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The economic cost of unwanted automatic fire alarms

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ABSTRACT

Although automatic fire alarm (AFA) systems are vital technologies for informing building occupants of a fire, each year Fire and Rescue NSW (FRNSW) responds to tens of thousands of unwanted AFA activations; equating to approximately 97% of all call-outs. The aim of this study was to estimate the economic burden of false AFA system activations by using data collected in NSW for the period 2008–2018. Costs were considered as comprising: business/government productivity losses and other related costs such as false alarm fees; injuries or fatalities sustained in collisions with a responding fire brigade vehicle; wages of FRNSW personnel and other service responders; utility costs of FRNSW; and opportunity costs to the fire brigade, residents and bystanders. This study found that in 2018/19 false AFA system activations resulted in an average economic cost of AUD$246 million per annum to NSW society in a best-case scenario, and AUD$349 million per annum in a base-case scenario; equating to an average cost of between AUD$4952 and AUD$7403 per system initiated false alarm incident. The economic cost of these unwarranted call-outs is prohibitively high and this study indicates the importance of further initiatives geared toward safely reducing the frequency of false AFA system activations.

1. Introduction

Automatic fire alarm (AFA) systems are vital technologies that alert building occupants to the presence of a fire and, in the case of higher risk premises,[1] automatically notify fire departments. While AFAs sent approximately 48,000 alerts to Fire and Rescue NSW (FRNSW) in the period of 2019–2020, 97% of these notifications were system initiated false alarms; with the result that FRNSW attended scenes at which there was no fire or other emergency present [14]. Such a high percentage of false, or unwanted, AFA alerts is a phenomenon not only experienced in Australia, but in many other countries, including the United States [2], New Zealand [6], and the United Kingdom (Scottish Fire and Rescue Service 2020).[2] This is due to the fact that AFAs have been found to falsely send out alerts due to: the activation of manual call points (MCPs), whether accidently – such as when trolleys, hospital beds, or forklift trucks collide with MCPs – or with malicious intent [24]; 19); common household sources, such as cooking, water mist, or heightened sensitivity caused by prolonged contamination [9]; 1197); poor design, installation or placement of the AFA system [20]; lack of maintenance, inspection and testing of the alarm system [2]; 80); and technical malfunctions, power surges, incorrect tests or weather conditions [11].

Research has shown that frequent unwanted AFAs leads to complacency in building occupants, meaning that they are less likely to evacuate when an alarm sounds [8]; 82). In the case of residential smoke alarms, unwanted alarm activations have been found to be a cause of disabled, removed, or disconnected alarm systems, with two-thirds of residential fire deaths occurring in premises without working smoke alarms [9]; 1197). According to Dinaburg and Gottuk [9]; eliminating what they term 'nuisance alarms' could reduce fire-related deaths in the US by 10% (1197).

In addition to unwanted alarms desensitising people to the importance of AFAs or the imperative need to evacuate when one sounds, unwanted AFAs also have a significant economic cost. This cost includes: business productivity losses due to evacuation,[3] loss of fire fighting

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[1] FRNSW defines 'higher risk premises' as including: hospitals, universities, backpacker accommodation, nursing homes, multistorey buildings, shopping centres, and places of entertainment (2019, 50).

[2] In 2014, US fire departments responded to approximately 2.5 million unwanted AFAs [2]; 78). Fire and Emergency NZ (FENZ) respond to more than 20,000 unwanted AFAs annually, comprising between 50% and 70% of the total callouts for certain fire stations [6]. In the period of 2018–2019, the Scottish Fire and Rescue Service attended more than 28,000 unwanted AFAs, comprising 31% of all incidents responded to that year [14].

[3] In 2009, Ashe, McAneney and Pitman estimated the economic cost to businesses in Australia due to fire to be $50 million per annum (128). For the United Kingdom, business losses have been estimated at an annual cost of £40 million [23]; 8). Businesses in New Zealand have been estimated to have lost approximately NZ$70 million in the decade 2009–2019 due to false fire alarms [6]; 24).

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resources, and additional maintenance fees to fix an ill-functioning alarm system [10]. Added to these costs is the increased risk of driving collisions during an emergency response, with 17% of US firefighter deaths occurring during the drive to, or return from, unwanted AFA sites [18].

Although there have been studies undertaken to gauge the fiscal burden of bushfires (Fanham 2020), as well as the total cost of fire to the Australian economy [3], there has been little research conducted into the economic cost of unwanted AFAs in Australia. Marks, He and Buckley (2017) estimated that false fire alarms bear a cost of AUD$14, 766, 805 annually, with this cost being incurred directly by the fire authority and indirectly by society. In their study of unwanted AFAs in Class 3 tourist accommodations in the Sydney CBD, Marks et al. determined that unwanted alarms bore a direct correlation to human activity, with significant increases in the prevalence of system initiated false alarms occurring during peak periods of hotel room occupancy – 8:00 to 10:00 a.m. and 7:00 to 8:00 p.m. (2017, 104). This study seeks to build on the work of Marks et al. by estimating the economic burden of unwanted AFAs on FRNSW, other service providers, businesses, bystanders, residents, and the wider community during the period 2008–2018.

2. Methodology

2.1. Definition of unwanted automatic fire alarms

The terms 'unwanted alarms' and 'false fire alarms' are often used interchangeably. The United States' National Fire Protection Association (NFPA) defines unwanted alarms as any alarm that occurs that is not the result of potentially hazardous condition (NFPA 72, National Fire Alarm Signaling code). These are broken down into four main types: malicious alarms, nuisance alarms, unintentional alarms, and unknown alarms [22]. The Australasian Fire and Emergency Services Council (AFAC) defines an unwanted fire alarm as 'a notification to an emergency response agency to attend a reported emergency incident, which on investigation turns out not to be an emergency incident' ([4]; 5). Similarly, Fire and Emergency New Zealand (FENZ) classifies an unwanted fire alarm as 'a fire alarm system activation where the call may have occurred due to the detection of heat, smoke or airborne contaminants, occupancy activity or fire alarm system faults which did not result from an actual fire' [6]; 1). For the purpose of this research, we define unwanted automatic fire alarms as alarm system activations resulting from stimuli other than fire, which send an alert to fire departments to respond. FRNSW in their annual reports uses the term "false alarms" and provides data on the number of system initiated false alarms responded to and charges made for false alarms. Consistent use of terms based on their data sources was made in this paper.

2.2. Data collection

For this study, data was collected from FRNSW, the Australian Bureau of Statistics (ABS), and the NSW Centre for Road Safety (NSWCRS), as well as from literature reviews and media reports.

2.2.1. Fire and Rescue NSW data provision

Fire incident data was provided by FRNSW using AIRS (Australian Incident Reporting System), for the period up to 2015, and eAIRS (electronic Australian Incident Reporting System), for the period from 2016 onwards. FRNSW are required to fill in an eAIRS report for every emergency incident attended [15]. For the period 2010–2015, the AIRS data provided only the incident type, while the eAIRS data of 2016–2018 offered additional information on the emergency site, such as: the property use, type of complex and even information on the owner. This data was supplemented by the extraction of incident data from the FRNSW annual reports of 2008–2018. AFA system initiated false alarms and malicious false alarms were summated and their proportion of overall FRNSW attended incidents determined. Expenditure data for each financial year was also extracted from the annual reports.

FRNSW also supplied data on the average response time for responding to AFAs, the incident response agency, the type of equipment used (aerial or pumper) as well as the equipment cost and length of use at each incident. Information was also offered on the type of responder – whether they were permanent or on-call personnel – and the number of emergency responses that had the NSW Rural Fire Service (RFS) as the first or second responder.

2.2.2. Other data sets

In order to estimate business productivity losses due to unwanted AFAs, data was sourced from the Australian Bureau of Statistics (ABS) on the Australian national accounts gross value added by industry (catalogue 5206.0). Average weekly earnings figures (catalogue 6302.0) from the ABS were collected to estimate the wage costs of AFA respondents and data on the opportunity costs hourly value was used to determine the cost of responding to false fire alarms when compared to an alternate, productive employment of that time.

NSWCRS was another valuable source of data used for this study as their provision of figures pertaining to collisions involving a fire brigade vehicle from 2014 to 2018 enabled the estimation of the economic cost – to both FRNSW and the public – of driving incidents occurring in an emergency response to a false AFA. While this data included police crash reports, extraction of figures was only undertaken in cases when at least one person had been killed or injured.[4] Statistical statements of road traffic casualty crashes in New South Wales for the period 2008–2018 were used to gather further data on driving incidents including emergency vehicles. However, we were conscious that such data would understate the number of traffic collisions involving emergency vehicles as incidents are only recorded by police when: a person is killed or injured; the drivers did not exchange insurance and/or other contact details; or when a vehicle involved had to be towed from the scene.

Business productivity costs and the fiscal burden on the fire service in relation to false AFAs was estimated by using figures from Marks et al., 's 2017 paper *False Alarms and Cost Analysis of Monitored Fire Detection Systems.* Various sources were drawn upon to approximate the average number of personnel per complex type that would need to evacuate during a false AFA activation. This figure was supplemented by data from media reports on false fire alarm activations, with sensitivity analysis applied.

To calculate the economic cost of using service providers after an AFA system activation, written consultation was undertaken with fire alarm provider companies. This information was supplemented by a survey uploaded onto SurveyMonkey and sent to members of the Real Estate Institute of NSW and the Property Owners' Association of NSW. The survey consisted of four questions:

- Question 1: What percentage of times does a service technician attend as a result of an unwanted alarm activation using a sliding scale 0–100%;
- Question 2: What is the average cost of a service call after an unwanted alarm activation: Less than AUD$100; Between AUD$100 to AUD$200; Between AUD$200 to AUD$300; Between AUD$300 to AUD$400; Between AUD$400 to AUD$500; and More than AUD $500
- Question 3: Would you be interested in assisting Fire and Rescue NSW and Western Sydney University in research on unwanted alarms?
- Question 4: If you are interested in participating further in the study, please provide your contact details.

[4] It is important to note that these reports lacked detail and that this is a limitation of police crash reports as a data source.

31 respondents completed the survey with 18 providing their details for further participation in the study.

2.3. Data analysis

This study used three main methods for determining the societal costs of false AFAs. These methods vary in their sophistication and ability to afford detailed, nuanced findings.

2.3.1. Method 1: percentage figure of total expenses of the response agency

The least sophisticated method employed determined the cost of unwanted AFAs purely for the fire agency by calculating the proportion of fire alarms that were false call-outs and multiplying this figure by the agency's total expenditure. This method afforded only a starting economic value as it only considered the financial burden of false AFAs to FRNSW and not the wider societal costs.

2.3.2. Method 2: calculating the average costs from public data

Publicly available data was sourced to determine the direct costs to the fire brigade when responding to a false AFA. This detail included the average dispatch time, average cost to personnel, average wage of personnel with on-costs (at 40%), as well as the average number of personnel who respond. Added to this were estimated figures pertaining to the fee for fuel per incident and the costs of using the incident command vehicle. The added costs of other service providers were sourced in addition to the price of fines for false alarms and statutory fire safety charge fees incurred by business owners.

2.3.3. Method 3: AIRS and eAIRS data

AIRS and eAIRS data was used to estimate the societal costs to different agents involved in unwanted AFAs. Where required information was unavailable, estimates with justifications were used.

2.3.4. Economic costs borne by the fire brigade

In order to calculate the economic costs incurred by the fire brigade for a false fire alarm incident, the following methodology was applied:

(1). Length of time between dispatch and return, calculated in minutes.

A 30 min response time per incident was estimated by using the average response time of FRNSW to AFAs (19.36 min) and adding an additional 10 min for fire responders to dress and get in and out of emergency vehicles.

(2). Number of staff and assets (e.g. trucks, equipment) were used to calculate wage/equipment costs.

The standard practice of sending two trucks and eight personnel to each incident (treated as a fire unless otherwise determined) enabled the costing of assets used per false AFA [17].

The cost of paying staff responders, pro-rata, was estimated as the associated salaries (plus on-costs) multiplied by (1). The ABS's figure of the average weekly earnings in NSW for an adult male (ordinary earnings, averaged over four quarters) was used with additional on-costs of 40% factored in.

The cost of other FRNSW staff involved in emergency responses was calculated and set as per Marks et al.'s [19] figure of AUD$137 per hour (2011/2012).

(3). Other resource costs

These further costs to the fire brigade were calculated using the figure of AUD$2092 per hour estimated by Marks et al. [19].

2.3.5. Costs to other service providers

In this study, other service providers involved in unwanted AFA activations comprised:

- Other fire services, including the RFS;
- Other emergency services; and
- Fire alarm system service providers

The same methodology used for estimating the costs to the fire brigade was employed when calculating the cost to other service providers. When approximating the cost to RFS in responding to a false AFA activation, similar costs to FRNSW for using fire fighting equipment were assumed. Data supplied by FRNSW on the proportion of unwanted AFAs attended by the RFS was drawn upon when estimating the costs to this other fire service. The cost of false AFAs to business premises owners (fines for false alarms etc.) was estimated by using the survey data collected from property owners and real estate agents.

2.3.6. Cost to business/government

This study considered the cost of unwanted AFA call-outs to businesses and the government as comprising FRNSW fees for false call-outs as well as productivity losses and shut down costs.

- Productivity losses

The location of the call-out was used to determine whether the site of an unwanted AFA was residential or used primarily for business purposes. If the site was classified as an office building, the researcher corresponded with the building management in order to make an estimate of the average number of people employed who would need to be evacuated. This figure varied by time of day, with separate estimates made for a normal working day (9 a.m.–5 pm, Monday–Friday) and outside of traditional working days/hours.

The cost to business from lost productivity was then calculated by multiplying the number of employees evacuated with the average wage rate (using ABS data). This estimated figure was adjusted pro-rata for the duration of the incident.

In order to estimate the gross domestic product loss during a false AFA activation, the researcher used incident figures supplied by FRNSW for the period 2015/16 and 2019/20 to identify the percentage of unwanted AFA sites that were used for business purposes (this ranged from 16% to 21%). For the years 2008–2014, the researcher applied the rate of 16%: using the percentage garnered from FRNSW data of the 2015/16 financial year. The estimated 30 min response time per incident was applied as a conservative time frame for business shutdown and the lost output of unnecessary evacuations was calculated using gross domestic product for each year.

- Beyond productivity losses

AIRS and eAIRS data supplied to the researcher were used to estimate further costs to businesses or the government from false fire alarm activations. This data indicated that the most common facilities of unwanted AFAs were shopping, residential medium-rise buildings, medical care centres, and residential high-rise complexes. Data provided by FRNSW put response time for business/government buildings at 0.5 h per incident. However, for nursing homes, rail, prison or detention centres, retirement villages, shopping centres or other public venues (libraries, town halls etc.) the length of time spent by FRNSW at each incident was assumed to be 1 h.

Assumptions were made for each type of complex concerning: the number of hours spent by the response agency and other service providers; the number of working personnel evacuated; the number of residents evacuated or their time lost during the unnecessary evacuation; the number of bystanders and the length of time they spent assisting or observing an unwanted AFAs incident. These assumptions

for method 3 are provided in Appendix F. The business or government costs, beyond lost productivity, and the human costs were calculated using method 2. These were refined with data on the average number of people per type and size of complex extracted from the literature and from survey responses.

2.3.7. Opportunity cost to residents

Where the site of a false AFA was residential, the researcher calculated a time cost to residents from an evacuation. An opportunity cost is not a tangible, out-of-pocket loss but, rather, is used to refer to a lost leisure/psychosocial cost. This loss was estimated using the average wage rate supplied by ABS which was adjusted pro-rata for the time spent needlessly evacuating the residence.

2.3.8. Opportunity cost to bystanders

This study also sought to estimate the opportunity cost to bystanders of an unwanted AFA event. This figure was calculated by using the same method applied to estimate the opportunity cost to residents. Assumptions were made concerning the number and duration of time spent by onlookers, as well as the time value of those bystanders who assisted during the incident or merely observed.

2.3.9. Opportunity cost of unwanted alarm call-outs to the fire brigade

In order to estimate the loss of potential gain FRNSW could have enjoyed had they not attended to a false AFA, the following methodology was employed:

(1). Calculations to estimate the cost of the fire brigade being unavailable to respond to, or delayed in responding to, a real emergency.

The average probability of FRNSW being unavailable to respond to a real emergency, or delayed due to the duration of a false call-out, was estimated as 0.25%. This figure is an estimate of the percentage of cases in which the fire brigade will become involved in a collision on route to, or returning from, a false AFA site. Collision data collected from the NSWCRS was used to calculate the probability of death, serious injury or moderate injury occurring during an emergency response to an unwanted AFA. These probability figures are as follows:

- The probability that an unnecessary emergency response will result in injury or death due to a traffic collision was estimated at 5.1%.
- The probability that an unnecessary emergency response will result in serious injury due to a serious traffic collision was estimated at 25.6%.
- The probability that an unnecessary emergency response will result in serious injury due to a minor traffic collision was estimated at 26.9%.
- The probability that an unnecessary emergency response will result in moderate injury due to a moderate traffic collision was estimated at 42.3%.

The number of people who died or sustained serious, moderate or minor/other injury as the result of a traffic crash involving emergency vehicles was then multiplied by the willingness to pay,[5] using data from the NSWCRS.

It is noted that the economic cost of road collisions resulting in injuries or fatalities associated with attending an unwanted AFAs does not include the probabilities of vehicle crashes that are not reported to the police. In addition, the economic cost of road congestions and its indirect effects have not been included in the estimated figures.

The financial costs of fining businesses for false AFAs was treated as a cost to businesses and as revenue to FRNSW. In addition, as FRNSW received support from the RFS for a percentage of unwanted AFA call-outs, necessary adjustments have been made to the overall cost of false AFAs to FRNSW.

3. Results

Table 1 (Appendix A) outlines the number and type of incidents/emergencies attended by FRNSW for the period 2008–2018, calculated per financial year. The total number of unwanted AFAs call-outs ranged from 46,384 to 57,356 per annum.

3.1. False AFAs as a percentage of FRNSW's total expenses

The findings from employing method 1 (unwanted AFAs as a percentage figure of the overall expenses of the response agency) are presented in Table 2. These annual estimates of the economic costs of false AFAs were generated by using the data on the number of system initiated false alarm incidents attended by FRNSW (presented in Table 1). This summation included system initiated false alarms divided by total fires, explosions and other emergencies. The total number of unwanted AFA system callouts – as a proportion of total incidents responded to by FRNSW – ranged from 36% to 42% during 2008–2018. This proportion was then applied to FRNSW's total expenditure (retrieved from FRNSW's annual financial reports) in order to attain a broad estimate of the financial cost of false AFAs incurred by the fire brigade.

The data presented in Table 2 demonstrates that the rate of unwanted AFA incidents has been consistent since 2012; however, the number of false AFAs as a proportion of connected alarms has dropped. In NSW – particularly the Greater Sydney Region – there have been high rates of building development with the establishment of fire alarm systems connected to a monitoring service [12].

Fines or charges for false alarm call-outs were introduced in July 2003 by FRNSW, increasing gradually in price from AUD$400 to the current rate of AUD$1600 per incident.[6] Fines for false alarm call-outs increased dramatically from a revenue of AUD$6 million in 2008/09 to AUD$36 million in 2018/19 [13], with an average for the 11 years being AUD$23 million per annum. These figures were subtracted from the gross cost of attending to false AFAs in order to determine the net cost to FRNSW. The average net cost of false AFAs for FRNSW was estimated as AUD$234 million, with a median net cost of AUD$229 million. The maximum cost to FRNSW in any one year was AUD$264 million (in 2018/19).

The average net cost to FRNSW per false alarm was AUD$4713 (median: AUD$4636). The lowest annual cost per incident was AUD $4000 in 2008/09 and the highest cost per incident was AUD$5611 in 2018/19 (unadjusted for inflation). The costs computed using this method are for the FRNSW agency only and do not include any other costs incurred by the wider society.

Fig. 1 outlines the number of false AFAs as well as the number of Alarm Signaling Equipment (ASE) connected during 2003–2018. In an effort to reduce unwanted AFAs, FRNSW has increased fines for false alarms, provided education and consultation, and targeted sites with high rates of unwanted alarm system activations for improvement plans. Such efforts can be seen to be reducing false alarm call-out frequency with a marked reduction in unwanted AFAs identifiable from 2012.

3.2. The economic cost of false fire alarm activations per annum

3.2.1. Staff and utility costs for FRNSW and other service providers

Table 2 outlines the costs of using fire brigade appliances and resources as well as paying attending staff for unwanted AFA activations.

[5] A term used to value injuries sustained and/or lives lost as the result of a motor vehicle collision.

[6] Fines for system initiated false alarm call-outs are typically applied to second or subsequent incidents during a period of 60 days (*Fire Brigades* [16].

Table 1
Method 1: Costs of unwanted AFAs to FRNSW (Net of Fines).

Year	Unwanted AFAs/Total incidents (%)	FRNSW Total Expenditure (AUD$)	Gross Cost to FRNSW (AUD$)	Revenue to FRNSW - Fines: Charges for False Alarms (AUD$)	Net Cost to FRNSW (AUD$)
2008/09	42	563,788,000	235,524,884	6,083,000	229,441,884
2009/10	41	578,236,000	238,126,093	11,480,000	226,646,093
2010/11	40	614,004,000	246,197,129	11,579,000	234,618,129
2011/12	40	645,826,000	258,693,914	16,541,000	242,152,914
2012/13	37	644,004,000	237,062,690	15,654,000	221,408,690
2013/14	37	656,606,000	239,884,789	25,653,000	214,231,789
2014/15	38	674,322,000	256,316,702	28,919,000	227,397,702
2015/16	39	702,000,000	272,540,635	30,316,000	242,224,635
2016/17	39	716,000,000	277,046,943	35,759,000	241,287,943
2017/18	36	735,000,000	261,453,064	35,278,000	226,175,064
2018/19	37	813,996,000	300,290,231	36,461,000	263,829,231

Source: FRNSW Annual Reports 2008/09, 2009/10, 2010/11, 2011/12, 2012/13, 2013/14, 2014/15, 2015/16, 2016/17, 2017/18, 2018/19.

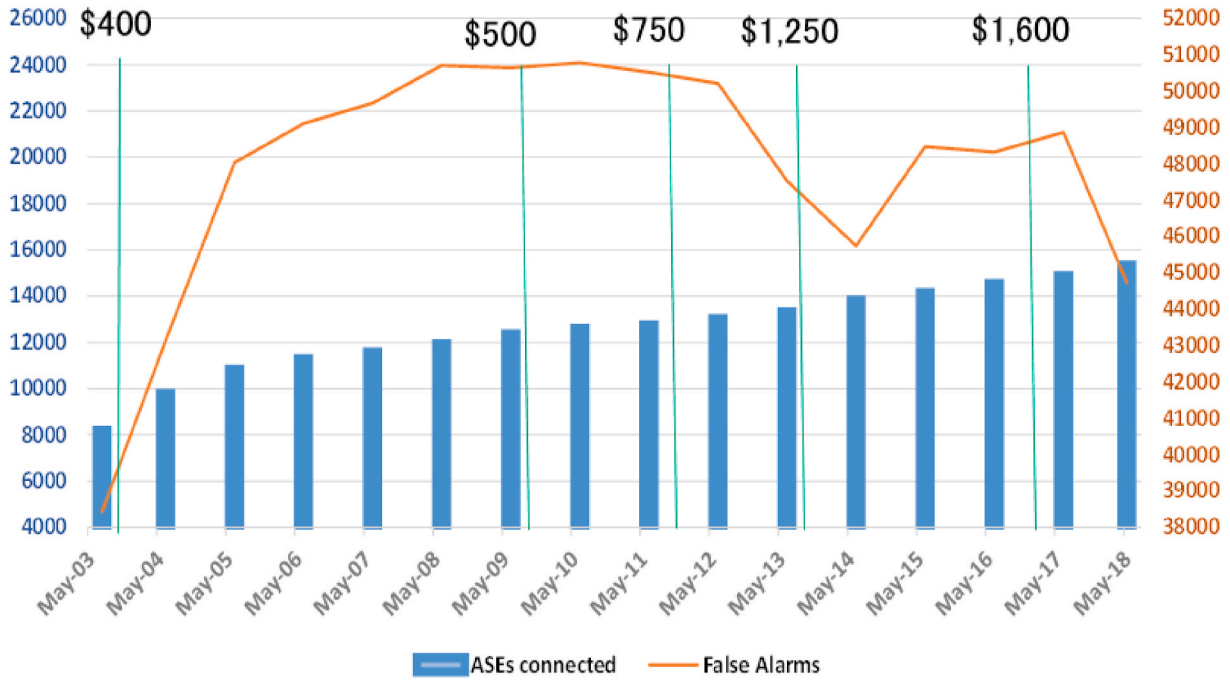

Fig. 1. Number of False Alarms, Connected Alarm Systems for Monitoring and False Alarm Fines (AUD$, line by date of introduction).

These costs were based on [19] hourly fee costing for fire alarm responses, which they estimated as:

- AUD$576 per hour for attending staff
- AUD$137 for other staff cost
- AUD$846 for appliance costs
- AUD$2092 for resource costs

However, as Marks et al.'s study was based on false alarm incidents in 2011/12, their hourly rates were adjusted for inflation using the ABS's Consumer Price Index (catalogue no: 6401.0) for the years 2008/09 to 2018/19.

The average annual staff and utility costs for FRNSW to attend to false AFAs over the 11 years of this study was AUD$94 million (based on a 0.5 h response time).

In order to account for the economic costs borne by other service providers for false fire alarms, we conservatively assumed that their attendance would be at half of the unwanted alarm activations for a period of 1 h and that their costs would be 20% of that of FRNSW – meaning that the cost for other service providers in 2011/12 was AUD $730.[7] This equates to an average annual cost to other service providers of almost AUD$19 million per annum.

[7] This figure was supported by survey results from property owners and real estate agents.

Table 2
Cost to Fire Service and Other Service Providers for unwanted AFAs (AUD$).

Year	Unit Cost to FRNSW per hour[a,b]	Cost to FRNSW using unit cost per *30 min*	Costs to other service providers per hour	Gross Costs to FRNSW + Other Service Providers (	Revenue to FRNSW - Fines: Charges for False Alarms	Net Costs to FRNSW + Other Service Providers
2008/09	3367	96,551,871	19,310,374	115,862,246	6,083,000	109,779,246
2009/10	3411	95,019,418	19,003,884	114,023,302	11,480,000	102,543,302
2010/11	3514	92,235,030	18,447,006	110,682,036	11,579,000	99,103,036
2011/12	3651	95,354,993	19,070,999	114,425,991	16,541,000	97,884,991
2012/13	3745	92,102,580	18,420,516	110,523,096	15,654,000	94,869,096
2013/14	3851	89,307,892	17,861,578	107,169,470	25,653,000	81,516,470
2014/15	3934	95,768,253	19,153,651	114,921,904	28,919,000	86,002,904
2015/16	3971	94,035,855	18,807,171	112,843,026	30,316,000	82,527,026
2016/17	4058	97,048,201	19,409,640	116,457,841	35,759,000	80,698,841
2017/18	4141	91,641,626	18,328,325	109,969,951	35,278,000	74,691,951
2018/19	4210	98,987,837	19,797,567	118,785,405	36,461,000	82,324,405

[a] Based on hourly cost by Marks, He and Buckley [19] for per hourly rate in 2011/12.
[b] Inflated using annual rate of inflation for Sydney from ABS Consumer Price Index (6401.0).

3.2.2. *Cost of false fire alarm activations to businesses or the government*

The costs incurred by businesses or governments as the result of unwanted fire alarms was identified as comprising three components: FRNSW fees for false call-outs, productivity losses and shut-down costs.

- Fines: As FRNSW data indicated that 85% of unwanted AFA activations were from business or government sites, the annual fine revenue figures from FRNSW (shown in Table 2) were multiplied by this percentage to account for fees paid by businesses or the government.
- Productivity losses: to calculate this factor of economic cost we made the very conservative assumption that 20 persons would be evacuated for a period of 2 h per unwanted AFA incident, with a yearly estimated productivity loss figure of AUD$71 million.

- Shutdown costs: these estimated figures were calculated by taking the gross domestic product (GDP) for the financial year (using GDP [Production] Australia Original [5206.0]) and assuming both that the length of shutdown per incident would be 1 h and that the businesses operate 365 days a year, 12 h per day. This resulted in an estimated cost of AUD$13 million per annum.

These three components of business/government costs due to unwanted AFA activations added up to AUD$103 million per annum, shown in Table 3. These costs refer to absenteeism and are very conservative in terms of the number of persons evacuated and the assumption of average wage applied. The additional costs that can be added when measuring productivity losses to business/government employers is presenteeism. Efficiency loss in work (presenteeism cost) for the rest of the day after the evacuation process adds to productivity loss. If it is assumed that a 5% efficiency loss occurs for 4 h following the AFA for employees, this will add an extra AUD$4 million per annum. Further, if there are incidents of injury during the process of evacuating from the premises, it will exaggerate productivity loss. If it is assumed that 5% of false fire alarms incidents involve injury of employees and injury of 1% of the people results in 1% loss in GDP per hour on average as well as they remain absent for five working days, it will cost the business an extra $400 thousand per annum. These costs are also considered as absenteeism costs in addition to productivity loss that occurs during the evacuation process. Adding the additional absenteeism and presenteeism costs to the productivity loss for 2018/19 increases it from AUD$112 million to AUD$116 million.

Table 3
Cost to Businesses or the Government's Businesses from unwanted AFA (AUD$).

Year	FRNSW Fines for False Alarms	Productivity loss @ 20 persons for 2 h	Shut-down Costs (GDP per hour of incident shut-down	Costs to Businesses or Government
2008/09	5,170,550	81,962,871	16,275,568	103,408,989
2009/10	9,758,000	79,606,417	15,807,641	105,172,058
2010/11	9,842,150	75,027,837	14,898,461	99,768,448
2011/12	14,059,850	74,644,860	14,822,413	103,527,122
2012/3	13,305,900	70,280,633	13,955,797	97,542,330
2013/14	21,805,050	66,283,664	13,162,109	101,250,823
2014/15	24,581,150	69,568,981	13,814,483	107,964,613
2015/16	25,768,600	67,685,532	13,440,482	106,894,614
2016/17	30,395,150	68,352,885	13,573,000	112,321,034
2017/18	29,986,300	63,242,709	12,558,260	105,787,269
2018/19	30,991,850	67,192,520	13,342,583	111,526,954

Additional costs not considered include: losses due to brand impact/loss of potential business; unwanted alarm activations as the result of perverse occupant or resident behaviour (such as building owners isolating fire alarm systems); and the additional administrative costs to FRNSW of processing waivers for unwanted AFA.

3.2.3. *Costs to residents*

The cost to occupants of residential sites was calculated as being in the form of fines for false alarms and opportunity costs of leisure. In order to estimate this cost, we assumed that 15% of false alarm fines per residential site were paid by occupants; 20 people on average would need to evacuate; the evacuation period would be 2 h; unwanted AFA in

these buildings would comprise 15–20% of all FRNSW call-outs; the opportunity cost of their leisure time lost was the product of average weekly earnings as per ABS data; and the length of the evacuation.

The average annual cost of unwanted AFA for residents was estimated at AUD$12 million. For scenario analysis, if we assumed that the number of evacuees was 40 persons (double the earlier figure), and with all other assumptions unchanged, the average annual cost to residents was AUD$20 million (Table 4). If we were to assume that the average number evacuated was 70 people and that the period of evacuation was 1 h – as in the backpacker fire of 2010 – the average cost for residents would have been AUD$32 million.

The psychological impact of unwanted AFA on individuals and families needing to evacuate their homes has been studied at length with regard to natural disasters [26]. This impact has been alluded to in the case of unwanted AFA [5] but has not been costed in this study.

3.2.4. Costs to bystanders

The term 'bystander' was used in this study to refer to those people present at an unwanted AFA site but who did not take part in the incident: a chance spectator (Merriam- [27]. In measuring the costs to these persons, the following assumptions were made: the average length of time they would be present at an unwanted AFA site was 1 h, with opportunity costs measured by applying the same method as for resident opportunity costs; the number of bystanders per incident was two; and the number of incidents bystanders would stop to support was 40%, with sensitivity testing of 60% and 80%.

The average opportunity cost to bystanders if they support 40% of false fire alarms is AUD$2 million per annum. This figure rises to as high as AUD$4.9 million if two people stop to support 80% of unwanted AFA for 1 h per incident (Table 5).

3.2.5. Costs borne by those involved in Collisions with emergency response vehicles

In order to extinguish a fire as quickly as possible, the FRNSW brigade use their lights and speed on route to the site of a fire alarm activation. However, the speed required to attend to an emergency means that the risk of a driving collision on the way to, or return from, an emergency site is higher. There is also the risk of the diversion or delaying of FRNSW brigade resources as the result of responding to real fires or other types of incidents.

Data was supplied from the NSWCRS on crashes involving emergency vehicles that resulted in fatalities, serious injuries or minor injuries during the calendar years of 2008–2018. Probabilities of these collisions and rates of injury were accordingly determined. Whether those involved in such driving crashes were willing to pay for casualties and hospitalisation for major injuries was also obtained from NSWCRS. However, as not all data required was readily available, the following assumptions were made and sensitivity analysis undertaken[8]

- There was a 0.1%, or 1 in 1000, probability of a FRNSW truck being involved in a collision either on route to, or during the return from, an unwanted AFA activation site.
- There was a 5.1% probability of death as the result of a collision involving a FRNSW truck, with the same probability found for a delayed attendance.
- The willingness of a person involved in a collision with a FRNSW truck that resulted in a fatality to pay damages was estimated as AUD $10, 374, 640.
- There was a 25.6% probability of serious injury as the result of road crashes involving a FRNSW truck or delayed attendance at an emergency site by the fire brigade. The willingness of a person to pay for serious injury was estimated as AUD$486,105.
- There was a 42.3% probability of moderate injury as the result of road collisions involving a FRNSW truck. The willingness to pay per person was assumed to be half that of serious injury: AUD$243,052.
- There was a 26.9% probability of minor injury as the result of road collisions involving a FRNSW truck or delayed attendance at an emergency site by the fire brigade. The willingness to pay per person is assumed to be half that of moderate injury: AUD$121,527.

The number of events that resulted in a collision or greater harm from delayed attendance of the fire brigade, from 2008/09 to 2018/19, averaged 50 per year. This resulted in approximately two fatalities, 13 major injuries, 21 moderate injuries, and 13 minor injuries. The estimated willingness to pay – or cost to society – as the result of these fatalities and injuries averaged at AUD$38 million per annum (Table 6).

For comparison, the average number of deaths and injuries per year in the state over the same period of 2008/09 to 2018/19 was 19 persons [1] and 1008 persons respectively (Steering Committee for the [[25] teering Committee for the Review of Government Service Provision, 2021]. The costs, using the same methodology as above for injury allocation and valuation of statistical life, was AUD$338 million per annum.

3.3. Total economic costs

The above costing figures have separated the fiscal burden of unwanted AFAs into those exclusively borne by individual groups or persons involved, whether directly or indirectly, with unwanted AFA activations. In this section, economic costs are summed across all categories.

When estimating the total cost of false AFA system activations to NSW society, the best-case scenario gives an average economic cost of AUD$246 million per annum (Table 8, Appendix B). This equates to an average cost per incident of AUD$4,952, with 2018/19 having had a cost of AUD$5185 per unwanted AFA activation. The second scenario – or base-case scenario – presented in Table 9 (Appendix C) determines the average cost of unwanted AFA incidents to be AUD$349 million per annum. This equates to an average cost per incident of AUD$7,025, with 2018/19 having had a cost of AUD$7403 per unwanted AFA activation.

Table 10 (Appendix D) outlines the eAIR data provided for the period of 2016–2018 on the type of complex, property use, and information on the owner of the site with false AFA system activations.

Table 11 (Appendix E) provides the total economic cost of unwanted alarm activations for each year by type of complex. The average economic cost of false AFAs to business/government averaged AUD$791 million or AUD$15,307 per incident for 2016 to 2018. These figures are estimates as the true number of persons who had to be evacuated, or who were directly or indirectly affected, were not provided. As such, the method for determining these economic costs is particularly sensitive to the assumptions that were made (presented in Appendix F).

By type of complex, where they are assigned, unwanted AFA in shopping complexes, residential high rises and residential medium rises have the highest economic costs. When assessed by average cost per incident, unwanted AFA in airports are the most expensive at AUD $657,184. This is followed by high rise residential buildings, primary or secondary education and rail at AUD$43,787, AUD$30,858 and AUD $28,414 respectively. The lowest per incident economic cost is unwanted AFA in road complexes at AUD$4451 (Table 12, Appendix G). The average economic cost per incident regardless of complex is AUD $15,307 for all agents.

By agency, the total economic cost for service providers of FRNSW and others was AUD$129 million and AUD$45 million respectively. The determination of economic costs for each agent involved in unwanted fire alarm activations is presented in Fig. 2 (Appendix H).

[8] It is important to note that the following probabilities and costings are based on road collisions involving a fire brigade vehicle only in NSW.

Table 4
False Alarm Cost to Residents, with Two Scenarios on Number of People Evacuated (AUD$).

Year	Fines for false alarms	Opportunity Cost @20 persons evacuated	Opportunity Cost @40 persons evacuated	Total Costs to Residents @20 persons evacuated	Total Costs to Residents @40 persons evacuated
2008/09	912,450	7,232,018	14,464,036	8,144,468	15,376,486
2009/10	1,722,000	7,401,789	14,803,578	9,123,789	16,525,578
2010/11	1,736,850	7,973,106	15,946,211	9,709,956	17,683,061
2011/12	2,481,150	8,183,135	16,366,270	10,664,285	18,847,420
2012/13	2,348,100	8,020,437	16,040,875	10,368,537	18,388,975
2013/14	3,847,950	7,770,248	15,540,495	11,618,198	19,388,445
2014/15	4,337,850	8,155,376	16,310,752	12,493,226	20,648,602
2015/16	4,547,400	8,535,647	17,071,293	13,083,047	21,618,693
2016/17	5,363,850	8,649,939	17,299,878	14,013,789	22,663,728
2017/18	5,291,700	8,268,791	16,537,582	13,560,491	21,829,282
2018/19	5,469,150	9,057,463	18,114,925	14,526,613	23,584,075

Table 5
Unwanted AFA Costs to Bystanders, with Three Scenarios on Number of Bystanders (AUD$).

Year	Opportunity Cost to Bystanders @40% of unwanted AFA	Opportunity Cost to Bystanders @60% of unwanted AFA	Opportunity Cost to Bystanders @80% of unwanted AFA
2008/09	1,928,538	2,892,807	3,857,076
2009/10	1,973,810	2,960,716	3,947,621
2010/11	2,126,161	3,189,242	4,252,323
2011/12	2,182,169	3,273,254	4,364,339
2012/13	2,138,783	3,208,175	4,277,567
2013/14	2,072,066	3,108,099	4,144,132
2014/15	2,174,767	3,262,150	4,349,534
2015/16	2,276,172	3,414,259	4,552,345
2016/17	2,306,650	3,459,976	4,613,301
2017/18	2,205,011	3,307,516	4,410,022
2018/19	2,415,323	3,622,985	4,830,647

4. Discussion

This study has provided estimated figures on the economic costs of unwanted AFA system activations by using data collected in NSW for the period 2008 to 2018. Costs were considered as comprising: business/government productivity losses and other related costs such as false alarm fees; injuries or fatalities sustained in collisions with a responding fire brigade vehicle; wages of FRNSW personnel and other service responders; utility costs of FRNSW; and opportunity costs to the fire brigade, residents and bystanders. The findings from the modellings and data linkage indicate that, on average, attending unwanted AFA activations costs the fire services AUD$94 million per annum and other service providers approximately AUD$19 million per annum. Business and government services incur a fiscal burden of approximately AUD $105 million per annum, with residents bearing an average cost of AUD $20 million per year due to unwanted AFA system activations. Bystanders incur opportunity costs that range from AUD$2–4 million a year. The total economic cost of false AFA system activations to society is AUD$246 million per annum (Table 8) in a best case scenario and AUD $349 million per annum (Table 9) in a base case scenario. A conservative approach was undertaken in making these estimates with the result that these values may be understated.

In an effort to provide estimated costs for unwanted fire alarm activations, this research study found that 97% of call-outs involving AFA systems in NSW are unwanted AFA. These unwarranted call-outs are a tax on FRNSW and other service provider's time and resources and produce substantial costs that are borne by the fire service as well as businesses, residents and bystanders. While the research findings demonstrate that FRNSW's efforts to lower the frequency of unwanted AFA system activations have led to a reduction in unwanted AFA call-outs since 2012, further initiatives are required to lessen their economic impact on society and their drain on the fire brigade's time and assets.[9] The positive impact of freeing up these resources would be enormous, especially with increasingly intense bushfire seasons in Australia and the ever-growing need for greater community outreach, preparedness and training. The economic cost of unwanted AFA system activations is prohibitively high and safely reducing the burden of these alarms on all stakeholders is an important goal to strive for.

While this research study identifies the significant fiscal burden of false AFA activations on society, it is important to acknowledge its limitations. The findings in this study are reliant upon assumptions of figures when there was no available data. This was the case for the time spent by the fire brigade at each unwanted AFA incident and each complex type; the number of persons that evacuate from businesses, government complexes, or residences in alarm activations; and the number of collisions involving a fire brigade truck that result in fatalities and/or injuries. Economic estimations were also made for the productivity loss of evacuated workers, loss of business during the period of evacuation, the economic value of lost leisure time, as well as estimates of the amount of people involved in collisions with a fire truck who were

[9] For instance, a study by the Building Research Establishment (BRE) estimated that if just one factor influencing unwanted AFAs activations could be prevented – the accidental or malicious activation of manual call points – this would reduce unwanted AFA call-outs by 58,000 a year in the United Kingdom, with an estimated annual saving of £147 million for UK businesses [7]; 16).

Table 6
Cost to individuals from fatalities and injuries.

Year	Probability of collision @0.1%	Probability of death @5.1%	Probability of serious injury @25.6%	Probability of moderate injury crash @ 42.3%	Probability of minor/other injury crash @26.9%	Estimated cost to community (AUD$)
2008/09	57	3	15	24	15	46,071,640
2009/10	56	3	14	24	15	45,585,535
2010/11	53	3	14	22	14	44,977,904
2011/12	52	3	13	22	14	44,491,800
2012/13	49	2	13	21	13	33,752,581
2013/14	46	2	12	19	12	32,658,846
2014/15	49	2	13	21	13	33,752,581
2015/16	47	2	12	20	13	33,023,424
2016/17	48	2	12	20	13	33,023,424
2017/18	44	2	11	19	12	32,172,741
2018/19	47	2	12	20	13	33,023,424

willing to pay for casualties and hospitalisation for injuries sustained. The provision of more detailed eAIRs data that includes the exact time that the fire brigade spent at each incident; the size of the complexes attended; the fire brigade station sourced; and other available administrative information on the incidents/complexes will enable future research to determine more exact measurements of the economic cost of false fire alarms.

The economic cost of disrupted sleep when unwanted AFAs occur during the night, interrupts sleep and rest and its flow-on effects were not measured. Studies by Rosekind et al. [21] demonstrated that insufficient sleep had lowered productivity, performance and safety outcomes. These costs were not estimated in this study and is a limitation to its findings.

The costs to business from lost productivity calculated was calculated based on the number of employees evacuated with the average wage rate and adjusted for the duration of the incident. This is recognised as underestimating the economic cost as it uses the duration of the incident and does not include lost time from interrupted meetings or flow of thought or work processes. It also does not include loss in current and future sales due to customer dissatisfaction because of repeated false fire alarms in the same place.

Another limitation of the study is that the psychological impact of false AFA activations on workers, business operators, residents and the wider population was not costed and no attempts were made to estimate it. It is worth considering that the psychological repercussions of unwanted AFA will likely be most keenly experienced by the responding fire fighters and that future studies should attempt to estimate this associated cost. Finally, the costs borne from traffic congestion produced in an emergency response was not estimated.

5. Conclusions

False AFA system activations present a substantial economic burden to fire brigades and wider society. They drain the resources and time of the responding fire brigade and incur productivity losses to businesses and opportunity costs to evacuated residents and bystanders. Although this study approached the economic costs of unwanted AFA conservatively and made assumptions where data was unavailable, a best case scenario of AUD$246 million per year is a significant fiscal burden the fire brigade and wider society bears due to unwanted AFA system activations. With 97% of AFA system call-outs in NSW being unwarranted, further attention to initiatives aimed at declining unwanted AFA incidents would enable the allocation of such monetary and material resources to real emergencies as well as boost business productivity.

Ethics declaration

Ethical approval for this study was obtained from the Western Sydney Human Research Ethics Committee (HREC), Western Sydney University, approval number: H12399. Consent was obtained from all participants and no participants were identified in the research.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

Table 1
Number and type of incidents/emergencies per financial year.

Number and type of incidents/ emergencies	2008/ 09	2009/ 10	2010/ 11	2011/ 12	2012/ 13	2013/ 14	2014/ 15	2015/ 16	2016/ 17	2017/ 18	2018/ 19
Fires and Explosions											
Structure Fires	7448	7495	7054	6711	6766	6258	6244	5842	5623	5741	5667
Outside storage fires	289	303	260	257	234	232	258	260	252	310	297
Vehicle fires	4384	4202	4001	3939	3763	3303	3060	3130	3270	3179	3209
Bush and grass fires	9915	9904	6974	6393	10,153	8449	5929	6509	6678	8929	6854
Rubbish fires	9629	8918	7972	7926	7593	6753	5652	5264	5112	5232	5049
Other fires	265	214	354	30	375	345	650	1325	1198	1241	1210
Total fires and explosions	**31,930**	**31,036**	**26,615**	**25,256**	**28,884**	**25,340**	**21,793**	**22,330**	**22,133**	**24,632**	**22,286**
Non-Fire Rescue Incidents											
Motor vehicle crashes with extrication victims	4905	5104	4981	5086	4909	5012	4808	4705	4946	4716	4591
Medical assistance	796	926	2790	2962	2878	3132	3318	2068	2447	2697	3230
Animal rescues	2506	2621	1032	1057	1062	1178	1466	1683	1610	1593	1770
Other non-fire rescues incl industrial & vertical	1411	2060	2056	2117	1894	1745	1790	3137	3422	3610	3811
Total non-fire rescue calls	**9618**	**10,711**	**10,859**	**11,222**	**10,743**	**11,067**	**11,382**	**11,593**	**12,425**	**12,616**	**13,402**
Hazardous material incidents	16,475	15,224	15,558	15,594	15,901	15,453	16,120	15,833	15,767	16,515	16,567
Storm, floods, other natural disasters, calls assist	5739	6088	3126	3679	3713	3973	5579	4593	4769	5309	7038
Other service calls			3327	3359	3388	3307	3714	3811	3738	3894	4205
Good intent calls	10,744	11,105	10,849	11,127	12,059	11,753	11,991	14,050	14,466	14,345	15,205
System initiated false alarms	53,803	52,647	52,503	52,235	49,181	46,384	48,683	45,961	46,378	42,754	45,532
Malicious False Alarms	3553	3060	2560	2147	2071	1615	1156	1404	1454	1502	1488
Other Calls	5434	5401	5543	5785	7665	8069	7658	2426	2487	2846	1734
Total other emergencies and incidents	**105,366**	**104,236**	**104,325**	**105,148**	**104,721**	**101,621**	**106,283**	**99,671**	**101,484**	**99,781**	**105,171**
Total Fires, Explosions and Others	**137,296**	**135,272**	**130,940**	**130,404**	**133,605**	**126,961**	**128,076**	**122,001**	**123,617**	**124,413**	**127,457**
Total False Alarms	**57,356**	**55,707**	**52,503**	**52,235**	**49,181**	**46,384**	**48,683**	**47,365**	**47,832**	**44,256**	**47,020**

Source: FRNSW Annual Reports 2008/09, 2009/10, 2010/11, 2011/12, 2012/13, 2013/14, 2014/15, 2015/16, 2016/17, 2017/18, 2018/19.

Appendix B

Table 8
Total Economic Cost to Society - Best Case Scenario (AUD$).

Year	Net Costs to FRNSW + Other Service Providers	Costs to Businesses or Government @20 persons for 1 h	Total Costs to Residents @20 persons evacuated	Bystanders Opportunity Cost @40% of unwanted AFA	Estimated cost to community @0.1% of unwanted AFA	Total Economic Cost to Society
2008/ 09	109,779,246	103,408,989	8,144,468	1,928,538	46,071,640	269,332,881
2009/ 10	102,543,302	105,172,058	9,123,789	1,973,810	45,585,535	264,398,495
2010/ 11	99,103,036	99,768,448	9,709,956	2,126,161	44,977,904	255,685,505
2011/ 12	97,884,991	103,527,122	10,664,285	2,182,169	44,491,800	258,750,367
2012/ 13	94,869,096	97,542,330	10,368,537	2,138,783	33,752,581	238,671,328
2013/ 14	81,516,470	101,250,823	11,618,198	2,072,066	32,658,846	229,116,403
2014/ 15	86,002,904	107,964,613	12,493,226	2,174,767	33,752,581	242,388,092
2015/ 16	82,527,026	106,894,614	13,083,047	2,276,172	33,023,424	237,804,284
2016/ 17	80,698,841	112,321,034	14,013,789	2,306,650	33,023,424	242,363,739
2017/ 18	74,691,951	105,787,269	13,560,491	2,205,011	32,172,741	228,417,463
2018/ 19	82,324,405	111,526,954	14,526,613	2,415,323	33,023,424	243,816,719

Appendix C

Table 9
Total Economic Cost to Society - Base Case Scenario (AUD$).

Year	Net Costs to FRNSW + Other Service Providers	Costs to Businesses or Government @40 persons for 2 h	Total Costs to Residents @40 persons evacuated	Bystanders Opportunity Cost @60% of unwanted AFA	Estimated cost to community @0.5% of unwanted AFA	Total Economic Cost to Society
2008/09	109,779,246	185,371,860	15,376,486	2,892,807	63,737,851	377,158,250
2009/10	102,543,302	184,778,475	16,525,578	2,960,716	63,737,851	370,545,922
2010/11	99,103,036	174,796,285	17,683,061	3,189,242	61,793,432	356,565,056
2011/12	97,884,991	178,171,982	18,847,420	3,273,254	61,793,432	359,971,079
2012/13	94,869,096	167,822,963	18,388,975	3,208,175	60,699,696	344,988,905
2013/14	81,516,470	167,534,487	19,388,445	3,108,099	59,849,013	331,396,515
2014/15	86,002,904	177,533,594	20,648,602	3,262,150	60,699,696	348,146,947
2015/16	82,527,026	174,580,146	21,618,693	3,414,259	59,849,013	341,989,138
2016/17	80,698,841	180,673,919	22,663,728	3,459,976	59,849,013	347,345,476
2017/18	74,691,951	169,029,978	21,829,282	3,307,516	48,380,638	317,239,365
2018/19	82,324,405	178,719,474	23,584,075	3,622,985	59,849,013	348,099,952

Appendix D

Table 10
Number of unwanted AFA Incidents by Type of Complex (2016–2018).

Complex	2016 No	2017 No	2018 No
Aboriginal settlement/mission	8	10	7
Airport	66	97	91
Backpackers	148	151	129
Caravan park		0	1
Carpark	49	30	35
Child Care	55	64	62
Communication services	127	102	80
Emergency services	75	91	84
Entertainment	440	396	480
Farm	9	13	7
Forestry	1	1	1
Hazardous/Dangerous Goods	47	26	31
Hospitality	823	728	619
Hotel	1421	1460	1469
Industrial plant, manufacturing	929	776	727
Local state and national parks, forest.	8	14	20
Medical care	2410	2532	2318
Military	532	555	493
Mining	2	6	7
Nursing Home	2021	2208	1914
Office	1937	1912	1773
Post-Secondary education	1444	1681	1510
Power production	34	31	26
Primary or Secondary Education	680	653	692
Prison or detention centre	537	556	845
Public venue (town halls, libraries, ..	211	181	152
Rail	164	171	211
Refuse/rubbish disposal	39	29	17
Registered Club (e.g. RSL, Sporting Complex)	327	293	285
Religious	117	140	111
Research	46	36	37
Residential (high rise - greater than..	1630	1903	1948
Residential (low rise - up to 3 store..	823	881	822
Residential (medium rise - up to 8 st..	1984	2452	2719
Residential (one-family and two-family)	42	32	28
Retirement Village	654	591	568
Road	5	19	8
Service station	2	4	7
Shopping	2871	3034	2945

(*continued on next page*)

Table 10 (*continued*)

Complex	2016 No	2017 No	2018 No
Sporting Complex (i.e. Basketball Are..	289	279	281
Theatre	73	38	43
Warehouse, storage	728	772	720
Waterfront or on water	61	67	51
Not assigned or complex not classified	21,831	21,297	20,324
Total	**45,700**	**46,312**	**44,698**

Appendix E

Table 11
Economic cost by complex type in 2018.

Complex	Costs to FRNSW	Cost to other service providers	Business or Government Costs	Lost Business	Opportunity cost to residents	Opportunity cost to volunteers	Cost of personnel - accidents/ injuries	Total economic cost
Aboriginal settlement/ mission	14,735	2947	980	3016	8989	90	5523	36,281
Airport	766,220	766,220	59,238,504	39,207	584,311	–	71,804	61,466,268
Backpackers	271,545	54,309	51,192	55,580	207,077	8283	101,788	749,774
Caravan park	2105	421	268	431	1284	13	789	5311
Carpark	73,675	14,735	13,889	15,080	44,947	2247	27,617	192,190
Child Care	130,510	26,102	88,300	26,713	7962	3185	48,921	331,693
Communication services	168,400	33,680	422,144	34,468	102,736	4109	63,124	828,662
Emergency services	176,820	35,364	443,251	36,191	107,873	4315	66,280	870,095
Entertainment	1,010,400	202,080	2,532,864	206,808	616,416	24,657	378,745	4,971,969
Farm	14,735	2947	18,959	3016	8989	360	5523	54,529
Forestry	2105	421	2708	431	1284	51	789	7790
Hazardous/ Dangerous Goods	130,510	13,051	163,581	13,356	39,810	1592	24,461	386,361
Hospitality	1,302,995	260,599	3,266,339	266,696	794,920	31,797	488,423	6,411,769
Hotel	3,092,245	618,449	7,751,619	632,919	9,432,449	75,460	1,159,116	22,762,256
Industrial plant	1,530,335	306,067	9,437,914	313,228	466,807	37,345	573,640	12,665,336
State/national parks	42,100	8420	28,484	8617	25,684	1027	15,781	130,113
Medical care	4,879,390	975,878	6,278,071	998,710	2,976,776	119,071	1,829,021	18,056,916
Military	1,037,765	207,553	1,968,352	212,409	316,555	25,324	389,002	4,156,961
Mining	14,735	2947	27,948	3016	4495	360	5523	59,024
Nursing Home	8,057,940	4,028,970	2,725,919	824,647	3,686,938	98,318	1,510,244	20,932,976
Office	7,464,330	746,433	23,017,086	763,897	2,276,887	91,075	1,398,988	35,758,696
Post-Secondary education	6,357,100	1,271,420	9,907,110	650,584	9,695,710	77,566	1,191,467	29,150,958
Power production	109,460	21,892	103,808	11,202	33,389	1336	20,515	301,602
Primary/ Secondary Education	2,913,320	291,332	4,540,212	298,148	13,329,996	35,547	546,023	21,954,578
Prison or detention centre	3,557,450	3,557,450	2,288,598	364,068	2,712,873	43,406	666,748	13,190,592
Public venue	639,920	127,984	802,074	65,489	390,397	7808	119,936	2,153,608
Rail	888,310	888,310	2,739,202	90,909	1,354,831	10,839	166,490	6,138,891
Refuse/rubbish disposal	35,785	7157	13,296	7324	5458	873	13,414	83,307
Registered Club	1,199,850	119,985	771,894	122,792	3,659,970	14,640	224,880	6,114,011
Religious	233,655	46,731	1,740,349	47,824	142,546	5702	87,585	2,304,392
Research	77,885	15,577	100,211	15,941	11,879	1901	29,195	252,589
Residential (high rise)	8,201,080	4,100,540	1,523,531	839,296	71,296,216	100,065	1,537,072	87,597,800
Residential (low rise)	1,557,279	346,062	326,202	354,159	2,744,592	42,224	648,600	6,019,119
Residential (medium rise)	11,446,990	3,434,097	1,428,182	1,171,481	49,757,292	139,670	2,145,430	69,523,144
Residential (1 or 2 family)	58,940	11,788	3920	12,064	17,979	1438	22,093	128,222
Retirement Village	2,391,280	1,195,640	808,946	244,723	1,823,564	29,177	448,181	6,941,511
Road	16,840	3368	3175	3447	2568	411	6312	36,121
Service station	14,735	2947	3677	3016	2247	360	5523	32,505
Shopping	12,398,450	3,719,535	11,758,207	1,268,853	18,909,844	151,279	2,323,756	50,529,924
Sporting Complex	1,183,010	118,301	219,770	121,069	360,860	14,434	221,723	2,239,168
Theatre	181,030	36,206	116,461	18,527	138,052	2209	33,929	526,413
	1,515,600	303,120	563,112	310,212	231,156	36,985	568,117	3,528,302

(*continued on next page*)

Table 11 (*continued*)

Complex	Costs to FRNSW	Cost to other service providers	Business or Government Costs	Lost Business	Opportunity cost to residents	Opportunity cost to volunteers	Cost of personnel - accidents/ injuries	Total economic cost
Warehouse, storage								
Waterfront or on water	107,355	21,471	26,788	21,973	16,374	2620	40,242	236,823
Not assigned or classified	43,369,314	17,112,808	107,245,683	8,756,595	26,100,080	1,044,004	16,036,675	219,665,159
Total	**128,638,233**	**45,061,314**	**264,512,780**	**19,258,132**	**224,451,062**	**2,293,173**	**35,269,008**	**719,483,709**

Appendix F. Assumptions for Method 3

Complex	FRNSW time spent (Hours)	Other Service Providers time spent (Hours)	Business Impact Lost Productivity (no. Persons)	Residents Impact (no. Persons)
Aboriginal settlement/mission	0.5	0.1	0	20
Airport	2	2	5068	100
Backpackers	0.5	0.1	2	25
Caravan park	0.5	0.1	1	20
Carpark	0.5	0.1	2	20
Child Care	0.5	0.1	10	2
Communication services	0.5	0.1	40	20
Emergency services	0.5	0.1	40	20
Entertainment	0.5	0.1	40	20
Farm	0.5	0.1	20	20
Forestry	0.5	0.1	20	20
Hazardous/Dangerous Goods	1	0.1	40	20
Hospitality	0.5	0.1	40	20
Hotel	0.5	0.1	40	100
Industrial plant, manufacturing	0.5	0.1	100	10
Local state and national parks, forest etc.	0.5	0.1	10	20
Medical care	0.5	0.1	20	20
Military	0.5	0.1	30	10
Mining	0.5	0.1	30	10
Nursing Home	1	0.5	10	30
Office	1	0.1	100	20
Post-Secondary education	1	0.2	50	100
Power production	1	0.2	30	20
Primary or Secondary Education	1	0.1	50	300
Prison or detention centre	1	1	20	50
Public venue (town halls, libraries etc.)	1	0.2	40	40
Rail	1	1	100	100
Refuse/rubbish disposal	0.5	0.1	5	5
Registered Club (e.g. RSL, Sporting Complex)	1	0.1	20	200
Religious	0.5	0.1	121	20
Research	0.5	0.1	20	5
Residential (high rise - greater than 9 storeys)	1	0.5	5	570
Residential (low rise - up to 3 storeys)	0.45	0.1	2	52
Residential (medium rise - 4 to 8 storeys)	1	0.3	3	285
Residential (one-family and two-family)	0.5	0.1	0	10
Retirement Village	1	0.5	10	50
Road	0.5	0.1	2	5
Service station	0.5	0.1	3	5
Shopping	1	0.3	30	100
Sporting Complex (i.e. Basketball Area)	1	0.1	5	20
Theatre	1	0.2	20	50
Warehouse, storage	0.5	0.1	5	5
Waterfront or on water	0.5	0.1	3	5
Not assigned or complex not classified	0.5	0.2	40	20

Appendix G

Table 12
Average Economic Cost by Type of Complex (AUD$).

	Average Total Economic Cost by Type of Complex	Average number of incidents	Average Economic Cost by Type of complex
Aboriginal settlement/mission	42,385	8	5086
Airport	55,641,600	85	657,184
Backpackers	812,451	143	5695
Caravan park	1770	0	5311
Carpark	204,252	38	5375
Child Care	317,081	60	5255
Communication services	1,037,089	103	10,069
Emergency services	843,077	83	10,117
Entertainment	4,437,067	439	10,115
Farm	73,525	10	7606
Forestry	7617	1	7617
Hazardous/Dangerous Goods	420,494	35	12,130
Hospitality	7,293,826	723	10,084
Hotel	21,884,243	1450	15,093
Industrial plant	13,713,626	811	16,916
State/national parks	89,753	14	6411
Medical care	18,428,589	2420	7615
Military	4,337,164	527	8235
Mining	41,527	5	8305
Nursing Home	21,938,318	2048	10,714
Office	36,788,813	1874	19,631
Post-Secondary education	29,080,791	1545	18,823
Power production	343,415	30	11,321
Primary/Secondary Education	20,828,891	675	30,858
Prison or detention centre	9,902,566	646	15,329
Public venue	2,501,975	181	13,798
Rail	5,171,349	182	28,414
Refuse/rubbish disposal	135,808	28	4793
Registered Club	6,294,304	302	20,865
Religious	2,475,959	123	20,184
Research	264,660	40	6672
Residential (high rise)	79,999,328	1827	43,787
Residential (low rise)	6,029,921	842	7161
Residential (medium rise)	59,539,723	2385	24,964
Residential (1 or 2 family)	152,785	34	4494
Retirement Village	7,221,711	604	11,950
Road	47,475	11	4451
Service station	19,920	4	4597
Shopping	49,388,981	2950	16,742
Sporting Complex	2,211,978	283	7816
Theatre	611,433	51	11,911
Warehouse, storage	3,563,431	740	4815
Waterfront or on water	272,229	60	4562
Not assigned	218,632,187	20,791	10,516
Not classified	4,506,523	359	12,541
Total	**697,551,612**	**45,570**	**15,307**

Appendix H

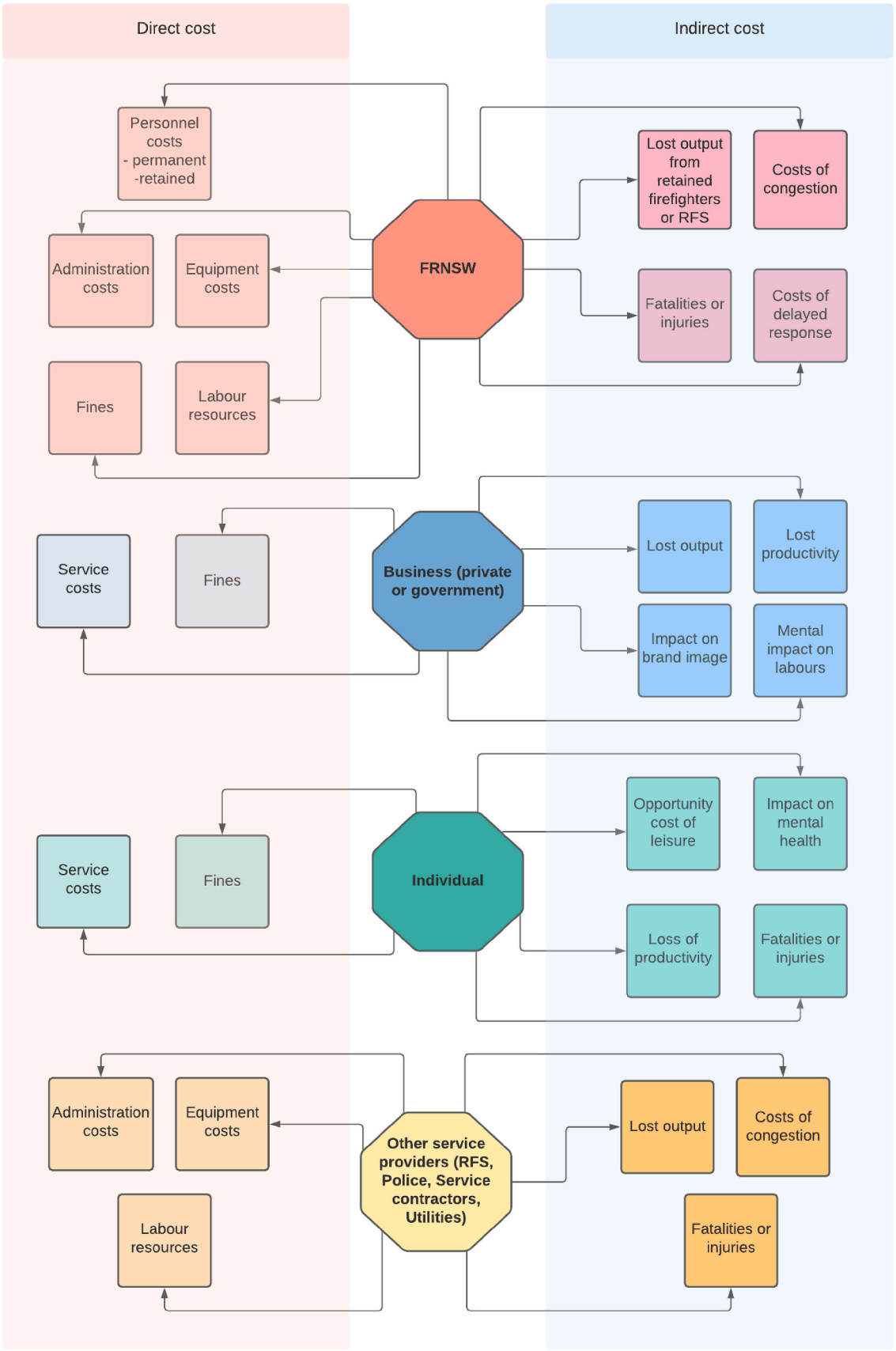

Fig. 2. Economic costs by agent and type (direct or indirect).

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