Emergency

Fire and Emergency's Fire Incident Recording System (FIRS) identified 1,716 cases of NFFRI occurring in the period 2013 – 2017. There were between 310 and 368 NFFRI events per year, with an average of 343 injuries per year across the 5 year study period. A slight decrease in the number and rates of NNFRI cases occurring each year was found (Table 20).

Table 20. Number of NFFRI as identified in the FIRS, 2013-2017

	Year of injury, n (%)					
	2013	**2014**	**2015**	**2016**	**2017**	**Total**
Number of injuries	368 (21)	350 (20)	349 (20)	339 (20)	310 (18)	1716
Rate per 100,000 person years	8.3	7.8	7.6	7.2	6.5	7.5
95% confidence interval	7.5, 9.2	7.0, 8.6	6.8, 8.4	6.5, 8.1	5.8, 7.3	7.1, 7.8

7.3.1 Personal Characteristics

Rates of Fire and Emergency attended NFFRI for the period 2013 - 2017 in relation to sex, age and ethnicity were calculated using available data. However, it is important to interpret these with caution given the substantial amount of data coded as unknown in this dataset, particularly for ethnicity. As can be seen in Table 21, a higher rate of NFFRI cases was observed among males compared to females. Individuals aged between 20-29 years, 30-39 years, and 60-69 years had higher rates of NFFRI when compared to other age groups, and a higher rate of NFFRI cases was evident for Māori compared to other ethnic groups. Asian ethnicity was associated with the lowest rate of NFFRI attended by Fire and Emergency across the study period.

Table 21. Sex, age and ethnicity of individuals with NFFRI as identified in the FIRS, 2013-2017

Characteristics	n (%)	% excluding unknown	Rate per 100,000 person years (95% CI)
Sex			
Male	1068 (62)	63	9.5 (8.9, 10.1)
Female	639 (37)	37	5.5 (5.0, 5.9)
Unknown	11 (1)		
Age (years)			
0-9	128 (7)	7	4.1 (3.4, 4.9)
10-19	151 (9)	9	4.9 (4.2, 5.8)
20-29	311 (18)	18	9.7 (8.7, 10.9)
30-39	296 (17)	17	10.5 (9.3, 11.8)
40-49	243 (14)	14	7.8 (6.8, 8.9)
50-59	222 (13)	13	7.3 (6.4, 8.4)
60-69	216 (13)	13	9.1 (7.9, 10.4)
70-79	81 (5)	5	5.6 (4.5, 7.0)
80+	64 (4)	4	7.7 (6.0, 9.9)
Unknown	4 (0)		
Ethnicity (prioritised)			
Māori	338 (20)	22	9.4 (8.4, 10.4)
Pacific Island	107 (6)	7	7.2 (5.9, 8.7)
Asian	113 (6)	7	3.8 (3.1, 4.6)
NZ European and Other	975 (57)	64	6.5 (6.1, 7.0)
Unknown	183 (11)		

7.3.2 Exposures

The frequency of NFFRI resulting from different types of fires (as identified in the FIRS) are shown in Figure 10. Structural fires with damage were the most common type of fires associated with NFFRI, responsible for 965 (56%) of all NFFRI attended by Fire and Emergency during the study period. This was followed by structural fires with no damage, which were linked to 389 (23%) NFFRI. Injuries resulting from mobile property fires were less frequent (n = 173, 10%), as were those occurring outdoors (n = 52, 3%) or as a result of hazardous substances (n = 61, 4%).

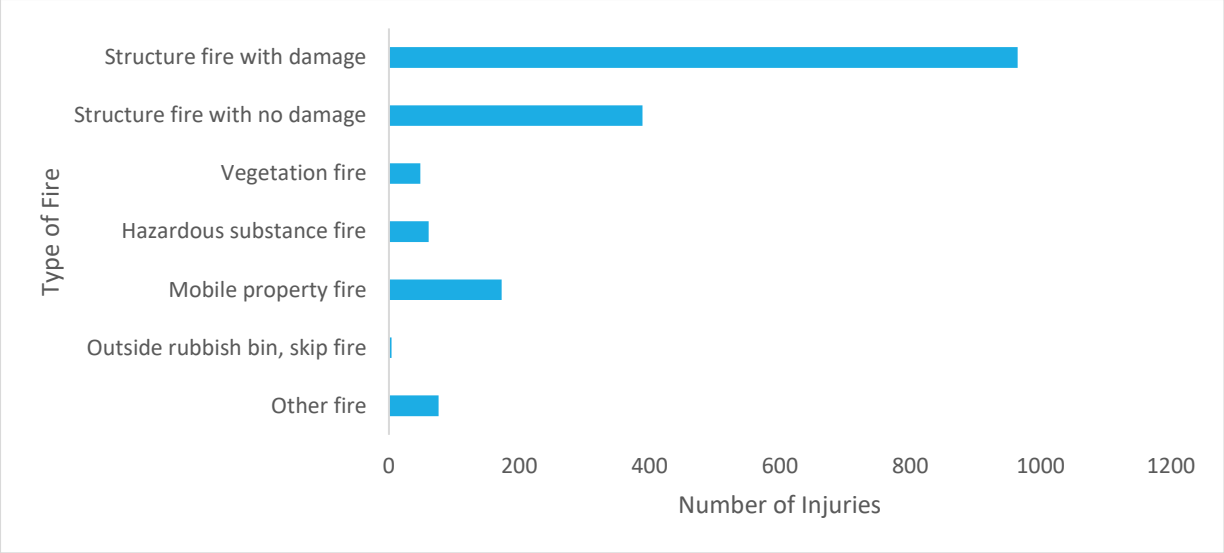

Figure 10. Number of NFFRI attended by Fire and Emergency by type of fire, 2013-2017

NFFRI most commonly occurred within a single house, with this property type associated with 950 injuries (55%) across the study period. Flats and apartments were the second type of property most frequently associated with NFFRI (n = 256, 15%).

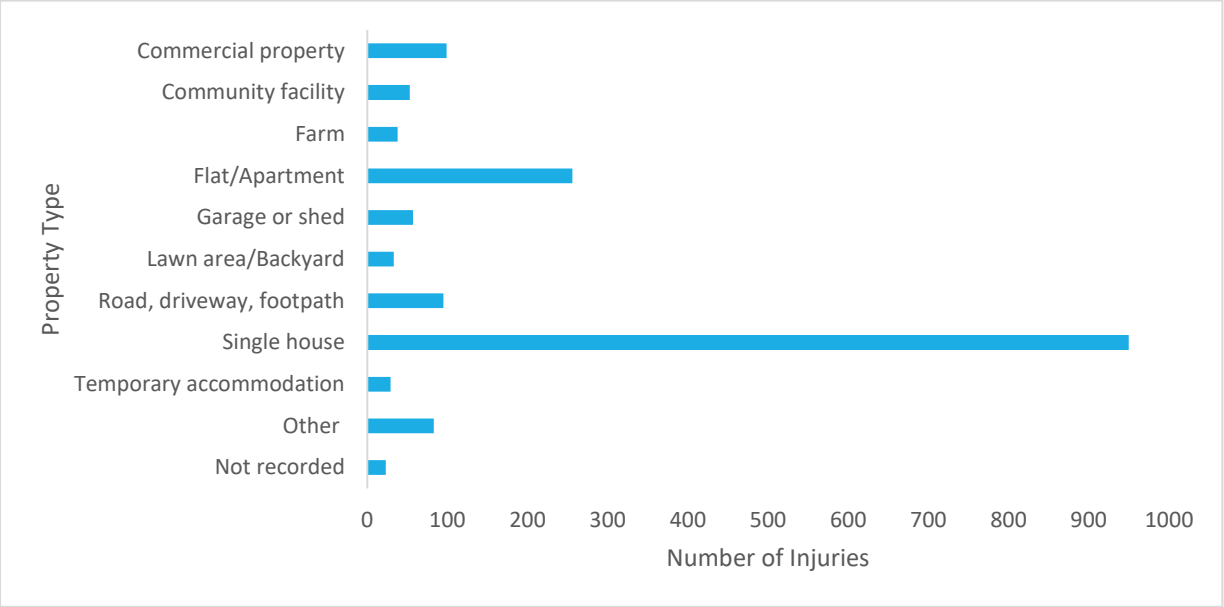

Figure 11. Number of NFFRI attended by Fire and Emergency by type of property, 2013-2017

The most common location of fires resulting in NFFRI attended by Fire and Emergency was the kitchen, with 634 injuries (37%; 40% when excluding 'not recorded' cases) due to a fire in this location recorded over the study period. A significant number of NFFRI cases also

resulted from fires originating in the bedroom (n = 223, 13%; 14% when excluding 'not recorded' cases).

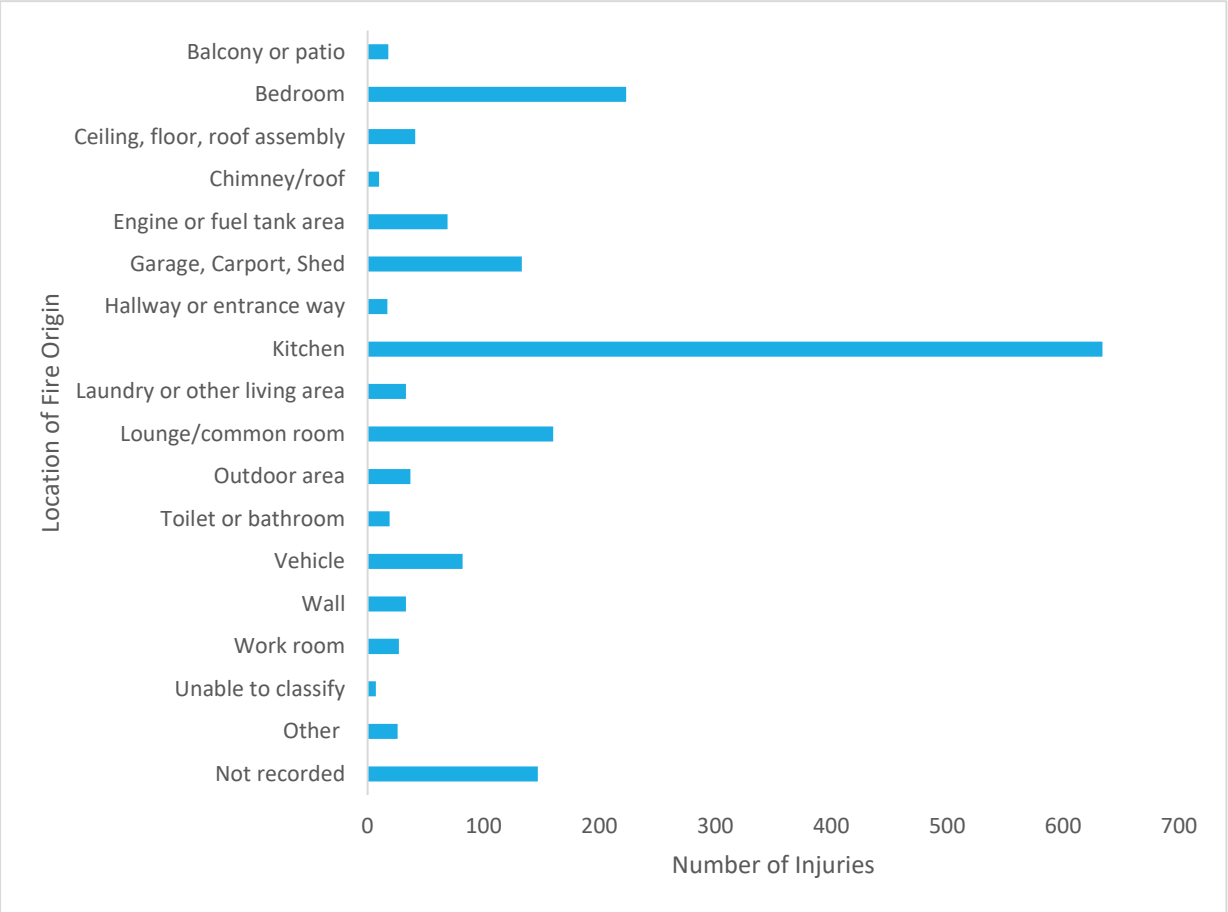

Figure 12. Number of NFFRI attended by Fire and Emergency by location of fire origin, 2013-2017

A large amount of data was not recorded with respect to the ignited object that led to NFFRI (see Figure 13 below). Cooking materials or food were the most frequently ignited objects leading to NFFRI attended by Fire and Emergency, related to 394 cases (26% when excluding 'not recorded' cases). Flammable liquid and gases were also frequently involved in ignition, identified for 216 (14% when excluding 'not recorded' cases) of NFFRI cases.

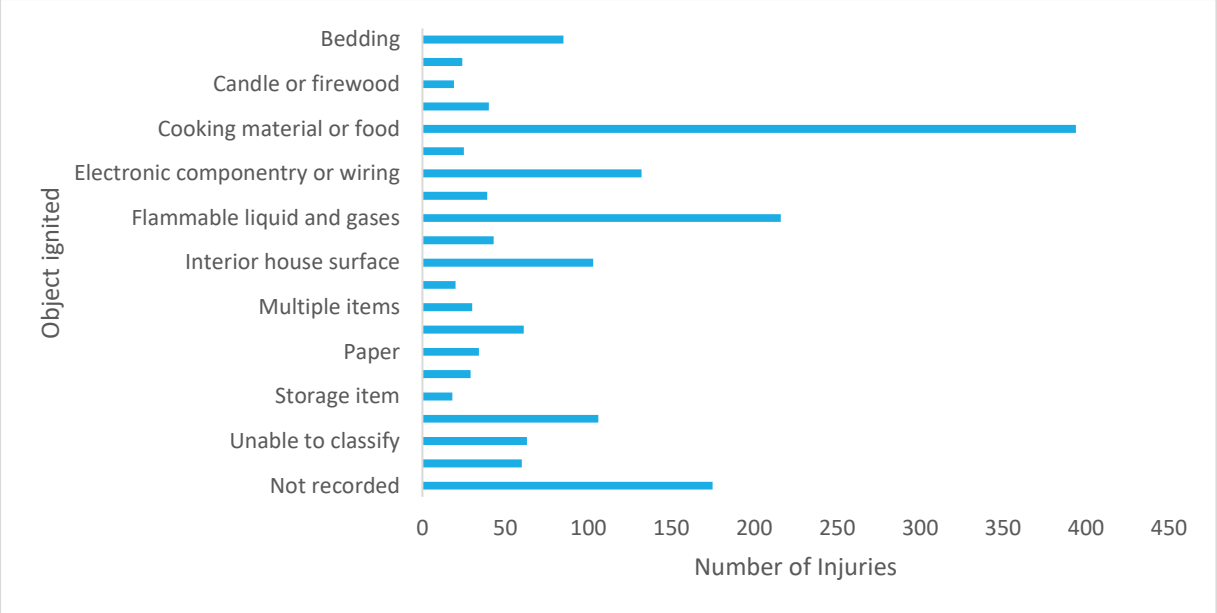

Figure 13. Number of NFFRI attended by Fire and Emergency by object ignited, 2013-2017

Regarding material ignited, this information was not recorded for 198 cases (12%) and a further 69 (4%) were unable to be classified. The material most commonly ignited for cases of NFFRI attended by fire and emergency was a flammable/combustible liquid, metal or gas (n = 430; 28% when excluding 'not recorded' cases).

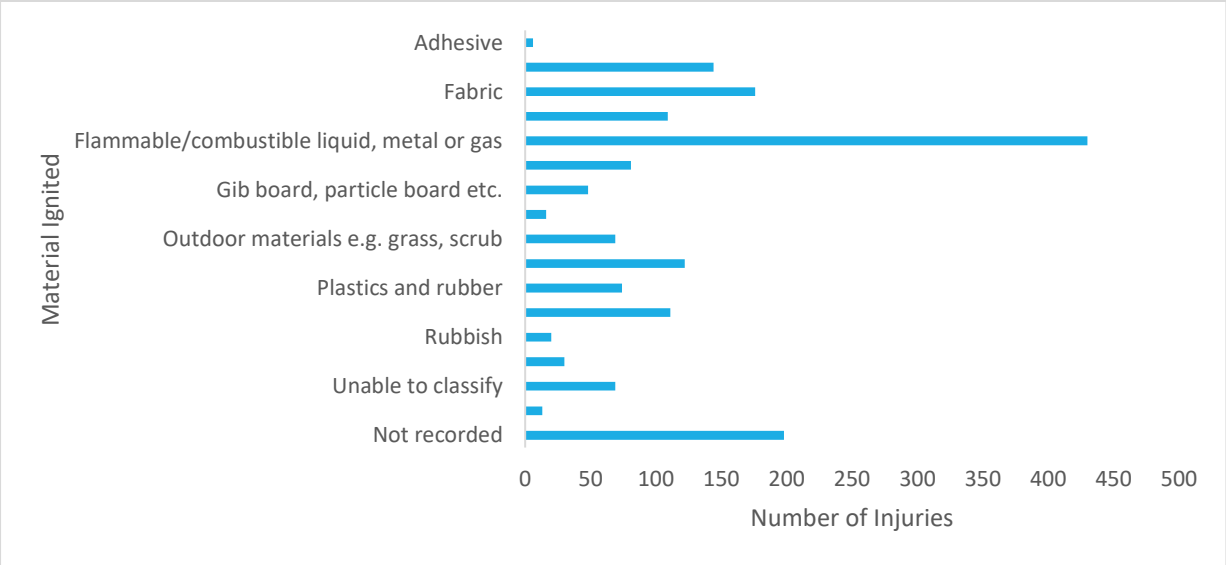

Figure 14. Number of NFFRI attended by Fire and Emergency by material ignited, 2013-2017

The equipment involved in the ignition of NFFRI attended by Fire and Emergency was largely unrecorded (n = 665, 39%). However, based on available information, there was often no equipment involved in ignition (n = 312, 30% when excluding 'not recorded' cases), although in a number of cases a stove was involved (n = 286, 27% when excluding 'not recorded' cases).

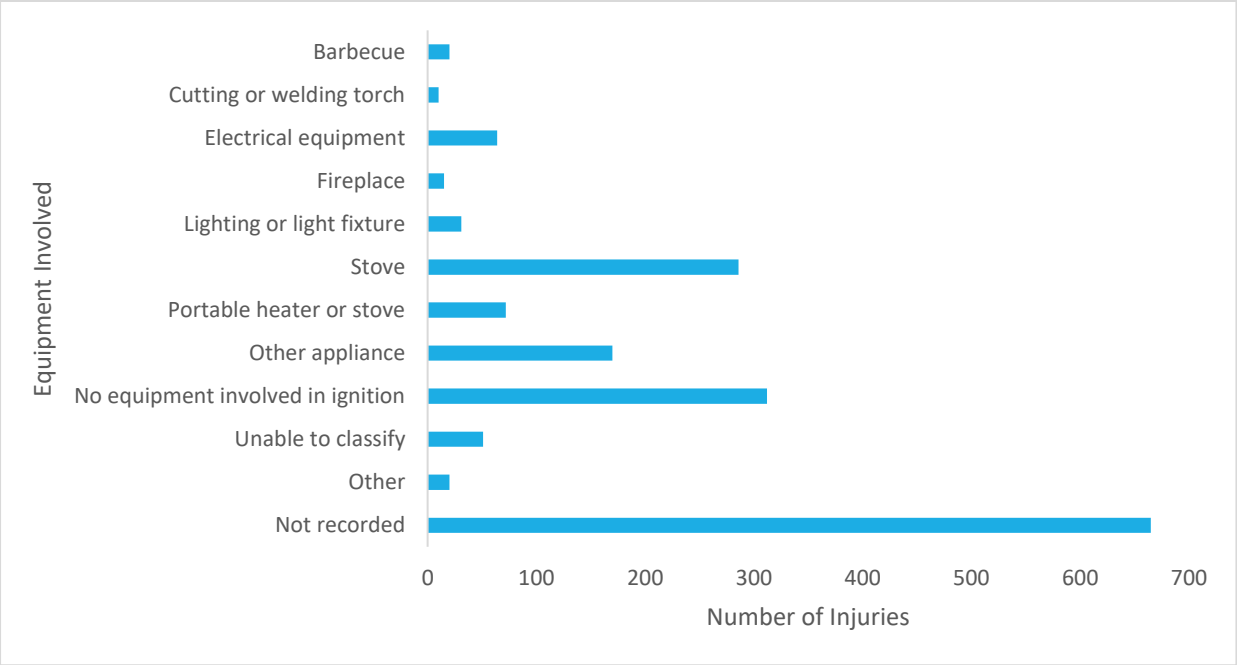

Figure 15. Number of NFFRI attended by Fire and Emergency by equipment involved, 2013-2017

The largest number of NFFRI attended by Fire and Emergency were attributable to unattended cooking, which was identified as responsible for 422 injuries (25%). The second most common cause of NFFRI was careless use of cigarettes, ashes, embers, or other heat source, resulting in 194 cases (11%). For 117 cases (7%), the cause of the fire could not be determined (Figure 16).

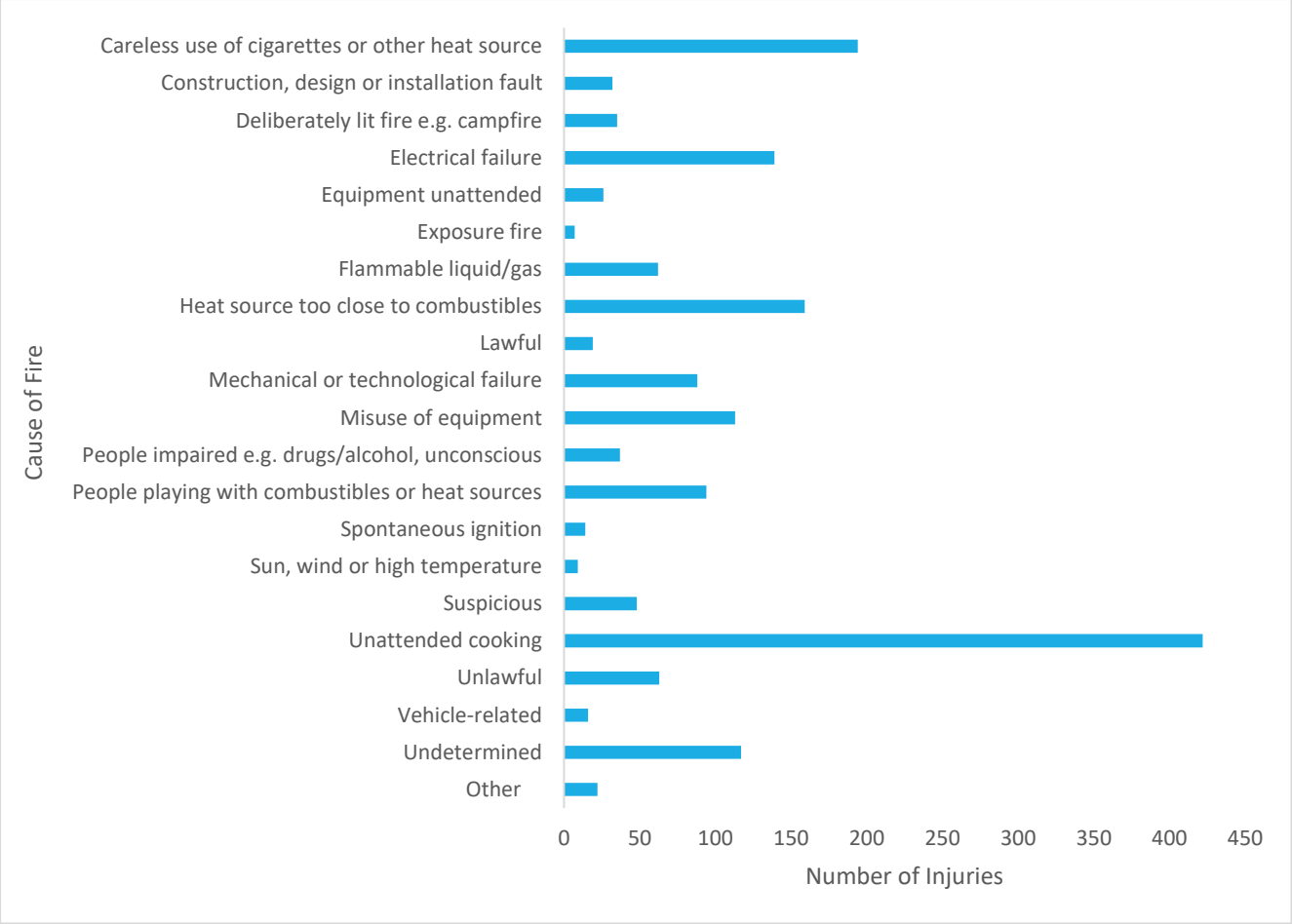

Figure 16. Number of NFFRI attended by Fire and Emergency by cause of fire as recorded in the FIRS, 2013-2017

Interestingly, heat from electrical equipment that was properly operating (rather than from electrical equipment that was defective or incorrectly used) was responsible for the largest number of NFFRI attended by Fire and Emergency (n = 508, 30%; 33% when excluding 'not recorded' cases). Lighters or matches were the heat source involved in 147 cases (9%; 9% when excluding 'not recorded' cases).

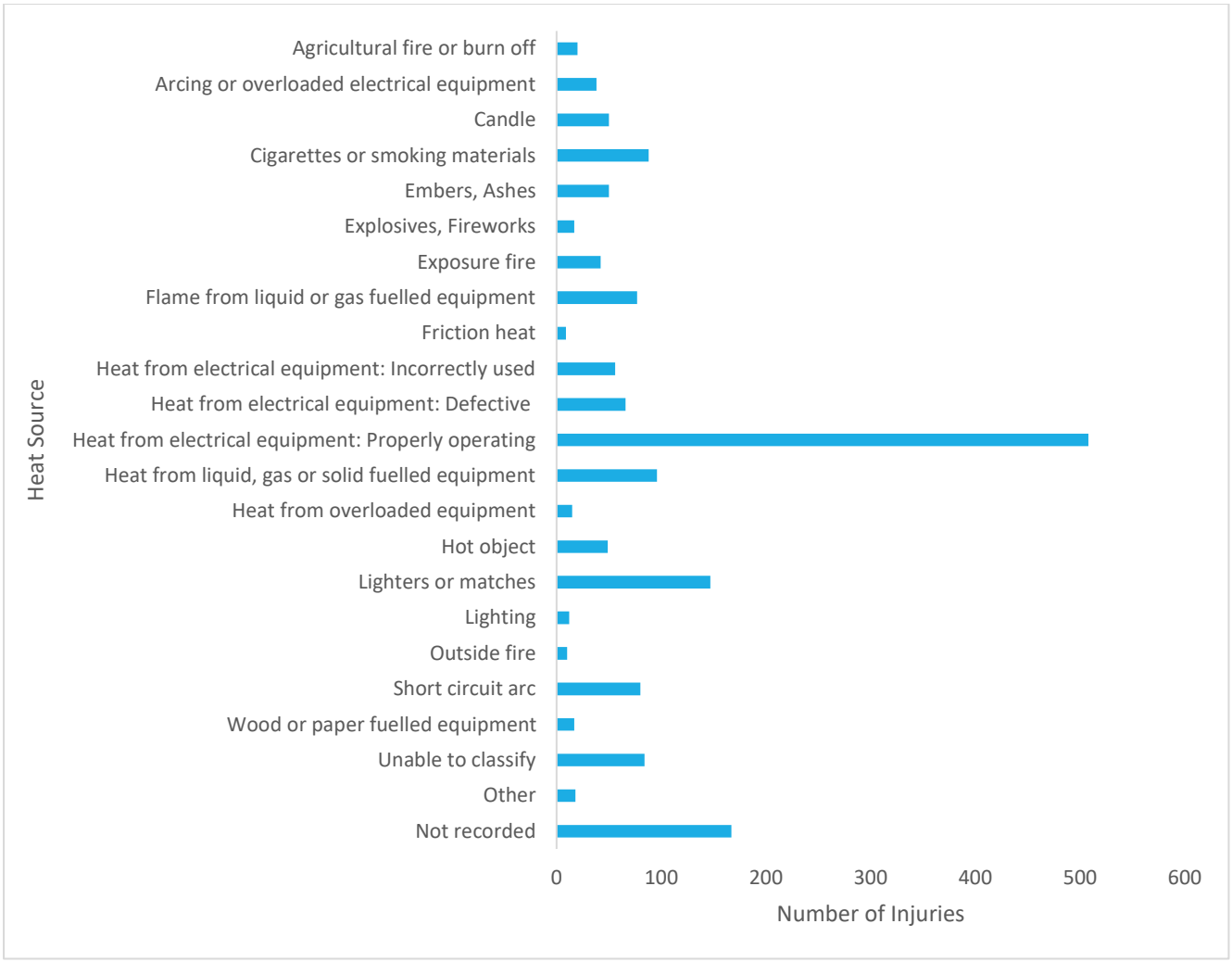

Figure 17. Number of NFFRI attended by Fire and Emergency by heat source, 2013-2017

7.3.3 Fire Detector Type and Performance

Type of fire detector was not recorded for 974 (57%) NFFRI attended by Fire and Emergency; it is unclear whether this was due to no fire detector(s) being present at the location in which the NFFRI occurred or if the information was unable to be captured at the time of the NFFRI. Of the 742 cases that had this information recorded, domestic smoke alarms were the most common type of fire detector (n = 591, 80%). In 279 cases (38%) fire detectors successfully alerted occupants. In 173 cases (23%) the fire detector did not operate in response to the fire. Reasons for fire detector failure were available for 156 cases; when considering these cases only, the detector not being in the room of origin (n = 61, 39%) and flat battery/inadequate maintenance of the detector (n = 61, 39%) were the most common reasons for failure to detect fire.

7.3.4 Outcomes

Injury severity is assessed by Fire and Emergency firefighting crew following the injury event. According to the Fire and Emergency data dictionary, injuries are classified as critical when the injury is critical and presents an immediate threat to life, serious when the injury is serious and potentially life threatening, moderate when the injury is moderate but unlikely to be life threatening, and minor when the injury is minor and not life threatening.

Injury severity was not recorded for two cases. For the remaining 1714 cases, 78 (5%) were classified as critical, 5 (<1%) were serious, 706 (41%) were moderate, and 925 (54%) were minor.

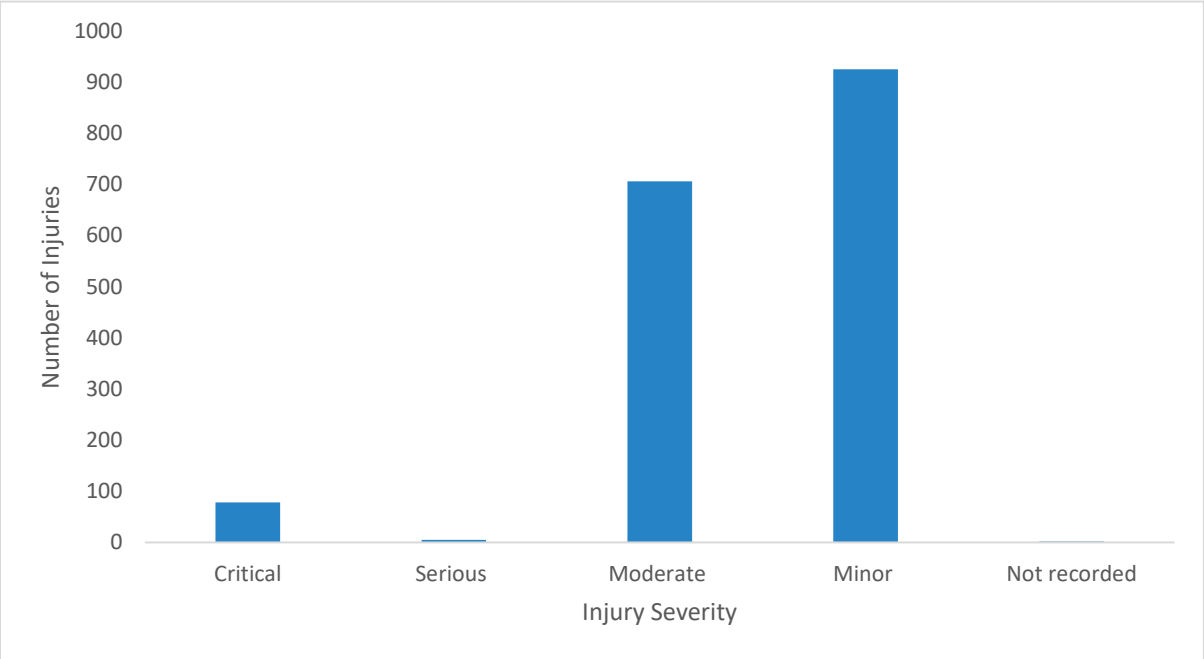

Figure 18. Severity of NFFRI attended by Fire and Emergency, 2013-2017

Type of injury was also not recorded for two cases. When considering the remaining 1714 cases, smoke inhalation was the most common injury type (n = 738, 43%), followed by burns from fire or hot objects (n = 577, 34%).

7.3.5 Action Taken By Firefighters

The most common action taken by firefighters was extinguishment, salvage and ventilation, occurring in 490 NFFRI attended by Fire and Emergency cases (29%) attended by Fire and Emergency. Extinguishment only occurred for 302 cases (18%), extinguishment and ventilation occurred for 296 cases (17%), and ventilation only occurred for 201 cases (12%). Fire-related investigation only was recorded for 243 cases (14%) and medical/first aid assistance was the action taken for 79 cases (5%).

7.4 Comparative Findings

A total of 10,268 NFFRI claim within the ACC database 2,257 NFFRI hospitalisations due to smoke, fire and flames were identified within the NMDS hospital discharge data, and 1,716 Fire and Emergency attended NFFRI within the Fire and Emergency Incident Recording System for the period 2013 – 2017.

The sex, age, and ethnic composition of injured individuals identified within each database is reflected using percentages in the graphs below.

A slightly higher percentage of males (73%) was identified within the NMDS compared to within ACC (66%) and Fire and Emergency datasets (63%).

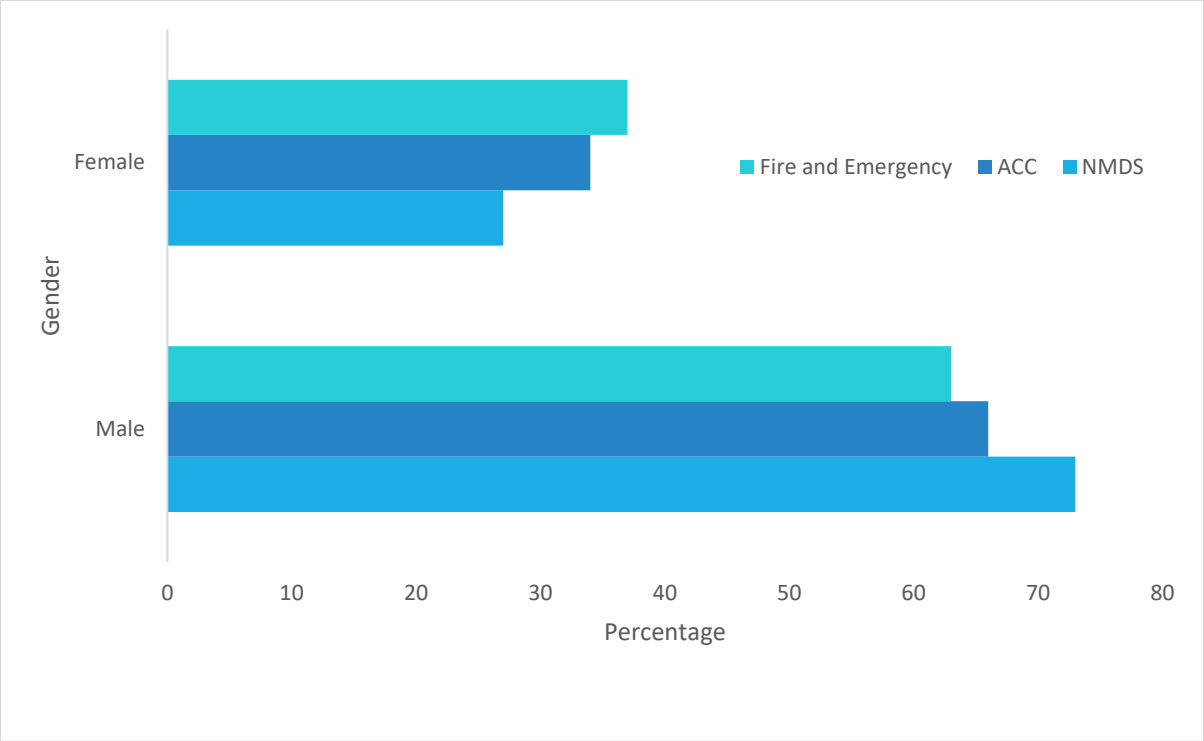

Figure 19. Sex distribution for NFFRI across three data sources (NMDS, ACC, Fire and Emergency)

Ethnicity was also distributed similarly across the three datasets. Slightly fewer injured individuals were identified as Māori within the Fire and Emergency dataset (20%) compared to within the ACC (23%) and NMDS (25%) datasets. A lower percentage of individuals of NZ European ethnicity were also identified within the Fire and Emergency dataset (57%). This may be attributable to the number of individuals with unknown ethnicity recorded by Fire and Emergency (11%).

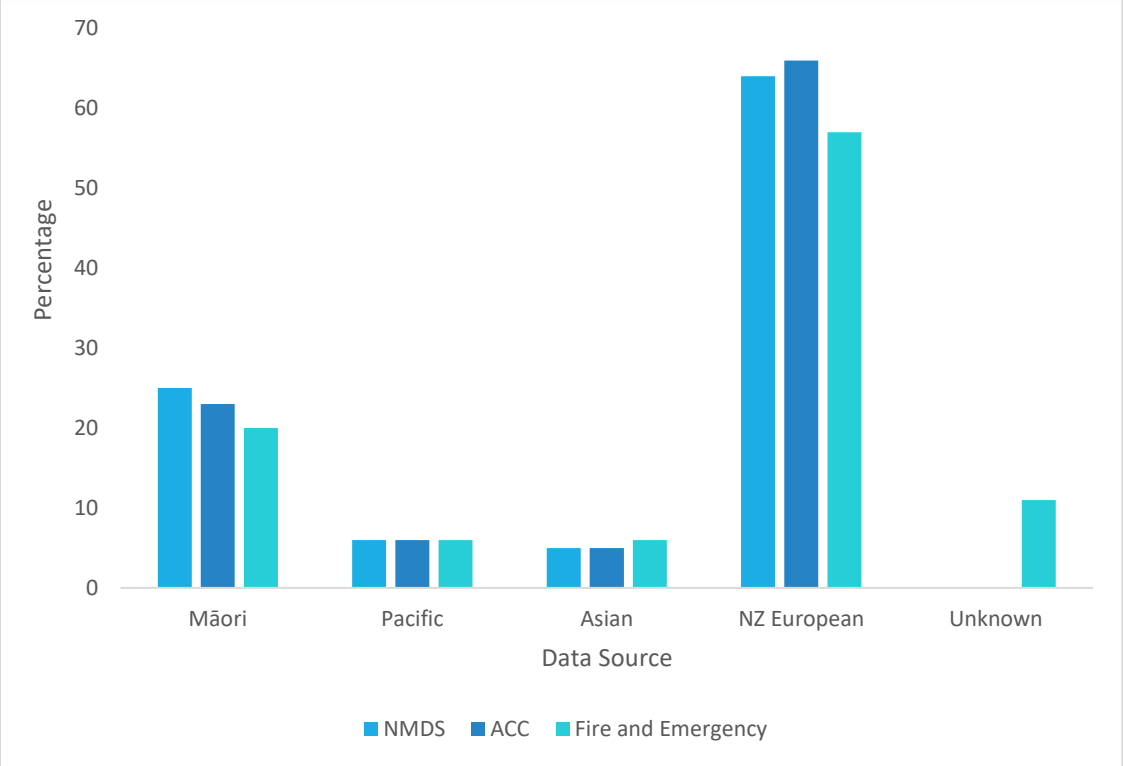

Figure 20. Ethnic distribution for NFFRI across three data sources (NMDS, ACC, Fire and Emergency)

Within the ACC database, more injuries in children and fewer in those aged over 70 years were identified compared to other datasets. Individuals aged 20-29 were more frequent within the NMDS dataset while individuals aged 30-39 and 50-69 were more frequent within the Fire and Emergency Incident Recording System.

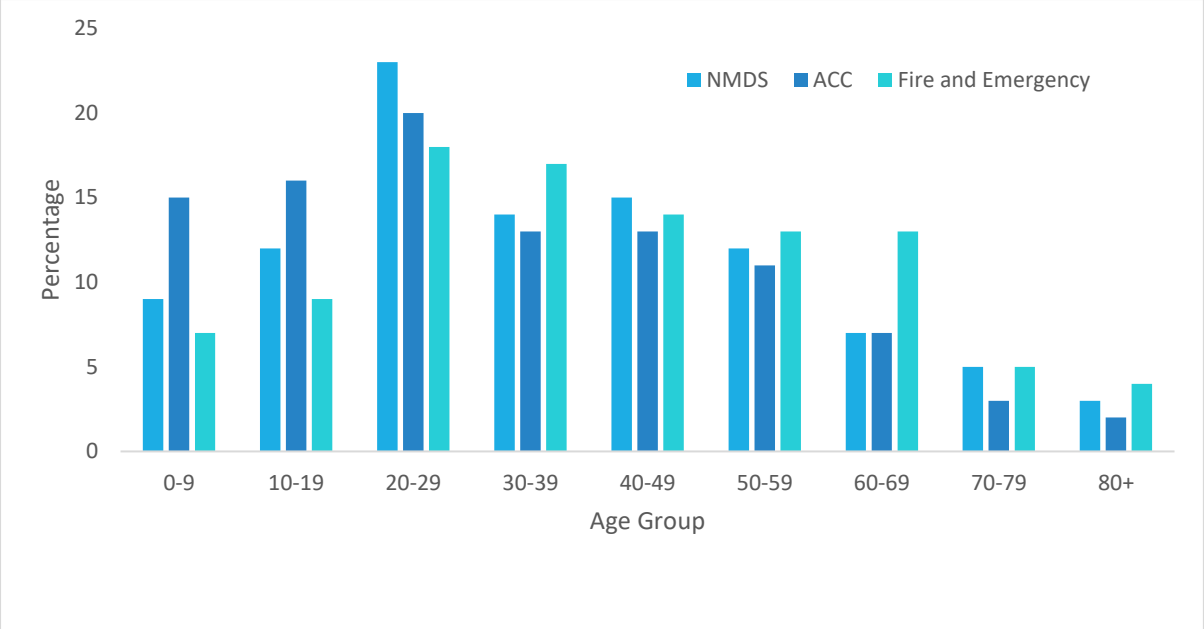

Figure 21. Age distribution for NFFRI across three data sources (NMDS, ACC, Fire and Emergency)

Rates of NFFRI were found to be highest using data from ACC when compared to data from the NMDS or Fire and Emergency; this is largely attributable to the substantially larger number of cases identified within the ACC dataset. The ACC figures will be an over-estimate, by around a third, as we have determined that only two thirds of these cases fit the study criteria of being due to smoke, fire and flames (but we were unable to easily remove these cases from this final dataset without time consuming manual review). It is also important to note that not all ACC claims would result in hospitalisation. Each dataset is likely to represent injuries of a different severity threshold.

Rates determined from NMDS hospitalisation and Fire and Emergency incident attendance data are of similar magnitude although the rate of people injured recorded by Fire and Emergency in 2017 was noticeably lower than that for NMDS.

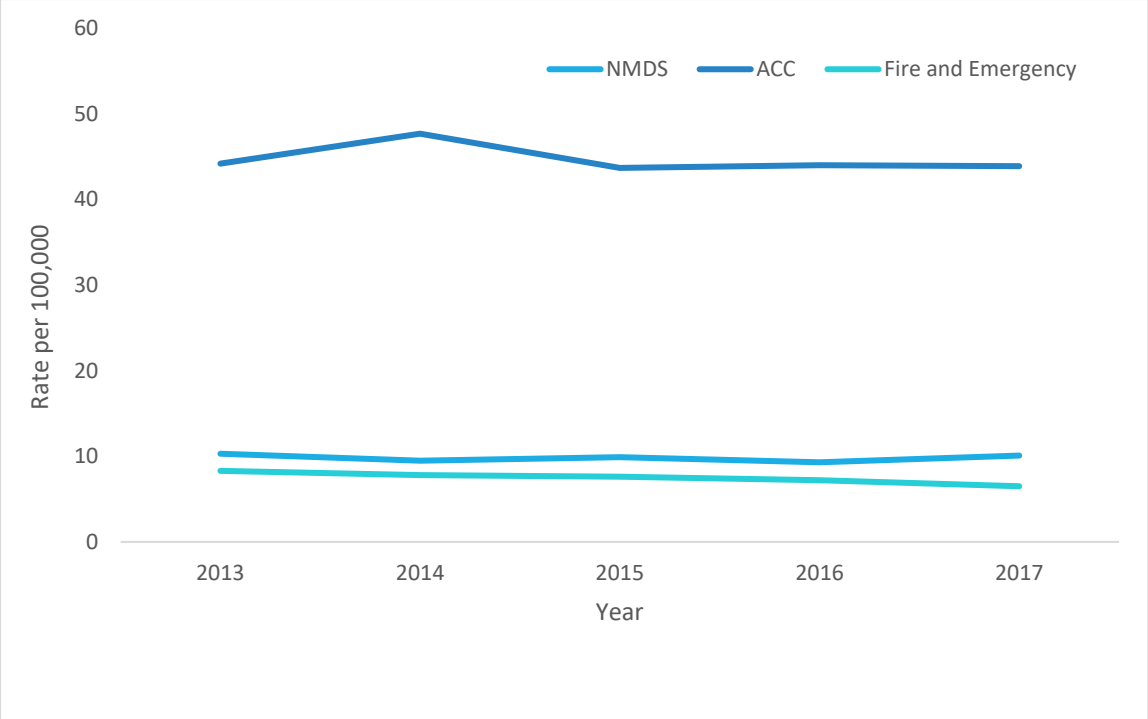

Figure 22. Rates of NFFRI by year across three data sources (NMDS, ACC, Fire and Emergency)

7.5 Data Linkage

Of 83 critical or serious cases identified by Fire & Emergency just under half were able to be matched to hospital discharge (NMDS, 46%) or claims data (ACC, 51%) (Table 22). The overlap in cases identified by NMDS, ACC and Fire & Emergency was minimal with only 30% of Fire and Emergency cases identified in both NMDS and ACC datasets. Table 22 presents the linkage findings by year and shows the variability in successful matches across time with the most recent year of 2017 having the poorest matching rates, with only 8% of cases matching to both NMDS & ACC data.

Table 22. Table of matching Fire & Emergency NFFRI cases to NMDS and ACC records, 2013-2017, critical and serious cases only

	Year of injury, n (%)				
	2013	2014	2015	2016	2017
Fire & Emergency: Number of NFFRI*	17	19	23	12	12
Successful match: NMDS	9 (52%)	8 (42%)	12 (52%)	5 (42%)	5 (42%)
Successful match: ACC	10 (59%)	9 (47%)	12 (52%)	8 (67%)	4 (33%)
Successful match: **both** NMDS and ACC	4 (23%)	6 (31%)	10 (43%)	4 (33%)	1 (8%)

*serious/critical cases only

Many issues were identified that limit the ability to match Fire & Emergency data to subsequent hospital admissions and/or ACC claims.

Firstly, the lack of person-level identifiers (e.g. name, date of birth) in the Fire and Emergency dataset is a major barrier to efficiently enabling the identification of cases within the NMDS and ACC datasets. Due to this, the matching undertaken in this report has been made on the basis of age group, sex, ethnicity and region of incident. Occasionally exact address matches were able to be made (14/83, 17%), however, the majority of cases had different residential addresses from those attended by Fire and Emergency (NMDS records usual residential address while Fire and Emergency records address of fire attended). The key variable available in Fire and Emergency for linkage was age, currently collected as broad 10 year age bands, however the quality of this variable varies. Age provided by Fire and Emergency was often out of alignment with the age recorded on the NMDS and ACC (10/43, 23%).

Secondly it is apparent there is incomplete capture of NFFRI within Fire and Emergency data. On occasion, where multiple cases at the same address were indicated in NMDS or ACC data, Fire and Emergency had only one of these casualties recorded. For example, from the NMDS two cases were admitted to hospital on the same day from a single house fire in Gore, while Fire and Emergency only captured one of these cases. This will possibly reflect the fact that Fire and Emergency collects data primarily about the fire incident, whereas personal-level data is captured within NMDS and ACC datasets.

Electronic probabilistic linkage of ACC and NMDS cases was undertaken. Of 2257 NMDS cases, a match with a relevant ACC fire-related claim was able to be made for 1357 cases (60%). This confirms that each dataset represents different populations of NFRRI and that

the overlap in datasets is moderate.

ACC has a critical injury flag, identifying claims with a high probability of increased rehabilitation and medical needs. Of the 17 critical fire-related injuries identified by ACC only four matched to critical/serious records within Fire and Emergency data. There was only one further event described by ACC as being a “house fire” that was unmatched to Fire and Emergency data. At least five of the 17 ACC critical cases involved burns due to falling into outdoor fires or individuals deliberately pouring hot or ignitable liquids onto themselves, scenarios unlikely to be attended by Fire and Emergency.

8. Discussion

8.1 Principal findings

This study aimed to accurately inform directions for non-fatal fire-related injury (NFFRI) prevention efforts by using administrative datasets to identify current high risk groups, causes and circumstances related to these injuries. This information can be used to effectively prioritise and target preventive action to reduce NFFRI through fire safety strategy and prevention programmes.

Through epidemiological analyses of administrative data on NFFRI available on hospital discharges (NMDS), ACC compensation claims, and fires attended by Fire and Emergency, the project endeavored to address the following key research questions: Who is at highest risk of NFFRI and what are the common causes and circumstances of NFFRI?

Across all three datasets examined males, Māori and those aged 20-29 years of age had the highest risk of NFFRI. The same pattern of risk was observed in an earlier review of hospitalisations for unintentional domestic injury from fire and flame occurring in New Zealand during 1996-2000 (Duncanson et al., 2002). This indicates patterns of risk have not yet shifted since this earlier study.

The common causes and circumstances of NFFRI are more difficult to determine as this information differed according the dataset examined with each dataset capturing different NFFRI events.

The NMDS cases revealed exposure to ignited highly flammable material was the most common exposure to result in a hospitalisation for NFFRI. However, males were significantly more likely to experience an injury as a result of exposure to highly flammable material than females, and were also more likely to be injured as a consequence of an explosion or a fire occurring outside of a building (controlled or uncontrolled). Significant differences in fire exposures were also found in relation to age and ethnicity.

Little data useful to describe NFFRI cause and circumstances was obtained from ACC claims data due to homogenous categorization of exposure variables within these aggregated fire-related cases. ACC cases revealed that the majority of claims were for NFFRI occurring within the home. One in five injuries occurred in the densely populated region of Auckland.

Fire incident cases from Fire and Emergency attendances revealed NFFRI are mainly from structural fires with damage, occurring in a single house, and from fires originating in the kitchen. The most common cause of Fire and Emergency attended NFFRI was unattended cooking, with cooking materials or food identified as the most frequently ignited objects. Information on fire detector presence and performance was frequently not recorded within the Fire Incident Recording System. The majority of injuries attended by Fire and Emergency

were classified as moderate or minor (95%). Smoke inhalation was the most common injury type, followed by burns from fire or hot objects.

Estimates of the impact of NFFRI are available in NMDS hospital discharge and ACC claims datasets. Almost one in five of individuals hospitalised due to a NFFRI were readmitted to hospital at least once after their initial injury. The total length of hospital stay in the first 12 months after the injury ranged from 0 (i.e. day stay Emergency Department patients) to 329 nights with an average (mean) total length of stay of 5.5 nights. Older adults (aged 70 and above) were more likely to spend 10 or more nights in hospital as a result of their NFFRI compared to other age groups.

Significant costs associated with NFFRI were identified using the ACC claim dataset. The average (median) total claims cost within 3 years after a compensated NFFRI was $209 (mean = $1779, std. dev. = $11190), although this is an underestimate as the data was provided by ACC in 2018 and the length of time used to calculate 'total cost' varies from a minimum of six months to a maximum of three years. Medical fee only NFFRI claims were more frequently than NFFRI entitlement claims, although entitlement claims were associated with the greatest cost per claim (median = $3052). Males had a higher number of both entitlement and medical fee only claims than females, and average entitlement and medical fee only claims were highest for older adults (aged 80 and above).

Comparisons between datasets identify substantial differences in the number of NFFRI in individual datasets, with a far larger number of ACC compensation claims for NFFRI than the number of hospitalised NFFRI recorded in the NMDS, or the number of incidents documented by Fire and Emergency. The magnitude of the rates for NFFRI obtained from Fire and Emergency attendances and NMDS hospital discharges are the most closely aligned. The sex and ethnic distribution within each dataset was relatively similar, with males and NZ Europeans making up the largest proportion of NFFRI cases. However, ethnicity information was unavailable for one in ten (11%) individuals within the Fire and Emergency dataset. Differences in age were found across the datasets, suggesting that each dataset is capturing different events resulting in NFFRI. Within the ACC database, more injuries in young people and fewer in older age groups were identified compared to other datasets. Individuals aged 20-29 were more frequent within the NMDS dataset, while individuals aged 30-39 and 50-69 were more frequent within the Fire and Emergency Incident Recording System. While a decrease in the number and rates of NFFRI occurring each year was detected in the Fire and Emergency data, this trend was not observed in the other datasets.

8.2 Data Issues

An attempt was made to link cases across all three data sets in order to create a rich cohort of NRFFI. In a data set limited to those NFFRI assessed by Fire and Emergency staff as being

"serious" or "critical" we found minimal linkage to both NMDS hospital discharge and ACC claims data. The assumption was that linkage would be even poorer for cases of moderate/minor injury as recorded by Fire and Emergency.

Linking of the available national data on fire-related injury was minimal, primarily due to the lack of common person-level identifiers in the Fire and Emergency dataset, therefore this linked cohort was not examined further. Other data issues limiting the ability to link between data sets included fire incident address versus residential address of injured person, missing cases especially in multiple casualty events, and incorrect data, such as age or ethnicity, collected on scene by Fire and Emergency staff or miscoded data upon data entry.

Due to these data quality issues it is difficult to obtain accurate estimates for NFFRI attended by Fire and Emergency that result in hospitalisation (i.e. in-patients) or ACC compensation claims or, conversely, the recorded Fire and Emergency attended NFFRI that do not result in admission to hospital or in an ACC compensation claim.

Previous attempts to link Fire Incident Report data to hospital discharge data (formerly called NZHIS (NZ Health Information Service) data) undertaken for the period 1996-2000 reported a similarly low level of overlap between datasets (10.8%, 179 matched out of 1651 Fire Incident Reporting System records) (Duncanson et al., 2002). Again, as found in our most recent analysis, the main data issue limiting linkage was an absence of common data fields across data sets (Duncanson et al., 2002).

Datasets capturing hospital discharges (i.e. in-patients) and ACC compensation claims due to fire-related injury offer better capture of the burden of these NFFRI on the healthcare system. These datasets, however, provide limited information on fire exposure and causation to inform prevention strategies to address NFFRI.

Claims data on fire-related injury from ACC has limited utility from a NFFRI surveillance perspective, as it is difficult to get robust, reproducible estimates of injuries due to fire, flames and smoke from existing claims management databases. This is due to the multiple non-specific search terms needed to identify these cases and need for machine learning to reduce a large number of potential cases to a refined set that more closely resembles eligible cases due to smoke, flame and fire exposures.

The NMDS currently offers the most stable and usable database in order to monitor the trends in the prevalence and incidence of NFFRI in New Zealand. As cases are coded to ICD-10-AM, cases of relevance to Fire and Emergency are easily identified using the codes specific to injuries due to the exposure to smoke, fire and flames, as well as other relevant exposures, such as explosions. ICISS, obtainable from variables within the NMDS, offers a more robust estimate of injury severity based on the likelihood of survival from particular injury diagnoses.

8.3 Strengths and weaknesses of the study

While each data source utilised in this study provides the most comprehensive data available to describe NFFRI in New Zealand, all these sources of data potentially underestimate the number of people with NFFRI that seek emergency help or treatment.

There are biases inherent in each source of data utilised for this study that may drive observed trends other than injury risk, such as trends in healthcare utilisation. The decision to admit an injured person into hospital is biased by factors including age, sex, ethnicity, social and housing circumstances, as well as whether the injury sustained required hospital level care (Cryer & Langley, 2008; Langley, Stephenson, Cryer, & Borman, 2002). The decision to submit an ACC claim is influenced by factors that determine whether an injured person visits a healthcare professional for healthcare, such as attitudes and access to healthcare treatment, perceived severity of injury, and a bias towards earners making claims (Cryer & Langley, 2008; Poland, 2018). Claim behaviour is also influenced by ACC compensation policy and is liable to change over time. Fire and Emergency data was found in this study to undercount attended NFFRI cases, particularly in multiple casualty incidents where only one to two cases were commonly captured.

9. Potential Risk Reduction Strategies & Recommendations

This study provides limited detailed information to inform the development and evaluation of national and local fire safety strategies and to target interventions at vulnerable populations. From the limited data it is clear that the main patterns of risk are persistent over time and require improved inter-sectoral and cross-cultural collaboration and partnership to address NFFRI from smoke, flame and fire.

This section outlines recommendations for prevention of injuries due to NFFRI in New Zealand as informed by these research findings and builds upon and expands the previous recommendations resulting from the examination of hospitalised NFFRI for the period 1996-2000 (Duncanson et al., 2002).

Injury prevention is based on the principle that injuries are predictable and preventable. There are clear commonalities in NFFRI that are prime for intervention to avoid unnecessary deaths. Opportunities to intervene focus in the main on primary prevention, thus prevention efforts are aimed at preventing the fire from occurring in the first place. The Haddon matrix suggests suitable approaches for primary prevention should focus on: preventing the existence of the fire causing agent; preventing the release of the fire causing agent; separating the fire from the host; and providing protection for the host (Haddon, 1980). Where a fire occurs, secondary prevention efforts should focus on: minimising the amount of the fire causing agent present, controlling the pattern of release of fire to minimise damage, controlling the interaction between the fire and host to minimise damage

and increasing the resilience of the host (Haddon, 1980). Furthermore, passive interventions, that don't require humans to actively engage in a behaviour to afford safety protections, are generally considered the most effective means of reducing injuries (Haddon, 1980).

Fire and Emergency has a stated aim of "reducing the consequences from emergencies" through "reductions in harm from fire". The following outlined strategies and recommendations, if implemented, will contribute towards reductions in NFFRI and better organisational understanding of the contribution of NFFRI attended by Fire and Emergency services to the healthcare system.

At risk groups: The high risk populations of adults aged 20-29 years, males, and Māori are consistent across the three datasets examined and are persistent across the time series of 2013-2017. It is concerning that the main population groups at risk of NFFRI have largely remained the same over time, since the previous study of NFFRI hospitalisations in 1995-2000 (Duncanson et al., 2002). International literature has also identified males to be at greatest risk of NFFRI (Turner et al., 2017), and those in the 15-59 year age bracket (Mulvaney et al., 2009).

The persistent disparities in NFFRI highlight the importance of designing fire safety strategies to reach all population groups. Existing fire safety strategies should be strengthened to ensure at risk populations are captured. Classic fire safety approaches (i.e. smoke alarms) that may be effective at the level of the general population appear to be less effective at reducing NFFRI for at risk populations. Little evidence exists on effective means of community fire risk reduction (Gielen, Frattaroli, Pollack, Peek-Asa, & Yang, 2018), therefore, increased evaluation of community based efforts is needed. Establishing active community partnerships to support Fire and Emergency fire safety programmes may produce more effective means of accessing and educating at risk communities (Duncanson, 2000; Gielen et al., 2018). A community based approach with careful consultation and attention to cultural sensitivity was seen to be crucial to the implementation of the Auahi Whatatūpato fire safety programme in the Eastern Bay of Plenty (Duncanson, 2000). Continuing to develop diversity initiatives within Fire and Emergency will also provide leverage opportunities to enhance community engagement through the likes of cultural liaison staff and cultural awareness of Fire and Emergency staff.

Recommendation 1: Efforts to reduce ethnic disparities should be a focus of fire safety activities. Fire and Emergency should continue supporting and developing: 1) bicultural policy and culturally appropriate services and networks to promote fire safety to Māori; and 2) effective fire safety strategies for Pacific peoples and other ethnic minorities. Culturally appropriate programmes should be adequately supported by Māori liaison staff in each region and ongoing training in cultural awareness should be provided to all fire-fighters. Establishing active community partnerships to support Fire and Emergency fire safety programmes may produce more effective means of accessing and educating at risk communities.

Cooking-related fires: While the data examined in this study were limited in their ability to identify areas of specific concern with regards to NFFRI, on the basis of Fire and Emergency attended incidents cooking-related fires are the most common. The danger of cooking with fat or oil, or leaving cooking food items unattended have been well recognised internationally with cooking-related fires commonly reported as the cause of NRRFI (Mulvaney et al., 2009). Interventions promoting safer cooking practices, as well as safer behaviours in response to cooking fires once discovered are needed.

Recommendation 2: That Fire and Emergency New Zealand continue and expand fire safety campaigns specifically addressing the risks of NFFRI from fires due to cooking.

Surveillance and data quality: It is clearly evident that better quality data is needed by Fire and Emergency to inform how much harm is occurring to people during fire events and to identify organisational opportunities to reduce these harms through prevention strategies and actions.

The key intelligence to inform Fire and Emergency's prevention strategies and actions should come from its own data collected at the scene of the fire incident. These data are the only source of exposure information available to inform understanding of the causes and circumstances associated with NFFRI in New Zealand. Improvements to these data are clearly warranted to create data that are fit for this purpose.

Firstly, the collection of accurate person level data, ensuring all injured persons in the incident are captured is important. Detailed person level data will allow for more accurate and reliable description and identification of the at-risk groups for targeted preventive actions.

Secondly, improved capture of the circumstances around fire incidents resulting in NFFRI would provide a more comprehensive picture of opportunities to intervene in such incidents to reduce harm from fire and smoke. Formal fire investigations are undertaken by Fire and Emergency following a fatality and these detailed investigations provide a wealth of intelligence on which to focus prevention strategies and activities to reduce fire fatalities, especially when aggregated (Duncanson, Ormsby, Reid, Langley, & Woodward, 2001; Lilley, McNoe, & Duncanson, 2018). Undertaking similar formal fire investigations, particularly in those cases with a NFFRI with serious or critical injuries resulting in hospitalisation, will provide for improved organisational knowledge to inform the development and evaluation of national and local fire safety strategies and to target interventions at vulnerable populations.

To improve the capture, accuracy and reliability of data on NFFRI at the scene of the

incident, Fire and Emergency staff need better guidance on how to capture data on NFFRI injuries sustained on scene. For example, Fire and Emergency staff need guidance on how to distinguish more serious injuries consistently. In order to achieve this, further research is needed to understand how Fire and Emergency staff currently assign injury severity and to assess the feasibility of improving the classification of injury using the existing Fire and Emergency definitions of injury severity. Recent revisions of the NZ Police administered Traffic Crash Reports allows attending Police Officers to capture casualty information and outcomes on scene using an internet based system completed with portable digital devices. The attending Police Officer is able to track the outcomes of causalities with the system as outcomes are notified and updated within a 30 day period following the incident. A similar system may have utility for on-scene and follow-up data capture by attending Fire and Emergency staff.

Recommendation 3: That Fire & Emergency New Zealand considers, develops and adopts appropriate strategies to improve the collection of fire safety information in residential fire incidents, particularly the collection of person level details (i.e. name, actual age, date of birth, normal residential address) in order to allow for future assessments of at-risk populations and outcomes following NRFFI.

Recommendation 4: That Fire and Emergency New Zealand considers undertaking formal fire investigations (as conducted for fatal fire incidents) in selected events based on severity of injury resulting in non-fatal injury to gain a more comprehensive picture of the circumstances associated with such injury. At an absolute minimum this should be undertaken for cases of Fire and Emergency attended cases with serious and critical injuries requiring hospitalisation.

Recommendation 5: That Fire and Emergency New Zealand investigate and address the current limited ability of attending staff to accurately complete current data fields in the Fire Incident Reporting System in fire incidents resulting in a NFFRI, particularly the injury severity field.

Base data for monitoring trends in injury incidence: The options for identifying indicators of NFFRI incidence were driven by the availability of national data on NFFRI. The main sources of data considered for NFFRI incidence include NMDS hospital discharge data, ACC compensation data and Fire and Emergency fire incident data.

The NMDS hospital discharge data with the addition of ICISS provides the most comprehensive data set available for monitoring trends in serious NFFRI outcomes, and is consistent with recommendations for national all cause non-fatal injury indicators (Cryer & Langley, 2008). Adding the severity threshold restricts the capture of fire-injury diagnoses to those with a high probability of hospital admission and allows for confidence that any trends observed reflect changes in the incidence of serious NFFRI over time rather than extraneous factors associated with improvements in diagnosis or healthcare, minimising threats to validity (Cryer & Langley, 2008). The indicator we propose (serious non-fatal

hospitalisations) draws attention to NFFRI judged as important because of their threat-to-life, however, it is unable to provide an estimate of threat of disability or other loss of function, impairment, or reduced quality of life.

Estimates of injury incidence from hospital discharge data are available via IPRU's National Injury Query System (NIQS available at https://psm-dm.otago.ac.nz/niqs/) through an online query or a customised request. Hospital discharge data are also available from the Ministry of Health for a charge. A limitation of the NMDS is the lack of exposure information available to inform fire safety actions. Linkage to improved future Fire and Emergency attended NFFRI data would overcome this limitation and provide the most comprehensive detailed dataset to inform fire safety strategies and actions.

Recommendation 6: That Fire and Emergency New Zealand considers adopting annual NFFRI incidence monitoring of serious non-fatal cases identified from NMDS hospital discharge data with derived ICISS.

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