CHAPTER 2

The science

2.1 The science underpinning this legislation is pivotal to its justification. The committee received as evidence a large amount of the research that has been conducted into the link between firefighting and cancer. These studies were used to inform this report and are all publicly available.[1] Given the quantity and quality of evidence presented, the committee is confident that a link between firefighting and an increased incidence of certain cancers has been demonstrated beyond doubt.

International studies

2.2 The health consequences of firefighting have attracted substantial academic research due to the occupational risks firefighters are exposed to. Studies have progressively become more sophisticated. The committee was informed that policymakers are now able to access several large-scale studies which conclusively show that a link exists between firefighting and cancer:[2]

> It has been stated that firefighting is the most studied occupation in the world when it comes to cancer. There are literally dozens of major studies from around the world spanning over twenty years and they have made a definitive connection between firefighting and elevated cancer risk.[3]

2.3 One of these studies, commissioned by the Canadian province of Manitoba in 2002, looked at evidence gathered from 1994 to 2002. Led by Tee L. Guidotti, the study analysed research conducted worldwide looking at firefighters and five specific types of cancer: brain, bladder, kidney, non-Hodgkin's lymphoma and leukaemia. Processing enormous volumes of information, the researchers concluded that a firm link exists between firefighting and these primary-site cancers. In his report to the Workers Compensation Board of Manitoba, Guidotti stated:

> The evidence available since 1994 suggests it is reasonable given the available scientific evidence to adopt a policy of presumption for brain cancer, bladder cancer, kidney cancer, non-Hodgkin's lymphoma (lymphatic cancer) and leukaemia (hematopoietic cancer) for claims associated with occupation as a firefighter.[4]

---

1 See *Submission 1 Attachments.*

2 Mr Alex Forrest, *Proof Committee Hansard,* 9 August 2011, p. 2.

3 Mr Alex Forrest, *Submission 1,* p. 6.

4 Tee L. Guidotti and David F. Goldsmith, 'Report to the Workers Compensation Board of Manitoba on the Association Between Selected Cancers and the Occupation of Firefighter,' *Submission 1 Attachment 5*, p. 26.

2.4 The conclusions were used to inform Manitoba's presumptive legislation, the first of its kind in the world, and subsequent presumptive legislation in other jurisdictions.[5]

2.5 Other studies have confirmed a link between more than just the abovementioned cancers and firefighting. Bates *et al* conducted a retrospective cohort study of mortality and cancer in professional New Zealand firefighters in 2000, following a cluster of testicular cancers detected in Wellington firefighters in the 1980s. They looked at the incidence of testicular cancer in a cohort of firefighters and compared it to the incidence among the general population, using data obtained from the New Zealand Health Information Service (NZHIS). The committee was told that the results of the Bates study:

> ...put the scientific world on its heels. They found that the level of testicular cancer for New Zealand firefighters—I believe they looked at 4800 New Zealand firefighters within about three decades—was upwards of five times that of the general population.[6]

2.6 Mr Alex Forrest, President of United Fire Fighters of Winnipeg and Canadian Trustee of the International Association of Fire Fighters, told the committee:

> When this study came out I read it and said: ' Five times the level—it just cannot be true.' Almost immediately different epidemiologists around the world took on the challenge of discrediting this study out of New Zealand. A gentleman by the name of Jockel out of Germany looked at all firefighters in Germany. What he found surprised him. His study almost exactly replicated the results—the rate of testicular cancer in New Zealand was the same as the rate in Germany. That just shows you the global aspect of this.[7]

2.7 Another large meta-study confirmed these results in 2006. Researchers led by Grace LeMasters '...looked at 110 000 firefighters and replicated the rate of testicular cancer....You have three studies—one from New Zealand, one from Germany and one from the United States—all showing the same rate of cancer.'[8]

2.8 The LeMasters study was commissioned by the Department of Environmental Health at the University of Cincinnati college of Medicine and is the largest study of its kind finalised to date. It looked at 32 other studies which addressed the cancer risk to firefighters who are routinely exposed to harmful substances such as lead, cadmium, uranium, chemical substances, harmful minerals and 'various gases that

5 Since then and following further research Manitoba has expanded its list of recognised occupational cancers for firefighters from five to fourteen.

6 Mr Alex Forrest, *Proof Committee Hansard,* 9 August 2011, p. 2.

7 Mr Alex Forrest, *Proof Committee Hansard,* 9 August 2011, p. 3.

8 Mr Alex Forrest, *Proof Committee Hansard,* 9 August 2011, p. 3.

may have acute, toxic effects.'[9] The LeMasters study found '...an elevated metarelative risk' of certain cancers among firefighters.[10]

2.9 Studies conducted in the years since Manitoba first introduced presumptive legislation in 2002 have led that province to expand the number of cancers its legislation covers from five to 14.[11]

2.10 The committee heard that most overseas jurisdictions with similar legislation in place have moved substantially beyond the five cancers covered by Manitoba's initial legislation in 2002 and those listed by the proposed Bill. Today, with the benefit of a large volume of scientific research, every province in Canada is moving towards covering 14 cancers.[12]

2.11 This increase in the number of cancers covered has been driven by growing scientific evidence over the past decade, with lung cancer being a strong example of how legislation has progressed:

> ...[T]here was a major study done out of British Columbia by Tee Guidotti which looked at lung cancer. Once you take out the factor of smoking, firefighters had a risk of lung cancer three or four times as high as the general population. So, within a few months of that study, we saw the provinces of first Manitoba and then Alberta, British Columbia and Saskatchewan add lung cancer in nonsmokers. Again, that shows the specific nature and narrow scope of the legislation, but it also shows that science really drives this more than anything.[13]

Scientific consensus

2.12 A submission from the ACT Chief Minister and Cabinet Directorate argued that a lack of scientific consensus exists on this issue among researchers and clinicians, posing challenges to this Bill.[14]

2.13 This view does not, however, appear to be supported by evidence received by the committee, nor was it expressed by representatives of the ACT Government subsequently. Mr Andrew Kefford, Deputy Director-General of the ACT Chief Minister and Cabinet Directorate, confirmed that a link between firefighting and cancer is recognised, explaining that he was not in a position to ascertain the strength of the scientific link:

---

9 Grace LeMasters et al, 'Cancer Risk Among Firefighters: A Review and Meta-analysis of 32 studies,' *Submission 1 Attachment 7,* p. 1189.

10 Grace LeMasters et al, 'Cancer Risk Among Firefighters: A Review and Meta-analysis of 32 studies,' *Submission 1 Attachment 7,* p. 1189.

11 See http://news.gov.mb.ca/news/index.html?item=10328 (accessed 9 September 2011).

12 Mr Alex Forrest, *Proof Committee Hansard,* 2 September 2011, p. 6.

13 Mr Alex Forrest, *Proof Committee Hansard,* 2 September 2011, p. 7.

14 ACT Chief Minister and Cabinet Directorate, *Submission 24,* p. 2.

> I do not think anyone is contesting that there is a link in the exposure of firefighters to smoke for at least the increased risk of contracting cancer later.
>
> ...
>
> But whether that is absolute or somewhere in between is not something in which I am in a position to comment. That is not my area of expertise.[15]

2.14 In the absence of clear evidence before the committee refuting the causal link between cancer and firefighting as defined by this Bill, the committee is satisfied that the science underpinning this legislation is sound.

Committee view

2.15 The committee is confident in the quality of the studies it has seen and considers them to be compelling evidence in support of this Bill.

2.16 The committee emphasises that, as outlined in Chapter 1 of this report, claims under the proposed legislation would be rebuttable. This reflects the fact that science tells us that if a firefighter with a certain number of years of service develops cancer, that cancer is *most likely* to be caused by occupational exposure to carcinogens. Not *definitely* caused by occupational exposure, but most likely. In that light, any potential lack of absolute scientific consensus—which is incidentally absent in most fields of study—becomes immaterial:

> Adjudication under workers' compensation requires an examination of the weight of evidence, not scientific certainty.[16]

2.17 The committee also notes that the body of scientific evidence has expanded since presumptive legislation was first introduced to cover five cancers in Canada in 2002. Researchers have since demonstrated that firefighters are at risk of a greater range of occupational cancers.

2.18 The committee is concerned that, even if passed, the proposed legislation would only serve to bring Australian commonwealth law into line with outdated jurisprudence. Considering that similar legislation has been in place overseas for nearly a decade, and has in fact been strengthened to cover more cancers as a result of growing scientific evidence, the committee would prefer to see Australia enact legislation in step with the most advanced jurisprudence available. The committee sees no reason to ignore scientific evidence demonstrating a link between firefighting as an occupation and a greater number of cancers than the seven listed by this Bill.

Recommendation 1

---

15 Mr Andrew Kefford, Deputy Director-General, Chief Minister and Cabinet Directorate, *Proof Committee Hansard*, 23 August 2011, pp 7–8.

16 Tee L. Guidotti, 'Evaluating Causation for Occupational Cancer Among Firefighters: Report to the Workers' Compensation Board of Manitoba,' *Submission 1, Attachment 4*, p. 52.

2.19 The committee recommends that the types of cancer listed by the proposed Bill be expanded to include multiple myeloma, primary site lung cancer in non-smokers, primary site prostate, ureter, colorectal and oesophageal cancers.

The healthy worker effect

2.20 Studies looking at firefighters and occupational disease also highlight the impact of what is known as the 'healthy worker effect'. The phenomenon is found across scientific literature and describes the protective effect of above-average health status on morbidity and mortality levels among groups who are otherwise at elevated risk of illness.

2.21 In the case of firefighters, the impact of the healthy worker effect means that their health and fitness levels, which are markedly higher on average than those of the general population, may protect them from diseases—including cancer—to a certain extent. In turn this suggests that were firefighters' health and fitness levels the same as those of the rest of the community, given their occupational exposure to carcinogens, they would suffer from cancers at a far greater rate than is currently the case.

2.22 It also means that the relatively high rates of certain types of cancers among firefighters are still lower than the rates we would see among the general population were the latter regularly subjected to similar carcinogenic environments.

2.23 The healthy worker effect therefore may mask the true level of risk firefighters are exposed to:

> One would expect the morbidity and mortality rates to be lower among firefighters than in the general population containing people who are ill, infirm and generally not suited for fire service.
>
> ...
>
> Because of this, a study may show no difference in morbidity or mortality rates between firefighter and the general population when, in reality, the firefighters may be sustaining greater illness and death than would be expected in a similar healthy group. Additionally, only healthy firefighters stay on the job. Those who become ill may leave the fire service without documented disability before retirement. Others may leave seemingly healthy, only to suffer the long-term effects long after their association with the fire service has ended.[17]

2.24 The effect has been observed where specific cancers, such as, for example, colon cancer, are concerned. Evidence exists suggesting that physical fitness and activity should protect individuals from certain types of cancer. This does not appear to be the case for firefighters:

17 Michael Smith, Deputy Chief Officer, South Australian Metropolitan Fire Service, *Submission 13*, p. 5.

> Despite the reports of a consistent inverse relationship found in other studies between physical activity and risk of colon cancer...we observed an increased risk of colon cancer among Philadelphia firefighters, suggesting factors exist that negate the protection that might be expected from the increased physical activity.[18]

2.25 Mr Forrest referred in his evidence to studies which concluded that:

> ...if firefighters never fought a fire, the mortality and morbidity rates for their particular health group would probably be anywhere from 60 to 70 per cent of that for the general population.[19]

2.26 Mr Forrest concluded that studies looking at cancer risk among firefighters were in all likelihood conservative in their conclusions due to the healthy worker effect.[20]

Exposure and protection

2.27 As outlined, studies and meta-studies conducted around the world, including in Australia in the 1980s, demonstrate that certain types of cancer are caused by the release of carcinogens from combusting materials in structure fires. These known carcinogens can include benzene, styrene, chloroform and formaldehyde, and are absorbed by firefighters through the skin or by way of inhalation.[21]

2.28 Submissions to this inquiry discussed the protection available to firefighters through the world-class safety gear and clothing Australian firefighters utilise.[22] The committee heard that this protective gear, although consistent with all national and international safety regulations, cannot and does not form an impenetrable barrier between firefighters and the toxins they work amidst.

Toxins

2.29 Mr Brian Whittaker, Commander of the Hazardous Materials (HAZMAT) Scientific Unit of the Metropolitan Fire Brigade, Melbourne, provided the committee with extensive evidence based on his expertise in HAZMAT response and public safety. Mr Whittaker concluded the following concerning the risk to firefighters:

---

18 Dalsu Barris *et al*, 'Cohort Mortality Study of Philadelphia Firefighters', *American Journal of Industrial Medicine,* vol. 39, p. 723.

19 Mr Alex Forrest, *Proof Committee Hansard,* 9 August 2011, p. 4.

20 Mr Alex Forrest, *Proof Committee Hansard,* 9 August 2011, p. 4.

21 Thomas Fabian et al, 'Firefighter Exposure to Smoke Particulates,' (Final Report) 1 April 2010, including Table 3-4 Effluent gases detected in combustion of material-level test samples, Submission 19, Attachment 10 and Appendix A.

22 See for example Mr Brian Whittaker, *Submission 16;* Mr Philip Taylor, *Submission 17;* United Firefighters Union of Australia, *Submission 19.*

> Their workplace is an uncontrolled environment where safety controls cannot eliminate all hazardous products encountered. Risk exposure to various toxic gases, vapours and particulate matter found in fire smoke does exist. These products can be carcinogenic and cause irritation, incapacitation, systemic toxicity and asphyxiation. The effects from exposure to the above products can be both acute and chronic.
>
> Many studies have concluded that the combustion or pyrolysis (heating) of general household materials can generate many carcinogenic products. The prediction of combustion products is a complex area and there is potential for generation of a huge range of products depending on the nature of the fire and the conditions of burning.[23]

2.30 Most operational activities undertaken by urban firefighters are structural and non-structural fire incidents. Car fires, although technically considered non-structural, produce toxic chemicals rivalling those found in structure fires. This, the committee heard, is due to the prevalence of plastic components found in cars.[24]

2.31 Unsurprisingly, even ordinary houses and household products release toxic chemicals when they burn.

> It is estimated there are tens of thousands of toxins and chemicals in the average household fire. Fabrics, furniture and construction materials give off a range of toxic gasses when burning. These toxins include acetic acid, phenol, formaldehyde, benzene, styrene, ammonia, carbon monoxide and cyanide. In a fire, the combination of these chemicals increases the toxicity significantly.[25]

2.32 The committee heard that although all fires have individual characteristics, there are a number of common toxic chemicals which may be present in most fire effluent:

- Polycyclic Aromatic Hydrocarbons (PAHs): naphthalene, benzo[a]pyrene;
- Irritant gasses: formaldehyde, acrolein, oxides of nitrogen; and
- Asphyxiant gasses: carbon monoxide, hydrogen cyanide.

2.33 Many of these are either known or suspected carcinogens. PAHs, for instance, are substances found in particles of soot and linked to certain types of cancer.[26] As far

23 Mr Brian Whittaker, *Submission 16,* p. 1.

24 Mr Philip Taylor, *Submission 17,* p. 3.

25 United Firefighters Union of Australia, *Submission 19,* p. 19.

26 Dalsu Barris *et al*, 'Cohort Mortality Study of Philadelphia Firefighters,' *American Journal of Industrial Medicine,* vol. 39, p. 724.

back as the year 1775, an increased rate of cancer among chimneysweeps routinely exposed to soot had already been reported.[27]

Smoke

2.34 Smoke is an aerosol consisting of liquid or solid particles dispersed in a gaseous medium. This gaseous medium consists largely of toxic gases.[28]

2.35 The toxicity of these gases has been rising with modernisation of industry practices, meaning that the modern environment presents greater hazards to firefighters than their colleagues in past years. This is partly due to changes made by the construction industry, namely the shift away from natural materials such as wood to lighter construction materials that feature synthetics and petroleum-based materials:

> These materials ignite and burn 2–3 times hotter and faster than conventional materials and when heated, emit a gas or smoke that will also ignite 2–3 times faster and burn 2–3 times hotter.[29]

2.36 Synthetic materials used extensively in commercial and residential properties include plastics, polymers such as styrofoam and polyutherine foam and nylons. Combustion has a marked effect on these synthetics and the smoke they produce when burning. They are commonly carbon based and bonded with nitrogen, sulphur, hydrogen and chlorine atoms. The increased speed at which they ignite and burn helps in the speedy creation of a toxic environment.[30]

2.37 It is this growing prevalence of synthetic materials that is an enormous cause for concern:

> Chemicals are highly pervasive in the modern world. Since World War II, astronomic increases in the variety and production volumes of synthetic chemicals have occurred. Today more than 70 000 distinct chemicals are used commercially in the United States and are registered with the U.S. Environmental Protection Agency. Approximately 1000 new chemicals are registered each year. These chemicals are combined into more than 7 million mixtures, formulations and blends that are found in homes, public buildings and workplaces across the United States.
>
> Testing of chemicals for their carcinogenic and other toxic effects has not kept pace with chemical production. Despite decades of concern about the toxic effects of chemical substances, the toxic effects of most of the chemicals currently in commercial use have never been evaluated...The absence of toxicity data on the majority of chemicals in commercial use means that firefighters are exposed on a daily basis to chemicals with unknown effects. It is quite likely, therefore that in addition to their

---

27 'Smoke', Vol. 2, 2009, *Submission 16, Attachment 1*, p. 1.

28 'Smoke', Vol. 2, 2009, *Submission 16, Attachment 1*, p. 1.

29 'Smoke', Vol. 2, 2009, *Submission 16, Attachment 1*, p. 1.

30 'Smoke', Vol. 2, 2009, *Submission 16, Attachment 1*, p. 3.

> exposures to known carcinogens, firefighters experience exposures to carcinogenic chemicals whose cancer-causing potential has not yet been identified.[31]

Protective clothing and equipment

2.38 The committee heard that occupational environments involving fire inherently preclude the design of personal protective clothing (PPC) that would provide an impermeable physical barrier between firefighters and the toxic smoke to which they are exposed.

2.39 Nevertheless, firefighters work hard to mitigate and eliminate workplace hazards in an emergency situation. Hazards are mitigated through a process known as the Hierarchy of Controls, which includes a range of options:

- Elimination of hazard;
- Substitution of hazard;
- Isolation of hazard;
- Engineering controls;
- Administrative controls; and
- Personal protective clothing.

2.40 The key principle of the hierarchy is to try and eliminate hazards at their source:

> In regards to the 'Hierarchy of Controls' the core activity of firefighters is to eliminate, substitute and isolate hazards. This is routinely achieved by the use of engineering controls (equipment), administrative controls (skills and operational protocols) and PPC/E [personal protective clothing and equipment]. However with the inherent nature of fire fighting it is impossible to eliminate all hazards.[32]

2.41 As all hazards cannot be eliminated or isolated, engineering and administrative controls, as well as PPC, remain the principal hazard control mechanisms available. These are far less reliable methods of hazard mitigation, are '...more costly and require more work to ensure they are maintained.'[33]

---

31 Philip J. Landrigan *et al*, 'Occupational Cancer in New York City Firefighters,' *Submission 1 Attachment 6*, p. 3.

32 Mr Brian Whittaker, *Submission 16*, p. 2.

33 Mr Philip Taylor, *Submission 17*, p. 3.

2.42 Respiratory equipment available to firefighters can also help eliminate inhalation as a source of exposure or contamination. Protective clothing, however, is limited in its capacity to mitigate contamination, so hazards are managed rather than eliminated through its use.

2.43 Managing hazards is achieved through standards for protective equipment set by the National Fire Protection Association (NFPA):

- Level A: Fully encapsulating gas tight suit with breathing apparatus (BA);
- Level B: Chemical splash suit (protection from liquids and solids) with BA;
- Level C: Chemical splash suit (protection from liquids and solids) with respirator; and
- Level D: Structural firefighting ensemble with breathing apparatus.[34]

2.44 Levels of protection are chosen to be fit for purpose. Levels A, B and C offer protection for incidents which involve hazardous materials but not fire or risk of fire. Therefore, Level A protection is suitable, for example, when firefighters attend an incident involving a chemical spill. The kind of protection required could change if the chemical spill involved fire or if detection equipment indicated a flammable environment.

2.45 In incidents involving fire or risk of fire, Level D protection is designed to offer the best possible protection. However, although it protects firefighters in environments involving fire, it does not offer fully encapsulated protection as provided by Level A:

> Structural fire fighting ensemble has limited protection from gases, vapours and particulate matter due to the requirement and necessity to have a compromise between protection from radiated heat exposure and the release of metabolic heat build up. In short the breathability is in effect a hazard to firefighters that cannot be eliminated.[35]

Breathability

2.46 An average structure fire can expose firefighters to temperatures approaching 1000 degrees Celsius.[36] This means that the protective clothing firefighters wear in fire incidents must be able to breathe in order for them to be able to operate in these extreme temperatures. If the clothing did not breathe, firefighters would suffer heat stress and could quickly perish from metabolic heat buildup damaging their internal organs.

34 Mr Brian Whittaker, *Submission 16,* p. 2.

35 Mr Brian Whittaker, *Submission 16,* p. 3.

36 Mr Philip Taylor, *Submission 17,* p. 2.

2.47 This requirement for breathability in protective clothing prevents firefighters from wearing fully encapsulated suits designed to seal all routes of chemical entry. The protective clothing they wear when fighting fires protects them from flames, but leaves them exposed to toxins through inhalation or absorption through eyes, skin, or wounds.[37]

2.48 Therefore, the very nature of the environment firefighters operate in prevents the design of protective clothing and equipment which could offer complete protection and isolation from toxic smoke.

'Flash-over' and response time

2.49 To minimise loss of life, property damage and interruption to business, '...fire services mandate a quick response by applying standards for their firefighters to respond to emergencies.'[38]

2.50 This response time standard is considered crucial:

> Underpinning fire services response time standards is scientific research that dictates that a fire must be suppressed within five to 10 minutes of ignition. The physical characteristics of fire cause the temperature in a building to rise extremely rapidly, and a sudden and dramatic simultaneous ignition of most combustible materials and gases is called flash-over. The time required for flash-over to occur varies according to building construction and furnishing materials and usage. The fire spreads quickly once flash-over has occurred. In order to maximise the potential of saving life and minimize damage to property, firefighters must enter the building to commence suppression activities to avoid flash-over. In short, firefighters must enter the toxic environment...It is not an option for a firefighter to delay entering a structure to commence rescue operations and suppression activities.[39]

Committee view

2.51 The committee understands that firefighters work in uncontrolled environments which make it necessary for their protective gear to breathe, therefore leaving them vulnerable to toxins and carcinogens.

On the weight of considerable evidence supplied to the committee supporting a likely causal link between firefighting and certain cancers, as well as the understanding that claims for compensation would be legally contestable, the committee is confident that rebuttable presumption is a solid—and fair—foundation for workers' compensation policy for career firefighters.

---

37 Mr Brian Whittaker, *Submission 16*, p. 3.

38 United Firefighters Union of Australia, *Submission 19*, p. 6.

39 United Firefighters Union of Australia, *Submission 19*, p. 7.