Australian Government
Australian Research Council

EI 2018 ENGAGEMENT AND IMPACT

Engagement and Impact 2018

Victoria University

VIC17 (HLS) - Impact

Overview

Title

(Title of the impact study)

Optimising smoke alarm signals: providing the evidence-base for potentially life-saving changes in fire and building regulations

Unit of Assessment

17 - Psychology and Cognitive Sciences

Additional FoR codes

(Identify up to two additional two-digit FoRs that relate to the overall content of the impact study.)

Socio-Economic Objective (SEO) Codes

(Choose from the list of two-digit SEO codes that are relevant to the impact study.)

92 - Health
86 - Manufacturing
97 - Expanding Knowledge

Australian and New Zealand Standard Industrial Classification (ANZSIC) Codes

(Choose from the list of two-digit ANZSIC codes that are relevant to the impact study.)

77 - Public Order, Safety and Regulatory Services
69 - Professional, Scientific and Technical Services (Except Computer System Design and Related Services)
24 - Machinery and Equipment Manufacturing
32 - Construction Services
67 - Property Operators and Real Estate Services

75 - Public Administration

Keywords

(List up to 10 keywords related to the impact described in Part A.)

smoke alarms

alarm signals

residential fires

fire fatalities

sleep

auditory arousal

human behaviour in fire

sleeping through alarms

fire signalling standards

fire and building codes

Sensitivities

Commercially sensitive

No

Culturally sensitive

No

Sensitivities description

(Please describe any sensitivities in relation to the impact study that need to be considered, including any particular instructions for ARC staff or assessors, or for the impact study to be made publicly available after EI 2018.)

Aboriginal and Torres Strait Islander research flag

(Is this impact study associated with Aboriginal and Torres Strait Islander content?
NOTE - institutions may identify impact studies where the impact, associated research and/or approach to impact relates to Aboriginal and Torres Strait Islander peoples, nations, communities, language, place, culture and knowledges and/or is undertaken with Aboriginal and Torres Strait Islander peoples, nations, and/or communities.)

No

Science and Research Priorities

(Does this impact study fall within one or more of the Science and Research Priorities?)

No

Impact

Summary of the impact

(Briefly describe the specific impact in simple, clear English. This will enable the general community to understand the impact of the research.)

A decade of research by Victoria University's Human Behaviour in Fire team created the evidence base for potentially life-saving revisions to fire codes and standards in Australia and the USA. The team's research findings led to the US National Fire and Signaling Code being revised to require the use of a low frequency 520Hz alarm signal in some new residential buildings such as hotels and motels, and in the homes of people with hearing loss. In Australia, the National Construction Code was revised to require the interconnection of smoke alarms in new homes. Queensland introduced new laws requiring alarms in every bedroom of new homes. Information campaigns and media reports also raised public awareness about the risks of some people, particularly children, not waking to a smoke alarm.

Beneficiaries

(List up to 10 beneficiaries related to the impact study)

Householders who install alarms in their homes with the low frequency 520Hz square wave signal, and/or multiple, interconnected smoke alarms

Millions of Americans and Australians in groups identified as being most at risk of dying in accidental residential fires

Hearing Loss Association of America and 48 million Americans with hearing loss; Canadian Hearing Society and millions of Canadians with hearing loss

People staying or residing in residential buildings in the USA with compliant low-frequency fire alarm systems

Parents and their young children who now have interconnected smoke alarms installed in the most effective locations in their homes

US Fire Administration, National Fire Protection Association, Fire Protection Research Foundation, and the NFPA 72: National Fire and Signaling Code

The Australian Building Codes Board and the National Construction Code

The Australian Government and state, territory and local governments

Manufacturers of compliant low-frequency alarm appliances sold in the US and beyond; eg Lifetone Technology,

System Sensor, SafeAwake, Edwards

The Victorian Country Fire Authority, Melbourne Metropolitan Fire Brigade and other fire authorities

Countries in which the impact occurred

(Search the list of countries and add as many as relate to the location of the impact)

Australia
United States of America
Puerto Rico
Guam
Northern Mariana Islands
Canada

Details of the impact

(Provide a narrative that clearly outlines the research impact. The narrative should explain the relationship between the associated research and the impact. It should also identify the contribution the research has made beyond academia, including:
- who or what has benefitted from the results of the research (this should identify relevant research end-users, or beneficiaries from industry, the community, government, wider public etc.)
- the nature or type of impact and how the research made a social, economic, cultural, and/or environmental impact
- the extent of the impact (with specific references to appropriate evidence, such as cost-benefit-analysis, quantity of those affected, reported benefits etc.)
- the dates and time period in which the impact occurred.

NOTE - the narrative must describe only impact that has occurred within the reference period, and must not make aspirational claims.)

Fire fatality records show that about half the people who die in residential fires are asleep when the fire starts. The most effective smoke alarms are therefore the ones most capable of waking people. Groups with a high risk of sleeping through an alarm include young children, deep sleeping young adults, the elderly, adults with hearing loss and adults impaired by alcohol or drugs.

Experiments by VU's Human Behaviour in Fire (HBiF) research team from 2002–12 [1] discovered which auditory, visual and tactile alarm signals were most effective at waking people in these groups. Their early experiments on children and young adults indicated that the high-frequency 3100Hz alarm commonly used in homes did not wake most of those tested. In 2006, the US Fire Protection Research Foundation (FPRF) commissioned the team to study the effectiveness of various alarm signals on three more high-risk groups. These studies [2, 3] proved that a low-frequency 520Hz square wave signal was vastly superior at waking adults with hearing loss, older adults and adults impaired by alcohol. The researchers also found that high-intensity strobe lights were not effective as a sole means of waking the deaf or hard-of-hearing. Strobes had been the primary fire alarm standard for the hearing impaired in the USA since the 1990s.

This empirical research provided the evidence base for changes to US signaling standards. In a 2007 media release, the Hearing Loss Association of America (HLAA) stated that: 'The findings of this study indicate that millions of people with hearing loss will not be wakened from deep sleep by audible alerts which only use one tone in the high frequencies ... [It] shows there is a critical need for emergency warning systems to be redesigned or supplemented as soon as technically feasible.'

The findings triggered a series of technical committee meetings within the NFPA, which culminated in revised standards in the 2010 and 2013 editions of the NFPA 72: National Fire Alarm and Signaling Code (in chapters 18, 24 and 29) [4]. The new minimum standards require 520Hz signals to be incorporated into alarm systems in new (and some renovated) buildings with commercial sleeping areas and a protected premises (building) fire alarm system, for e.g: college dorms, boarding houses, hotels, motels, retirement and assisted living facilities, and some

apartment buildings. In addition, Chapter 29 requires 520Hz signals in sleeping areas of households identified as having an occupant with mild-to-severe hearing loss.

The revised signalling standards came into full effect from January 2014 to give industry time to design and produce appliances to meet the new requirements. The 2012 editions of the US-based International Fire Code and International Building Code also cite NFPA 72 2010 as a referenced standard. A map on manufacturer System Sensor's website indicates that by 2015 the new standards had been adopted by over 40 US states. NFPA executive, Kathleen Almand advised that it takes a few years to achieve nationwide adoption. She confirmed that almost all states; many smaller jurisdictions; and the US territories of Puerto Rico, Guam and North Mariana Islands have complied.

The new standards had major impacts on the US fire alarm industry. Fire Alarms Online reported in 2015: 'This is going to be a huge adjustment for our industry, which will ultimately come with a large learning curve.' Alarm manufacturers had to re-tool factories and design new or improved low-frequency alarms, horns, speakers and sounder bases. For e.g, in 2015 Edwards launched 65 new low-frequency compliant models [5]. Some manufacturers issued guides explaining the changes and the underpinning research [5, 6]. Lifetone promotes its HL series as: 'The scientifically proven most effective device for awakening you in a fire emergency. It is best for senior citizens, people with hearing loss, people under the influence of alcohol or pre-teen children'. Lifetone founder David Albert MD states that the HBiF team's research was 'the genesis of the Lifetone HL series. We have sold many tens of thousands of those alarms since we introduced it in 2007. Just as important...was the scientific validation it provided to our efforts to change the NFPA 72 ... That effort was fought by virtually all the manufacturers (until they realized it could improve their sales and profits) but they did not have any real data to contradict your research so in the end we succeeded in changing the code, which I can tell you has resulted in the saving of lives.'

Research the HBiF team later undertook for the Australian Building Codes Board (ABCB) [7] led to the National Construction Code (NCC) being amended from May 2014 to require the interconnection of multiple smoke alarms within all new Class 1 dwellings, within sole-occupancy units of Class 2 or 3 buildings and in a Class 4 part of a building [8]. The researchers recommended interconnecting alarms so that when one alarm is triggered it activates all other alarms in the occupancy. A 2010 ABCB Regulation Impact Statement estimated this would affect installations in about 62,000 new homes in Australia each year. ABCB Director, Brian Ashe, advises that the research "was very significant in that it informed the Board's decision-making process and assisted in achieving an optimal community safety outcome for society".

The Queensland Government embraced more of the VU team's recommendations in its Fire and Emergency Services (Domestic Smoke Alarms) Amendment Act 2016 [9]. In a media release the Government claimed the new laws '...will make Queensland households the safest in Australia in relation to fire safety'. In addition to requiring alarms in new homes to be interconnected, the Act requires an alarm to be installed in all bedrooms, in hallways that connect bedrooms with the rest of the dwelling and on every level. By 2027, this will also apply to all existing dwellings in the state.

Associated research

(Briefly describe the research that led to the impact presented for the UoA. The research must meet the definition of research in Section 1.9 of the EI 2018 Submission Guidelines. The description should include details of:
- what was researched
- when the research occurred
- who conducted the research and what is the association with the institution)

Between 2002-12, VU's Human Behaviour in Fire team conducted experiments to compare how effective various smoke alarm signals were at waking sleeping people. Several studies revealed which signals and alarm locations were most effective for groups with the highest risk of sleeping through an alarm and dying in a fire. They included three studies funded by the US FPRF (2005-07) to examine smoke alarms' impact on older adults, adults with hearing loss and adults affected by alcohol. A study for the ABCB (2009-10) investigated optimum locations for smoke alarms in homes. A 2009-10 community-based study found that 78% of children failed to wake to their home smoke alarm.

Prof Dorothy Bruck from VU's School of Psychology led the research in collaboration with Prof Ian Thomas, Director of the (former) VU Centre for Environmental Safety & Risk Engineering. Several research associates and assistants were involved, including Dr Michelle Ball who researched arousal thresholds of children and deep sleeping young adults. The research identified:
- deficiencies in the high-frequency 3100Hz alarm signal used in most Australian and American homes and

residential fire alarm systems
- that a low-frequency 520Hz square wave signal was 4 to 12 times more effective at waking the groups tested
- that strobe lights could not be relied on as the sole means of waking people who are deaf or hard of hearing, and
- the benefits of having multiple, interconnected alarms, preferably in all bedrooms.

FoR of associated research

(Up to three two-digit FoRs that best describe the associated research)

17 - Psychology and Cognitive Sciences
09 - Engineering

References (up to 10 references, 350 characters per reference)

(This section should include a list of up to 10 of the most relevant research outputs associated with the impact)

1.Thomas I and Bruck D (2010), 'Awakening of Sleeping People: A Decade of Research'. Fire Technology Journal. 46. 743–761. 10.1007/s10694–008–0065–5.

2.Bruck D and Thomas I (2007), Waking effectiveness of alarms (auditory, visual and tactile) for adults who are hard of hearing; and (with Ball M) Waking effectiveness of alarms (auditory, visual and tactile) for the alcohol impaired. Reports from 2 of the 3 studies funded by the US Fire Protection Research Foundation

3.Bruck D and Thomas I (2008), 'Comparison of the effectiveness of different fire notification signals in sleeping older adults.' Fire Technology, 44(1), 15-38. (This paper won the 2009 US Harry C. Bigglestone Award for Excellence in Communication of Fire Protection Concepts)

4.National Fire Protection Association, USA, NFPA 72: National Fire Alarm and Signaling Code, 2010 edition (chapters 18, 24 and 29) and NFPA 720: Standard for the Installation of Carbon Monoxide (CO) Detection and Warning Equipment, 2012 and 2015 editions (chapters 6 and 9)

5.Edwards, United Technologies Corporation (2015), Low Frequency Emergency Signaling Handbook: A practical guide to compliance and its history (A manufacturer's guide). And Edwards Digital Technologies (2015), Edwards Launches 520Hz Signaling Product Line as New Solution for Fire and Life Safety Platforms (Media release on website)

6.System Sensor Applications Guide: Low Frequency Notification Appliances (July 2014) (https://systemsensor.com/en-us/Documents/LowFrequency_NotAppliances_AppGuide_AVAG424.pdf)

7.Thomas I and Bruck D (2010), Smoke alarms in dwellings: timely activation and effective notification. Report for the Australian Building Codes Board (based on an ARC Linkage grant-funded project)

8.Government of South Australia, Advisory Notice: Building 05/14. 'TECHNICAL: New requirements for the

interconnection of smoke alarms' (May 2014).
(https://www.saplanningportal.sa.gov.au/__data/assets/pdf_file/0005/285368/Building-advisory-notice-05-14-Technical-New-requirements-for-the-interconnection-of-smoke-alarms.pdf)

9.Queensland Government (2016), Information Sheet: New Smoke Alarm Legislation (Ver 10/2016). And 2017 media release: 'Changes to Queensland's smoke alarm legislation'.
(https://www.qfes.qld.gov.au/community-safety/smokealarms/documents/New-Smoke-Alarm-Legislation.pdf)
(https://www.qld.gov.au/about/newsroom/smoke-alarm-legislation)

10.Rochman, Bonnie. 'Children Sleep Right Through Fire Alarms, Study Shows', TIME Magazine (March 25, 2011) (http://healthland.time.com/2011/03/25/children-sleep-through-fire-alarms-study-shows/

Additional impact indicator information

Additional impact indicator information

(Provide information about any indicators not captured above that are relevant to the impact study, for example return on investment, jobs created, improvements in quality of life years (QALYs). Additional indicators should be quantitative in nature and include:
- name of indicator (100 characters)
- data for indicator (200 characters)
- brief description of indicator and how it is calculated (300 characters).)

Name

Increased awareness of the importance of using low-frequency alarms for people with hearing loss.

Indicator Data

The NFPA, HLAA, Canadian Hearing Society (CHS) and fire alarm manufacturers' websites around the world recommend using alarms or emergency alert devices fitted with low-frequency 520Hz signals.

Indicator Description

Alarms with low-frequency signals are more available and are being recommended for homes and other places where people with hearing loss live or stay. Over 48 million people in the US have hearing loss. According to CHS, high-frequency hearing loss affects 35.4% of Canadians aged 20–70.

Name

Low-frequency alarm sounders are now required in carbon monoxide(CO) warning systems in the USA.

Indicator Data

Amendments in the 2012 and 2015 editions of NFPA 720: Standard for the Installation of Carbon Monoxide(CO) Detection and Warning Equipment (in Chapters 6 and 9). Effective from 1 January 2015.

Indicator Description

NFPA 720 now incorporates 520Hz requirements that apply in the same residential buildings-sleeping areas as specified for fire alarms in NFPA 72 2010/2013 (i.e. in commercial residential buildings such as hotels, and in homes of people identified as hearing impaired).

Name

Improved, evidence-based home fire safety information being communicated by fire authorities.

Indicator Data

CFA website now warns: 'Studies have shown 85% of sleeping children do not wake to the sound of a smoke alarm' and recommends connecting an alarm outside a child's bedroom with one near an adult's.

Indicator Description

The research alerted fire authorities to the risks of some home occupants sleeping through a smoke alarm, especially children and the hard-of-hearing. As a result, some authorities have conducted public awareness campaigns and updated home safety and industry-focused information on their websites.

Name

VU researchers' contribution to fire protection knowledge base recognised with US industry awards.

Indicator Data

Bruck and Thomas were awarded the NFPA 2009 Harry C Bigglestone Award for Excellence in Communication of Fire Protection Concepts. Bruck was awarded Best Speaker at the 10th SUPDET Symposium in 2006.

Indicator Description

The Bigglestone Award is for the previous year's most outstanding paper published in Fire Technology journal. Bruck and Thomas won for their paper comparing the impact of different fire alarm signals on sleeping older adults. Bruck's SUPDET paper was on reducing fire deaths in older adults.