RESEARCH AND EVALUATION

New Zealand Carcinogens Survey 2021

OVERVIEW

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Te Kāwanatanga o Aotearoa
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WORKSAFE
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EXECUTIVE SUMMARY

According to the International Agency for Research on Cancer (IARC), worldwide, 10 million people died from cancer, and another 19.3 million new cases occurred in 2020. About 20% of the global population develops cancer during their lifetime (IARC, 2020a). For many of these people, occupational exposure (carcinogen) of one type or another will be either the cause or a contributing factor to this cancer.

Carcinogens are agents that, according to research, are known or likely to cause cancer in humans. In New Zealand, carcinogens and airborne substances are probably associated with one-third of work-related harms. Cancer and respiratory diseases contribute to 70% of all work-related deaths (WorkSafe New Zealand, 2019).

In New Zealand, the current estimates of harms from carcinogens are primarily based on the international attributable fractions of work-related exposures applied to the health data. There is no baseline exposure database on occupational carcinogenic agents. Previous exposure surveys heavily relied on workers' self-reported information, which might not reflect an accurate picture of occupational exposure in New Zealand. The Occupational Integrated Database Exposure Assessment System (OccIDEAS), developed by researchers from Curtin University (Australia), is a web-based application used to assess occupational exposure in epidemiological studies. OccIDEAS provides assessments of the likelihood of exposure to specific hazardous agents for each job on an individual basis using worker-specific job task module algorithms and experts' opinions (occupational hygienists, physicians, and epidemiologists). It has been successfully applied for the Australia Work Exposure Survey and modelled in Malaysia.

Using OccIDEAS, the New Zealand Carcinogens Survey (NZCS) covers over 50 carcinogens in Group 1 (carcinogenic to humans) or Group 2A (probably carcinogenic to humans) based on IARC criteria. Surveying (including cognitive testing, pilot, field work, and exposure assessment) was conducted from January to December 2021, with 4,051 workers aged 18 years and over who were employees working for wages or salary. The data has been weighted based on the Statistics New Zealand population counts, so the overall sample is representative of the population of interest based on age, gender, risk group of occupation, and industry.

Findings from the survey will support WorkSafe's Hoe Nuku (priority) of carcinogens and airborne risks and the Government *Health and Safety at Work Strategy 2018–2028*. These results could be used to estimate the future burden of harm from carcinogens, develop the New Zealand profiles on occupational and environmental exposure for known and probable carcinogenic agents, and prioritise which agents to focus on. WorkSafe will be conducting further analysis to understand better carcinogen exposure and socio-demographics, occupation, industry, regions, and exposure circumstances.

Key findings of the survey

Over half (57.5%) of workers are probably exposed to at least one carcinogen at any level. Some 23.3% are probably exposed to five or more carcinogens at any level. Over half (53.1%) of workers are exposed to at least one carcinogenic agent at a low level. Nearly three in ten (28%) workers are probably exposed to at least one carcinogen at a high level.

The top ten most common carcinogenic exposures in New Zealand are benzene (30%), solar UV (26.8%), ocular UV (25.5%), diesel engine exhaust (23.7%), environmental tobacco smoke (14.6%), styrene (12.2%), crystalline silica (10.3%), shiftwork (8.6%), wood dust (8.4%), and other polycyclic aromatic hydrocarbons (PAHs) (8.1%).

When looking at the overall level of exposure to carcinogens, the most frequent exposures at a high level among New Zealand workers are benzene (7.3%), solar UV (6.8%), shiftwork (6.8%), wood dust (4.5%), ocular UV (4.1%), diesel engine exhaust (3.7%), environmental tobacco smoke (2.9%), glyphosate (2.6%), crystalline silica (2.4%), artificial UV (2.2%), other PAHs (1.4%), and chromium VI (1.2%).

Workers could be exposed to carcinogens in various ways involving different tasks.

Common exposure circumstances are maintenance of brakes or clutches on vehicles built before 2003 (asbestos), refuelling vehicles with petrol (benzene), working outdoors (solar UV and ocular UV), working between midnight and 5am (shiftwork), wood sanding (wood dust), working near someone smoking (environmental tobacco smoke), welding and soldering (artificial UV, welding fumes, chromium VI, nickel, other PAHs), working with concrete and mixing cement (crystalline silica), mixing or applying glyphosate (glyphosate or pesticides), cutting or sanding plywood or particle board through carpentry and painting (formaldehyde), stripping old or lead-based paint (lead), and working indoors near a diesel vehicle with engine running (diesel engine exhaust and styrene).

The self-reported use of controls varies significantly by task and could contribute to developing a harm prevention plan to reduce workers' exposure to carcinogens.

Industry and occupation are important contributors to occupational exposure.

Exposures of at least one carcinogen at any level are highest in Mining (97.5%), Electricity, Gas Water and Waste Services (92.7%), Agriculture, Forestry and Fishing (88.9%), Construction (76.8%), and Transport, Postal and Warehousing (75.3%). The most frequent exposures across all industries are benzene, diesel engine exhaust, solar UV, and ocular UV.

When looking at the overall level of exposure to carcinogens, there are some notable differences by industry. At medium and high levels of exposure, shiftwork is the most common carcinogen in Healthcare and Social Assistance, and Public Administration and Safety (17.5% and 12.3%, respectively). Diesel engine exhaust is the most common carcinogenic agent in Electricity, Gas Water and Waste Services, Manufacturing, Professional, Scientific and Technical Services, and Mining. Meanwhile, solar UV is the most common carcinogen in the remaining industries. Exposure to at least one carcinogen at a medium and high level is highest in Mining (92.5%), followed by Agriculture, Forestry and Fishing workers (82.7%), Electricity, Gas Water and Waste Services (80.6%), Construction (63.4%), and Transport, Postal and Warehousing (56.6%).

Exposure to carcinogens varies significantly across occupational groups. Construction workers, farmers, and emergency workers experience the highest average number of exposures, with each group exposed to more than seven carcinogenic agents. Office workers, teachers, and hospitality workers are among the groups experiencing the lowest average number of exposures (1.3, 1.4, and 0.9, respectively).

Exposures to carcinogenic agents are distributed unevenly across ethnic groups. These findings are essential for identifying work-related health inequities in New Zealand.

Māori workers are the most likely group to be exposed to at least one carcinogen (65.6%) at any level. When looking at the overall exposure level, Māori and New Zealand European workers are more likely than Asian workers and workers of other ethnicities to be exposed to at least one carcinogen at medium and high levels. On the other hand, Asian workers are less likely than Māori, Pacific, and New Zealand European workers to be exposed to five or more carcinogenic agents at any level.

There are notable differences in carcinogen exposure among ethnicities. Māori and Pacific workers are more likely to be exposed to environmental tobacco smoke and shiftwork. New Zealand European and Māori workers are more likely to be exposed to styrene and wood dust. Asian workers and workers of other ethnicities are less likely than New Zealand European and Māori workers to be exposed to crystalline silica.

In addition to ethnicity, gender and age are significant factors in occupational carcinogen exposure in New Zealand. These two factors should not be overlooked in developing healthy work plans.

Compared to females, male workers experience a higher prevalence of exposure across all carcinogenic agents at any level or medium and high levels. Among men, exposures to at least one carcinogen are highest in handypersons, painters, heavy vehicle drivers, miners, and electrical workers. In contrast, among women, construction workers, plumbers, vehicle workers, and emergency workers are most likely exposed to carcinogens.

Workers aged 18–34 and 35–44 are more likely to be exposed to environmental tobacco smoke than those aged 45–54 and 55 and over. Young workers under 35 years of age are less likely to be exposed to other PAHs. They are also less likely than those aged 45–54 and 55 and over to be exposed to wood dust.

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1.0
Background

Carcinogens are agents that, according to research, are known or likely to cause cancer in humans. The International Agency for Research on Cancer (IARC) reviews and evaluates the evidence of carcinogenic risks to humans through the IARC Monographs Programme. More than 500 agents have been classified as possibly carcinogenic to humans.

Researchers affiliated with the IARC have sought to identify agents with occupational relevance from their database to develop a list of occupational carcinogens (Loomis *et al*., 2018; Siemiatycki *et al*., 2004). A recent study used data from the IARC Monographs (1971–2017) and applied specific criteria to identify substances, mixtures, or types of radiation with sufficient evidence of human carcinogenicity from studies of exposed workers and with proof of occupational exposure. The authors developed a range of criteria and identified a list of 47 confirmed occupational carcinogens (Loomis *et al*., 2018).

Several countries have established national registers of exposure to selected carcinogens. For known carcinogens, businesses are required to record the number of workers exposed and at what level. Data from these systems can provide evidence for exposure for each required agent. Generally, these systems partly collect information on workers exposed to certain carcinogens and are entitled to medical examinations as a result (Lissner *et al*., 2014). For example, the Finnish Register of Workers Exposed to Carcinogens records the use of carcinogens and workers exposed, and employers in Finland are obliged to update this data annually (Kauppinen *et al*., 2007). In Germany, the Institute for Occupational Health and Safety and the Germany Social Accident Insurance operate the central exposure database (ZED), which maintains a registry of exposure for each worker (IFA, 2016).

CAREX (or CARcinogen EXposure) is an exposure information system initially developed by the Finnish Institute of Occupational Health and further developed to estimate the number of workers exposed to occupational carcinogens in Europe. CAREX was first used to assess occupational exposure to carcinogens in 19 countries of the EU (Kauppinen *et al*., 2000). CAREX Canada was modelled after the EU CAREX project and estimated the prevalence of occupational exposure to 44 carcinogenic agents (Peter *et al*., 2015). In Great Britain, CAREX data was used to estimate the current burden of occupational cancer (Hutchings *et al*., 2012). CAREX contains the most known and suspected carcinogens evaluated by IARC criteria but has some limitations. It uses an international exposure database where local data is not available; therefore, it might underestimate or overestimate the current exposure if the sector distribution is too different by country (Kauppinen *et al*., 2000).

Assessing workers' exposure to occupational agents that cause diseases or health problems is a significant challenge in New Zealand. A version of CAREX was set up for New Zealand (NZ-CAREX) to estimate the carcinogen exposure in each industry and the number of workers exposed ('t Mannetje, 2011). However, it is still being determined whether the database has been updated since its creation. Previous exposure surveys in New Zealand have captured self-reported exposure from respondents. However, self-reported data sometimes is not sufficient to explore the number of workers being exposed to specific hazards in the workplace, the level of exposure, in what industries the exposures occur, and what control measures are being used. Also, workers are often unaware of their exposure to specific harmful substances; therefore, their information might be inaccurately or inadequately reported.

Developed by Curtin University (Australia), the Occupational Integrated Database Exposure Assessment System (OccIDEAS) is a web-based application used to assess occupational exposure in epidemiological studies (Fritschi *et al*., 2009). Using worker-specific job task module algorithms, OccIDEAS provides assessments of the likelihood of exposure to specific agents for each job on an individual basis. Unlike other survey instruments, OccIDEAS combines self-reported information from workers and exposure assessment from occupational epidemiologists and hygienists, providing more reliable information on workers' exposure by agents, sectors, and occupational groups. It allows researchers and policymakers to map occupational exposures and identify which industries or population groups are at higher levels of exposure than others. OccIDEAS covers a broader number of agents than any other database that often includes general solids, gases, and liquids (EU-OSHA, 2018).

OccIDEAS has been successfully applied for the Australia Work Exposures Survey (AWES) in 2011/2012 among 5,000 workers. The AWES included 38 relevant carcinogens in Australia (Carey *et al*., 2014a). OccIDEAS was prototyped in the Australian Mesothelioma Registry to assess asbestos exposure history (MacFarlane *et al*., 2012). It was extended to include additional safety and health risk factors and successfully applied in Malaysia and China (Fritschi *et al*., 2020). OccIDEAS surveying was supposed to be implemented in EU countries in 2020 but has been suspended due to the COVID-19 pandemic.

WorkSafe, in collaboration with the OccIDEAS team and Research New Zealand, conducted the NZCS to estimate the current exposure to carcinogens among New Zealand workers. Using OccIDEAS surveying tools allows WorkSafe to obtain robust data on the current occupational exposures to carcinogens and benchmark and monitor the levels of harmful exposures occurring in New Zealand workplaces. Findings from the NZCS will support the Government *Health and Safety at Work Strategy 2018–2028* and WorkSafe's Carcinogens and Airborne risks Programme.

2.0
The international classification of carcinogens

The International Agency for Research on Cancer (IARC) reviews and evaluates the evidence of carcinogenic risks to humans through the IARC Monographs Programme.

The IARC Monographs seek to identify the environmental factors that can increase the risk of cancer in humans, including chemicals, complex mixtures, occupational exposures, physical agents, biological agents, and lifestyle factors. Interdisciplinary working groups of expert scientists review the published studies and evaluate the weight of the evidence that an agent can increase the risk of cancer. The agent is then designated in one of the following groups.

GROUP	DESCRIPTION OF GROUP	NUMBER OF AGENTS
Group 1	**The agent is carcinogenic to humans** This category is used when there is sufficient evidence of carcinogenicity in humans.	121
Group 2A	**The agent is probably carcinogenic to humans** This category is used when there is limited evidence of carcinogenicity in humans and sufficient evidence of carcinogenicity in experimental animals.	93
Group 2B	**The agent is possibly carcinogenic to humans** This category is used for agents for which there is limited evidence of carcinogenicity in humans and less than sufficient evidence of carcinogenicity in experimental animals. It may also be used when there is inadequate evidence of carcinogenicity in humans but there is sufficient evidence of carcinogenicity in experimental animals.	320
Group 3	**The agent is not classifiable as to its carcinogenicity to humans** This category is used for agents for which the evidence of carcinogenicity is inadequate in humans and inadequate or limited in experimental animals. Agents not falling into any other group are also placed in this category. An evaluation in Group 3 is not a determination of non-carcinogenicity or overall safety. Further research is often needed, especially when exposures are widespread, or the cancer data are consistent with differing interpretations.	501

TABLE 1:
IARC Monographs, Volumes 1–131[1]

This table has been last updated on 22 August 2022 (IARC, 2022).

[1] Agents Classified by the IARC Monographs, Volumes 1–131 – IARC Monographs on the Identification of Carcinogenic Hazards to Humans (who.int)

3.0 The occupational integrated database exposure assessment system

IN THIS SECTION:

3.1 What is OccIDEAS?[2]

Developed by Curtin University (Australia), the Occupational Integrated Database Exposure Assessment System (OccIDEAS) is a web-based application used to assess occupational exposure in epidemiological studies (Fritschi *et al*., 2009; Fritschi *et al*., 2020). Using worker-specific job task module algorithms, OccIDEAS provides assessments of the likelihood of exposure and the level of exposure to specific agents for each job on an individual basis. Since the OccIDEAS survey methodology combines workers' self-reported information and exposure assessment from occupational epidemiologists and hygienists, it can provide more reliable information on workers' exposure by agents, sectors, and occupational groups.

OccIDEAS has been successfully applied for the Australia Worker Exposure Survey (AWES) in 2011/2012, covering 5,000 workers. It was also used in Malaysia and extended to include additional safety and health risk factors (Fritschi *et al*., 2020). OccIDEAS surveying was supposed to be implemented in EU countries in 2020 but has been suspended due to the COVID-19 pandemic.

On the website of OccIDEAS, an agent is 'a chemical, physical or other exposure that may occur at work'. An agent can be in either a chemical form such as asbestos or lead, a physical form such as radiation or vibration, or a combination such as pesticides or second-hand tobacco smoke. Three groups of agents are currently assessable in OccIDEAS; including carcinogens; noise, vibration, and ototoxic agents; and asthmagens. In OccIDEAS, more than 50 job-specific modules cover the most common jobs in developed economies. The job-specific modules are created around the kind of exposures that people might have. Each job-specific module has a set of task-specific questions. The OccIDEAS team has developed 44 task-specific and 92 noise-related task modules.

At this stage, the Carcinogen and Airborne Risk Programme is one of the six WorkSafe's Hoe Nuku[3] (priority areas). Where not explicitly stated otherwise, the report will only refer to the OccIDEAS survey instruments to identify occupational exposure to carcinogens.

3.2 OccIDEAS structure

OccIDEAS platform works with three types of question lists, including agents, job modules, and task modules. Therefore, exposure data can be analysed by agents, occupations, and the tasks that workers perform at work.

Agents are the foundation of the OccIDEAS system. There is a wide range of carcinogens available in OccIDEAS. All agents classified by the IARC as either: carcinogenic to humans (Group 1) or probably carcinogenic to humans (Group 2A) are selected for OccIDEAS. The list of carcinogens is updated regularly by the OccIDEAS team. The AWES 2011/2012 included 38 prioritised carcinogens relevant to Australian working conditions (Fernandez *et al*., 2012). The current prevalence of exposure to occupational carcinogens in Australia was estimated based on the list of 38 carcinogens (Carey *et al*., 2014). The current list of carcinogens in OccIDEAS consists of 49 carcinogens. In some circumstances, an agent not in OccIDEAS and relevant questions can be added to explore the possibility and level of exposure. For example, erionite, methyl bromide and carbamate have been added to the list of agents surveyed in New Zealand (see Section 4 for the list of carcinogens in OccIDEAS and the NZCS).

[2] For more information on OccIDEAS please check out the website www.occideas.org

[3] WorkSafe's Hoe Nuku include Ngā Paiaka (strong regulatory foundations), digital transformation, carcinogen and airborne risk, plant and structures, worker engagement, participation, and representation, working closer to the source of influence and control.

Job modules cover various questions related to a particular job or industry. Respondents are only asked questions that are relevant to their job. In OccIDEAS, people are not directly asked if they are exposed to a specific agent. Instead, workers are asked how they perform their work, if they use personal protective equipment or whether there are any health and safety measures available while they work. Since a person can do multiple tasks in their job, there might be various task modules included in a job module. For example, a farmer usually does multiple tasks on a day-to-day basis. Therefore, a job module on Crop and livestock farmer covers a range of task modules such as Driving/Maintenance (Drive or maintain vehicles as part of their work), Welding (Welding and brazing), Soldering (soldering), Fuel-powered equipment (Use fuel powered equipment like lawn mowers or chainsaws), Solar UV (working outdoor) etc.

Task modules are questions about a particular task and are included in relevant job modules. Task modules are used in multiple job modules. For example, a task module on Asbestos Removal (Removal of asbestos and asbestos-containing products from any location), contains a range of questions relevant to all jobs that are likely to be associated with asbestos exposure. Hence, the task module on Asbestos Removal is included in job modules for Firefighter (fire fighters), Construction Trades (Construction trade workers including electricians, painters, carpenters, plumbers, plasterers, labourers), Caretaker/Janitor (caretaker, janitors, handymen) or Fitter and Maintenance Mechanic (maintenance trade people in factories). This way, people doing the same task in different jobs are assessed similarly.

(Please refer to Appendix 10 for the list of job specific and task modules in OccIDEAS.)

3.3 OccIDEAS assessment rules

In OccIDEAS, questions are designed to assess whether workers are exposed to any agent and the exposure levels (high, medium, low, and unknown) based on the tasks/the frequency of tasks they perform. The level of exposure can also include information on the use of different types of personal protective equipment (for example, simply dust mask, chemical cartridge respirator, or air-supplied mask). The OccIDEAS team has developed a series of exposure rules for many years based on the existing literature and expert opinion. An automatic exposure assessment is created based on the workers' answers (Fritschi *et al*., 2009). Except for noise and vibration, the levels of exposure for OccIDEAS agents are approximately related to the occupational exposure limit (OEL), which is similar to the New Zealand workplace exposure standard (WES). WES are values that refer to the airborne concentration of substances at which it is believed that nearly all workers can be repeatedly exposed day after day without coming to harm (WorkSafe New Zealand, 2022d) (See Table 2 for the assessment of exposure level).

OccIDEAS team will perform manual assessments when the information obtainable from the job module is insufficient to ensure confidence in the assessment. More details on the manual assessment will be explained in the Section 4, NZCS.

If exposure is determined, it is reported as either:

- **high** – at or above the OEL/WES
- **medium** – between 10% and 90% of the OEL/WES
- **low** – above background level but not of concern to occupational health and safety professionals.

TABLE 2:
Occupational exposure levels in OccIDEAS

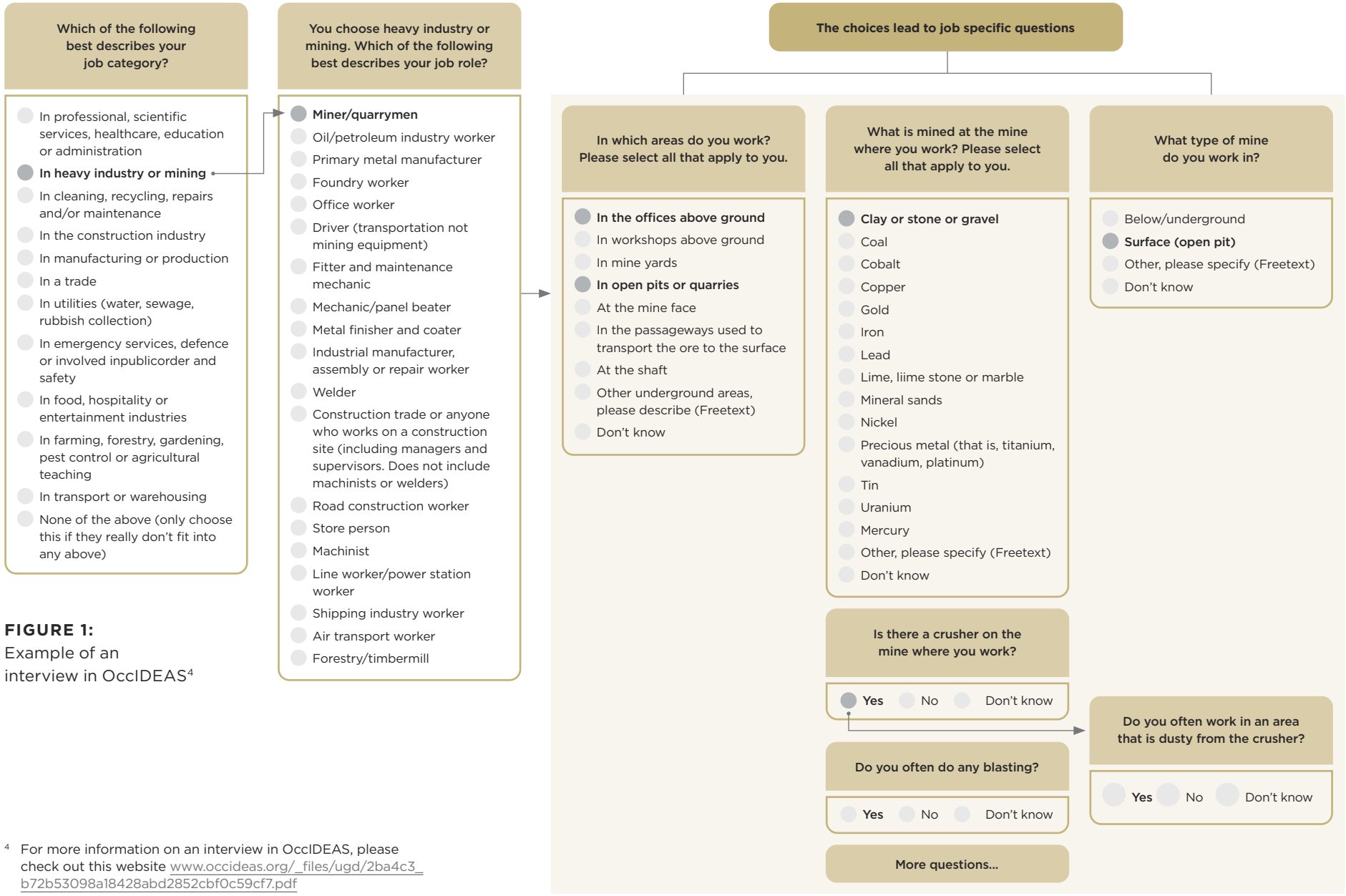


FIGURE 1:
Example of an interview in OccIDEAS[4]

[4] For more information on an interview in OccIDEAS, please check out this website www.occideas.org/_files/ugd/2ba4c3_b72b53098a18428abd2852cbf0c59cf7.pdf

An example of exposure to wood dust is described in Table 3. The likelihood of occupational exposure to wood dust in a construction worker depends on the type of tools used for cutting wood, the availability of exhaust ventilation in their work location, or their use of respirators while working (Fritschi *et al*., 2009).

QUESTION	ANSWER	EXPOSURE RULE
Do you often cut wood?	Yes	Probable exposure
To assess the level of exposure, the respondents are then asked: – which tool they often use to cut wood – whether they often use a respirator during working with wood, and – if their workplaces have local exhaust ventilation that removes wood dust from where they work	– power tool, and do not have any dust control or respiratory protection	High level
	– power tool, and use a rubber half face mask with cartridges	Medium level
	– Hand tool, and dust controls available at workplaces or use respiratory protection	Low level

(Fritschi *et al*., 2009)

TABLE 3:
Example of wood dust exposure in a construction worker who often works with wood

Below is another example of how occupational exposure to benzene is assessed. Please check out OccIDEAS website for more examples on exposure assessment.

- Example of a simple rule for the agent benzene:
  - If the person used petrol to clean used paint brushes, then exposure to benzene is probable, with medium level.
- Example of a more complex rule:
- If the person degreases machinery using petrol and they used a dip tank, with heating, but without a cover, and without an extraction fan and without cooling coils then exposure to benzene is probable, with high level.

In some situations, assessment rules can include extra information on characteristics of work locations or settings. Thus, for example, rules can specify that the level of exposure to asbestos is:

- probably low in workers who often do service tunnels in **buildings that were constructed before 1980**, or
- probably low in workers who often work in an engine room on **a boat built before 1990**.

4.0
The New Zealand Carcinogens Survey

IN THIS SECTION:

4.1 Adaption of the OccIDEAS tools for New Zealand working conditions

List of agents in the NZCS

The NZCS covers 54 agents relevant to New Zealand working conditions. Most selected agents are based on the most up to date OccIDEAS list of agents. Methyl bromide, carbamate, and erionite have been added to the survey since exposures to these agents are possible in some occupations in New Zealand.

Similar to the AWES, the carcinogens covered by the NZCS were included based on three criteria:

- evidence of carcinogenicity: exposures classified as group 1 (sufficient evidence of carcinogenicity in humans) or 2A (limited evidence of carcinogenicity in humans and sufficient evidence of carcinogenicity in experimental animals) based on the International Agency for Research on Cancer (IARC) assessment
- use in occupational circumstances
- evidence of use in the Australian and New Zealand industries.

Questionnaire and assessment rules[5]

Several changes (that include changes to specific questions, format, and wording) were made to the questionnaires to adapt to the New Zealand context and the online interview.

- all questions had been changed to present tense as they are asked about workers' current jobs
- all questions had 'Don't know' as the last option
- if people answered 'Don't know' all other options were automatically unchecked
- complex filtered questions were simplified
- clarification around shift work and cleaning was added
- frequency of tasks was asked as 'often' with the definition specified as: In the following questions, where it refers to 'often', it means do you do something at least once in a typical working week. For example: 'Do you often paint?' means 'Do you paint at least once in a typical working week?'.

Some job and task modules for the New Zealand context were developed, as below:

- new task module for working on the City Rail Link (aiming to identify the possibility of exposure to erionite)
- new task module for fumigation on the wharves
- new questions on exposure timing for solar UV
- new rules for fumigant exposure when opening and working in containers
- new rules for erionite, cobalt, and asbestos exposure in mining
- new rules for ocular UV exposure
- adjusted rules for PCBs (polychlorinated biphenyls) exposure in firefighters.

[5] This section has been adapted from discussions between WorkSafe, OccIDEAS team, and the survey company Research New Zealand, and the assessment paper developed by Professor Lin Fristchi (Curtin University/OccIDEAS team).

CATEGORY	AGENT	IARC GROUP	PRIMARY EXPOSURE ROUTE			CANCER SITE WITH SUFFICIENT EVIDENCE IN HUMANS (IARC)	CANCER SITE WITH LIMITED EVIDENCE IN HUMANS BUT SUFFICIENT EVIDENCE IN ANIMALS (IARC)
			Inhalation	Ingestion	Dermal contact		
Industrial chemicals	1,3 Butadiene	1	●			Haematolymphatic organs	
	Acrylamide	2A	●	●	●		Kidney
	Diethyl/Dimethyl sulphate	2A	●	●	●		Nasal cavity
	Epichlorohydrin	2A	●	●	●	Lung	
	Ethylene Oxide	1	●				Breast, leukaemia, Non-Hodgkin lymphoma, multiple myeloma
	Formaldehyde	1	●		●	Nasopharynx, leukaemia	
	Ortho-toluidine	1	●		●	Urinary bladder	
	Mineral oils (as mists)	1	●		●	Skin	
	PCBs	1	●		●	Skin	Breast, non-Hodgkin lymphoma
	Methyl Bromide	3	●		●	Not classified as a carcinogen	
	Acid mists	1	●	●	●	Larynx	
	MOCA	1	●	●	●	Bladder	
	Nitrosamines	2A	●	●	●		Oesophagus, oral cavity, pharynx
	Styrene	2A	●	●	●		Leukaemia, multiple myeloma
	Vinyl Chloride	1		●		Liver (angiosarcoma, hepatocellular carcinoma)	
Dusts	Asbestos	1	●			Lung, mesothelium, larynx, ovary	Pharynx, stomach, rectum, colon
	Erionite	1	●			Mesothelium	
	Silica (Crystalline silica dust)	1	●			Lung	
	Leather dust	1	●			Nasal cavity and paranasal sinus	
	Wood dust	1	●			Nasal cavity and paranasal sinus, nasopharynx	

CATEGORY	AGENT	IARC GROUP	PRIMARY EXPOSURE ROUTE			CANCER SITE WITH SUFFICIENT EVIDENCE IN HUMANS (IARC)	CANCER SITE WITH LIMITED EVIDENCE IN HUMANS BUT SUFFICIENT EVIDENCE IN ANIMALS (IARC)
			Inhalation	Ingestion	Dermal contact		
Metals	Arsenic	1	●	●		Lung, skin, urinary bladder	Prostate, kidney, liver, bile duct
	Cadmium	1	●			Lung	Prostate, kidney
	Chromium VI	1	●			Lung	
	Cobalt	2A	●				Lung
	(inorganic) Lead	2A		●			Stomach
	Nickel	1	●	●	●	Lung, nasal cavity and paranasal sinuses	
	Beryllium	1	●		●	Lung	
Products of combustion	Diesel Engine Exhaust	1	●			Lung	Urinary bladder
	Welding fumes	1	●			Lung, pharynx	Kidney
	Other PAHs (for benzo(a) pyrene)	1	●	●	●	Lung cancer and non-melanoma skin	Bladder cancer
	Environmental Tobacco Smoke	1	●			Lung	Larynx, pharynx
Radiation	Ionising radiation	1				Leukaemia, oesophagus, stomach, colon, lung, bone, skin, breast, kidney, bladder, brain	Rectum, liver, bile duct, pancreas, ovary, prostate
	Artificial UV	1			●	Eye	
	Ocular UV	1			●	Eye, skin	
	Solar UV	1			●	Skin (basal cell carcinoma, squamous cell carcinoma, melanoma)	
Solvents	Benzene	1	●		●	Leukaemia (acute myeloid)	Lung, multiple myeloma, leukaemia (chronic myeloid)
	Trichloroethylene	1	●		●	Kidney	
	Dichloromethane	2A	●				Bile duct, non-Hodgkin lymphoma
	Tetrachloroethylene	2A	●				Urinary bladder

CATEGORY	AGENT	IARC GROUP	PRIMARY EXPOSURE ROUTE			CANCER SITE WITH SUFFICIENT EVIDENCE IN HUMANS (IARC)	CANCER SITE WITH LIMITED EVIDENCE IN HUMANS BUT SUFFICIENT EVIDENCE IN ANIMALS (IARC)
			Inhalation	Ingestion	Dermal contact		
Pesticides	Glyphosate	2A	●	●	●		non-Hodgkin lymphoma
	Organochlorines	2A	●	●	●		Liver, bile duct
	Organophosphates	2A	●	●	●		non-Hodgkin lymphoma
	Phenoxy Herbicides		●	●	●		
	other Herbicides, other Pesticides		●	●	●		
	Carbamate	3	●	●	●	Not classified as a carcinogen	
Shiftwork that involves circadian disruption	Graveyard, Light at night, Phase shift, Sleep disturbances, Shiftwork and alcohol, Shiftwork and diet, Shiftwork and physical activity, Shiftwork and vitamin D	2A					Breast, colon, rectum, prostate

- MOCA is 4,4'-Methylenebis.
- PCBs are Polychlorinated biphenyls. Dichloromethane can be called Methylene Chloride.
- Tetrachloroethylene can be called perchloroethylene (perc).
- UV-Ultraviolet radiation.
- 'Other PAHs' are polycyclic aromatic hydrocarbons (PAHs) other than vehicle exhaust.
- Based on IARC, night shiftwork is defined as work during the usual sleeping hours of the general population.
- Erionite, Carbamate and Methyl Bromide have been added to the New Zealand survey.
- Methyl Bromide and Carbamate are not classifiable as carcinogens (based on IARC), but they have been added to identify the level of exposure in farmers and port workers. In this report, they are not included when calculating the prevalence of occupational exposure to carcinogenic agents.
- Information on cancer sites in this table is taken from IARC website at https://monographs.iarc.who.int/wp-content/uploads/2019/07/Classifications_by_cancer_site.pdf (last updated on 1 July 2022)

TABLE 4: List of agents captured in the NZCS

Exclusions and inclusions[5]

During the assessment, a few exclusions and inclusions were made to ensure the quality of responses.

- Exclude main and control subjects with exposures that seem extreme for the job title they have given. For example, an IT specialist who welds beryllium or a social worker who does everything including diathermy, X-rays, sterilising with ethylene oxide, embalming bodies etc.
- Exclude those who did not answer the final two questions of the survey.
- Include people with poor quality job information but whose answers to the questions were consistent with them being trades people.

Exposure assessment of New Zealand workers[5]

As described in Section 3.3, the assessment of probable exposure to carcinogens in New Zealand workers was done by the OccIDEAS team using the online application OccIDEAS. Questions in the OccIDEAS have been specifically designed to assess the level of exposure based on the actual tasks the workers perform.

The level of exposure is assessed to the occupational exposure limit (OEL), or the workplace exposure standard (WES). If exposure is determined, it is reported as either:

i. high: at or around the WES
ii. medium: between 10% and 90% of the WES, and
iii. low: above background, but not of concern to occupational health and safety professionals.

The assessment rules have been developed from literature and experts' opinions for many years.

Some carcinogens do not have an OEL/WES, for example acid mists. In this case, the OccIDEAS team look at the question and work out which acid mist it might be in that situation and take the OEL/WES of that acid mist. Similar approach is used for other PAHs and nitrosamines.

The OccIDEAS team performed automatic assessments of exposure for most agents. The manual assessment was necessary when the information obtainable from the job module was not adequate to ensure confidence in the assessment. This occurred when it was difficult to delineate the circumstances under which exposure might occur precisely. During the manual assessment, the OccIDEAS team reviewed the free text answers and compared them with the literature and safety data sheets required to ascertain exposure. In the NZCS, the main jobs requiring manual assessments from the OccIDEAS team were farmers, gardeners, manufacturing workers, and drivers.

The OccIDEAS team also spent extended time performing the exposure assessment for people answering the manufacturing job module. These workers didn't fit into any of the jobs available for manufacturing in the OccIDEAS (i.e., not ceramics, leather, textile, printing, oil, metal finishing, rubber). An initial question in the manufacturing module asked about other specific industries; but the workers might not fit into any of the categories in some cases. However, the OccIDEAS could identify if people were working in an area with fumes or dust. For example, assembling aluminium window frames workers are unlikely to be exposed to any agents of interest. In contrast, pulp-making and processing workers were assessed as having high exposure to formaldehyde and acid mists.

4.2 Methodology summary

Survey scope

There are two surveys in the NZCS, namely the Main and Control surveys.

The survey of potentially exposed occupations[6] is known as the 'Main survey'. The research also included an auxiliary 'Control survey', which involved a smaller, random sample of workers across **all** occupations (no matter whether they are presumed to be exposed to carcinogens) who were surveyed using generic questions.

Findings presented in the overall report are drawn from a combined dataset of the Main survey and the Control survey. A combination of two datasets enables WorkSafe to robustly report exposure levels across the entire workforce while progressing further analysis to understand the relative risk of exposure between the two groups. These results will contribute to the carcinogen exposure measure outlined in WorkSafe's Statement of Intent.

The population of interest includes people aged 18 or over who are currently working in paid employment in New Zealand.

Sampling frame and sample size

In total, 4,051 respondents completed the NZCS (3089 people from the Main survey and 962 from the Control Survey).

1. Respondents of the **Main survey** were sourced from the General and Māori Electoral Rolls.

   Potential respondents were selected from the General and Māori Electoral Rolls based on their responses to the **occupational free-text field**. A search protocol was developed to sample workers who may be working in the potentially exposed occupations (described in the *Survey scope* section above). A nationally representative sample of workers in potentially exposed occupations was stratified by age group and industry – based on a modified version of the ANZSIC industry list (see Appendix 8 for details). The sample was then 'cleaned' to remove overseas and duplicate addresses and sent for tele-matching (given that telephone contact numbers are unavailable through the Electoral Rolls).

   The tele-matching process involves sending the list of names and addresses to an external database marketing company, who then matches those records against the various consumer databases and telephone listings they have access to. Where there is a match, they append the respective landline and/or mobile telephone number(s).

   To increase the sample and ensure representativeness, additional respondents were sourced from:

   - Dynata, an online panel provider, which has the most extensive panel of its type in New Zealand: Dynata records and keeps up-to-date specific demographic data for each panel member; hence, information on which industry the panel members work can be extracted from Dynata's platform.
   - A database of operators provided by Maritime New Zealand: A survey registration email containing a general registration link was provided to operators who were registered with Maritime New Zealand. The email was distributed to workers who work for these operators to supplement those working in this industry.

2. The sample frame used for the **Control survey** was Dynata's online panel. The sample was stratified by age group, gender, and ethnicity.

[6] The list of potentially exposed occupations is based on the Australian Worker Exposure Survey Interviewer Training Manual, Procedure Manual, Carey *et al*. (2013) paper and discussions with Professor Lin Fritschi (Curtin University).

All surveys were completed online using a web-based surveying platform.

Data collection

The cognitive testing was completed between 1 and 15 March 2021 to identify if the respondents had any issues in understanding the language, content, logic, and flow of the questionnaire. The piloting was completed between 27 April and 20 May 2021 covering 250 respondents to test the data transfer to the OccIDEAS platform and the assessment process.

The Main Survey was completed between 9 June and 11 September 2021, and the Control Survey between 9 and 25 June 2021.

Data transfer to occideas platform

An application programming interface (API) was developed to transfer OccIDEAS questionnaires to Voxco via Qualtrics placed in the survey company. This allowed the survey company and Curtin University/OccIDEAS team to communicate and leverage each other's data and functionality.

Weighting

The data have been weighted, so the overall sample is representative of the population of interest based on age, gender, risk group of occupation, and industry, according to Statistics New Zealand population counts in Census 2018 (refer to Appendix 9 for more details on the survey weighting).

Statistical analysis

All statistical analyses were conducted using RStudio version 4.1.2. Reported differences between groups (or between a particular group) are statistically significant at the 95% confidence level ($p<0.05$) unless stated otherwise.

As done in the AWES, the overall prevalence of exposure in the NZSC was calculated as the proportion of workers assessed as having probable exposure to at least one of the carcinogenic agents in the current job (either at any level of exposure or by the level of exposure), regardless of frequency and duration. A similar approach was applied to define the prevalence of exposure to individual carcinogens. In order to be accessible to various audiences, this report does not include discussion of advanced statistical modelling.

Analysis of the exposure circumstances was restricted to 18 agents that are among the most common carcinogens in the New Zealand working environment (by their high level of exposure) and WorkSafe's interest carcinogens. For each relevant task, the prevalence of exposure was defined as the proportion of exposed workers with probable exposure in the given tasks or jobs. Where available, the use of controls (including personal protective equipment) was defined for each task. A cross-tabulation was used to compare the prevalence of workers who reported using controls within each given task.

Questionnaire

The NZCS comprises three sections based on the OccIDEAS question-set:

- Section 1: Questions about workers' current job
- Section 2: OccIDEAS module relevant to their job
- Section 3: Demographic questions.

The full questionnaire for Section 1 and Section 3 is provided in Appendix 11

Section 2 is a proprietary web-based questionnaire owned by OccIDEAS team and Curtin University (Please refer to the OccIDEAS website www.occideas.org for further information).

5.0
Key findings

IN THIS SECTION:

5.1 Overall occupational exposure to carcinogens in New Zealand

Over half (57.5%) of workers are probably exposed to at least one carcinogen at any level. Extrapolation to the New Zealand working population suggests that approximately 1.6 million of workers could be occupationally exposed to at least one carcinogenic agent.

As seen in Table 5, the top ten common carcinogenic agent (at any level of exposure) in New Zealand are benzene (30%), solar UV (26.8%), ocular UV (25.5%), diesel engine exhaust (23.7%), environmental tobacco smoke (14.6%), styrene (12.2%), crystalline silica (10.3%), shiftwork (8.6%), wood dust (8.4%), and other PAHs (8.1%).

When looking at the overall level of exposure to carcinogens, over half (53.1%) of workers are exposed to at least one carcinogenic agent at a low level. Nearly three in ten (28%) workers are probably exposed to at least one carcinogen at a high level. The most frequent exposures at a high level are benzene (7.3%), solar UV (6.8%), shiftwork (6.8%), wood dust (4.5%), ocular UV (4.1%), diesel engine exhaust (3.7%), environmental tobacco smoke (2.9%), glyphosate (2.6%), crystalline silica (2.4%), artificial UV (2.2%), other PAHs (1.4%), and chromium VI (1.2%). More information on these carcinogenic agents can be found in section 5.3.

5.2 Exposure combination

Figure 2 describes the co-exposure to carcinogens among workers using a correlation heatmap. Most of the correlations are low (less than 0.2). However, there are some notable points to consider.

Chromium VI, nickel, lead, cadmium, welding fumes, and artificial UV co-occur. It is not unexpected because these carcinogens are all associated with welding activities. This finding is consistent with the results from the Australian Worker Exposure Survey (Darcey *et al*., 2016a),

Unsurprisingly, solar UV and ocular UV exposure tend to occur together. Co-exposure to these two carcinogens and DEE is common. Shin *et al*. (2020) have concluded that meteorological factors such as solar radiation increases the probable exposure to diesel engine exhaust (DEE) in outdoor workers. Exposures to solar UV and ocular UV are also positively associated with exposures to benzene, wood dust, and crystalline silica.

Co-exposure to other PAHs, benzene, and DEE is common. According to Darcey *et al*. (2016a), these carcinogens are associated with refuelling equipment and vehicles with petrol; hence, co-exposure is likely to happen.

Exposures of wood dust and formaldehyde appear to occur together. The correlation can be explained by a joint task of sanding chipboard resulting in exposure to these two carcinogenic agents (Driscoll *et al*., 2016b).

Co-exposure to arsenic and wood dust is expected. Arsenic is often used to preserve timber in New Zealand (Robinson *et al*., 2004), which is a likely explanation for the correlation.

Exposure to dichloromethane seems to happen together with exposure to nickel, lead, welding fumes, artificial UV, wood dust, asbestos, and formaldehyde. Dichloromethane (containing methylene chloride) is an organochlorine compound found in paint stripping and vanishing remover solvents, which is likely to explain the correlation.

CARCINOGEN		BY EXPOSURE LEVEL (%)			CANCER SITE WITH SUFFICIENT/LIMITED EVIDENCE IN HUMANS (ICD-10 CODES)																								
	Exposure at any level (%)	At a low level	At a medium level	At a high level	Lung (C33-C34)	Leukaemia (C91-C95)	Mesothelioma (C45)	Melanoma of the skin (C43)	Skin (C44)	Larynx (C32)	Lip (C00)	Bladder (C67)	Stomach (C16)	Nasal (C30)	Ocular melanoma (C69)	Colorectal (C18-C20)	Pharynx (C10, C13)	Kidney (C64)	Nasopharynx (C11)	Breast (C50)	NHL (C82-C86)	Liver and bile ducts (C22-C24)	Prostate (C61)	Pancreas (C25)	Oesophagus (C15)	Haematolymphatic organ (C83)	Ovary (C56)	Oral cavity (C14)	Brain (C71)
At least one carcinogen	**57.5**	**53.1**	**32.2**	**28.0**																								
Benzene	30.0	21.7	1.0	7.3	○	●															○							
Solar UV	26.8	7.4	12.7	6.8				●							●													
Ocular UV	25.5	14.6	6.8	4.1											●													
DEE	23.7	9.5	10.4	3.7	●							○																
ETS	14.6	11.6	0.0	2.9	●					○							○											
Styrene	12.2	7.8	4.4	0.03		○																						
Crystalline silica	10.3	6.3	1.6	2.4	●																							
Shiftwork	8.6	6.1	7.3	6.8												○				○			○					
Wood dust	8.4	1.4	2.5	4.5										●					●									
Other PAHs	8.1	4.3	2.4	1.4	○																						●	
Formaldehyde	7.9	5.6	1.7	0.6		●													●									
Chromium VI	6.2	3.6	1.3	1.2	●									○														
Lead	5.0	2.1	2.3	0.6									○															

● Cancer site with sufficient evidence in humans based in IARC ○ Cancer site with limited evidence in humans, but sufficient evidence in animals (based on IARC)

CARCINOGEN		BY EXPOSURE LEVEL (%)			CANCER SITE WITH SUFFICIENT/LIMITED EVIDENCE IN HUMANS (ICD-10 CODES)																								
	Exposure at any level (%)	At a low level	At a medium level	At a high level	Lung (C33-C34)	Leukaemia (C91-C95)	Mesothelioma (C45)	Melanoma of the skin (C43)	Skin (C44)	Larynx (C32)	Lip (C00)	Bladder (C67)	Stomach (C16)	Nasal (C30)	Ocular melanoma (C69)	Colorectal (C18-C20)	Pharynx (C10, C13)	Kidney (C64)	Nasopharynx (C11)	Breast (C50)	NHL (C82-C86)	Liver and bile ducts (C22-C24)	Prostate (C61)	Pancreas (C25)	Oesophagus (C15)	Haematolymphatic organ (C83)	Ovary (C56)	Oral cavity (C14)	Brain (C71)
Asbestos	4.0	2.9	0.9	0.2	●		●			●			○			○	○										●		
Nickel	3.9	2.4	0.9	0.6	●									●															
Artificial UV	3.7	0.4	1.1	2.2											●														
Welding fumes	3.6	1.4	1.7	0.4	●												●	○											
Glyphosate	3.4	0.8	0.01	2.6																	○								
Cadmium	2.6	1.6	0.8	0.2	●													○					○						
Mineral oils	2.5	0.7	1.7	0.1					●																				
Other pesticides	2.0	1.6	0.08	0.3																									
Dichloromethane	1.3	0.6	0.5	0.2																		○							
Ionising Radiation	1.0	0.8	0.2	0.02	●	●			●			●				●		●		●		○	○	○	●		○		●
Arsenic	1.0	0.7	0.3	0.0	●				●			●						○				○	○						
Phenoxy herbicides	0.8	0.2	0.0	0.6																									
Cobalt	0.7	0.2	0.4	0.1	○																								
Other herbicides	0.6	0.2	0.01	0.4																									

● Cancer site with sufficient evidence in humans based in IARC ○ Cancer site with limited evidence in humans, but sufficient evidence in animals (based on IARC)

CARCINOGEN		BY EXPOSURE LEVEL (%)			CANCER SITE WITH SUFFICIENT/LIMITED EVIDENCE IN HUMANS (ICD-10 CODES)																									
	Exposure at any level (%)	At a low level	At a medium level	At a high level	Lung (C33-C34)	Leukaemia (C91-C95)	Mesothelioma (C45)	Melanoma of the skin (C43)	Skin (C44)	Larynx (C32)	Lip (C00)	Bladder (C67)	Stomach (C16)	Nasal (C30)	Ocular melanoma (C69)	Colorectal (C18-C20)	Pharynx (C10, C13)	Kidney (C64)	Nasopharynx (C11)	Breast (C50)	NHL (C82-C86)	Liver and bile ducts (C22-C24)	Prostate (C61)	Pancreas (C25)	Oesophagus (C15)	Haematolymphatic organ (C83)	Ovary (C56)	Oral cavity (C14)	Brain (C71)
Acid mists	0.5	0.3	0.1	0.1						●																				
Ethylene oxide	0.5	0.1	0.03	0.3															○	○										
1,3 Butadiene	0.4	0.3	0.1	0.01																						●				
Organophosphates	0.4	0.1	0.0	0.3	○																○									
Vinyl Chloride	0.3	0.3	0.0	0.0																		●								
Tetrachloroethylene	0.3	0.03	0.1	0.2								○																		
Trichloroethylene	0.3	0.1	0.02	0.2														●				●								
PCBs	0.3	0.2	0.0	0.0					●													●								
Beryllium	0.2	0.1	0.1	0.01	●																									
Organochlorines	0.1	0.1	0.03	0.0																		○								
Leather dust	0.1	0.1	0.0	0.0										●																
Erionite	0.1	0.1	0.0	0.0			●																							
Nitrosamines	0.0	0.0	0.02	0.0													○											○		
Acrylamide	0.0	0.0	0.0	0.0														○												

● Cancer site with sufficient evidence in humans based in IARC

○ Cancer site with limited evidence in humans, but sufficient evidence in animals (based on IARC)

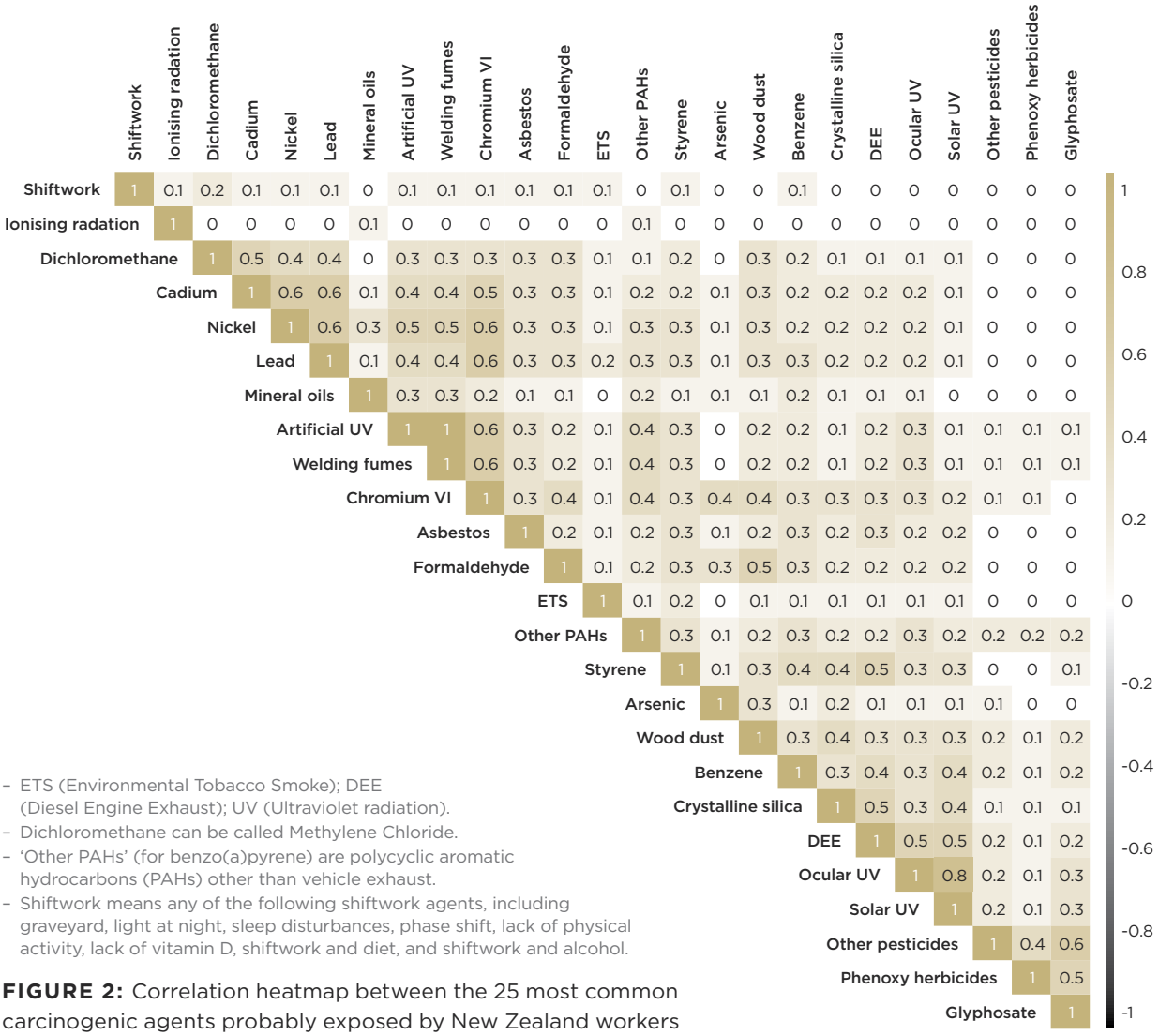
CARCINOGEN		BY EXPOSURE LEVEL (%)			CANCER SITE WITH SUFFICIENT/LIMITED EVIDENCE IN HUMANS (ICD-10 CODES)																							
	Exposure at any level (%)	At a low level	At a medium level	At a high level	Lung (C33-C34)	Leukaemia (C91-C95)	Mesothelioma (C45)	Melanoma of the skin (C43)	Skin (C44)	Larynx (C32)	Lip (C00)	Bladder (C67)	Stomach (C16)	Nasal (C30)	Ocular melanoma (C69)	Colorectal (C18-C20)	Pharynx (C10, C13)	Kidney (C64)	Nasopharynx (C11)	Breast (C50)	NHL (C82-C86)	Liver and bile ducts (C22-C24)	Prostate (C61)	Pancreas (C25)	Oesophagus (C15)	Haematolymphatic organ (C83)	Ovary (C56)	Oral cavity (C14)	Brain (C71)
Epichlorohydrin	0.0	0.0	0.0	0.0	●																							
Ortho-toluidine	0.0	0.0	0.0	0.0								●																
MOCA	0.0	0.0	0.0	0.0								●																

● Cancer site with sufficient evidence in humans based in IARC ● Cancer site with limited evidence in humans, but sufficient evidence in animals (based on IARC)

- The prevalence of exposure (at any level and by level of exposure) is calculated by dividing the number of exposed people to a given carcinogenic agent by the total of workers.
- MOCA is 4,4'-Methylenebis.
- PCBs are Polychlorinated biphenyls.
- Dichloromethane can be called Methylene Chloride.
- Tetrachloroethylene can be called perchloroethylene (perc).
- 'Other PAHs' are polycyclic aromatic hydrocarbons (PAHs) other than vehicle exhaust.
- ETS (Environmental Tobacco Smoke); DEE (Diesel Engine Exhaust); UV (Ultraviolet radiation).
- Shiftwork means any of the following shiftwork agents, including graveyard, light at night, sleep disturbances, phase shift, lack of physical activity, lack of vitamin D, shiftwork and diet, and shiftwork and alcohol. Exposure level is not assessed for graveyard, therefore, it has been excluded when calculating the exposure level of shiftwork.
- ICD-10- International Classification of Diseases version 10.

TABLE 5: Proportions of workers estimated to be probably exposed to carcinogenic agents – by carcinogens and level (%)

Co-exposure to crystalline silica and DEE is common. Glyphosate, phenoxy herbicides, and other pesticides tend to co-occur. Exposure to styrene is associated with exposure to DEE, wood dust, benzene, nickel, lead, welding fumes, artificial UV, and asbestos. It could be explained by the multiple tasks performed by workers in their workplace. Further analysis will be carried out by WorkSafe to investigate the circumstances of exposures, workers' jobs, and tasks.



- ETS (Environmental Tobacco Smoke); DEE (Diesel Engine Exhaust); UV (Ultraviolet radiation).
- Dichloromethane can be called Methylene Chloride.
- 'Other PAHs' (for benzo(a)pyrene) are polycyclic aromatic hydrocarbons (PAHs) other than vehicle exhaust.
- Shiftwork means any of the following shiftwork agents, including graveyard, light at night, sleep disturbances, phase shift, lack of physical activity, lack of vitamin D, shiftwork and diet, and shiftwork and alcohol.

FIGURE 2: Correlation heatmap between the 25 most common carcinogenic agents probably exposed by New Zealand workers

5.3 The most common carcinogenic agents in New Zealand

This section describes 18 agents that are among the most common carcinogens in the New Zealand working environment (by their high level of exposure) and WorkSafe's priority carcinogens. The carcinogens in this section are listed with a reference to Carey *et al*. (2017) on the number of cancer registrations attributable to occupational exposure in Australia.[7] WorkSafe will be conducting further analysis on each carcinogenic agent in relation to industry and occupation.

[7] New Zealand will be conducting a study to estimate cancer burden from occupational exposure to carcinogens.

ASBESTOS

Asbestos is classified by IARC as a Group 1 carcinogen (carcinogenic to humans). The IARC considers there is sufficient evidence that asbestos causes mesothelium, larynx, lung, and ovary cancer, and limited evidence that it causes stomach, rectum, and colon cancer (IARC, 2019). Asbestos is one of WorkSafe's priority carcinogens. WorkSafe's current focus is on addressing the risks of asbestos exposure.

Some 1366 cases of asbestos-related diseases were notified to the National Asbestos Medical Panel from 3/1992 to 7/2013. Among these, 245 cases were mesothelioma; 129 were lung cancer; 315 were asbestosis; the remaining cases (677) were pleural abnormalities (WorkSafe New Zealand, 2013). It is estimated that annually around 200–250 work-related health deaths in New Zealand are attributable to past exposure to asbestos (WorkSafe New Zealand, 2019).

The NZSC shows that about 4.0% of New Zealand workers are probably exposed to asbestos. Some 1.1% of New Zealand workers are deemed to have high and medium asbestos exposure. Extrapolation to the New Zealand working population suggests that approximately 30,800 workers could be occupationally exposed to asbestos at high and medium levels.

CIRCUMSTANCES OF EXPOSURE

Servicing, reparing, or replacing brakes or clutches on vehicle built before 2003 is the most common circumstance resulting probable exposure to asbestos (76.8%). There is no information on the age of the vehicle in the survey. Therefore, most workers (80.4%) performing this task are deemed to have probable low exposure to asbestos.

Other common activities causing probable exposure to asbestos include:

- unloading and loading friable asbestos-containing products (12.2%)
- overhaul, clean up, or sifting through the remains of a fire (6.1%)
- frontline fighting in residential or commercial fires (5.4%)
- working in the tunnels of the buildings that have pipes with fibrous or crumbly lagging or insulation (3.8%)
- disturbing or removing asbestos-containing materials (3.2%).

EXPOSURE CIRCUMSTANCES	EXPOSURE TO ASBESTOS* (%)	BY LEVEL OF EXPOSURE** (%)			
		Low	Medium	High	Total
Servicing, repairing, or replacing brakes or clutches on vehicles older than 2003	76.8	80.4	16.6	2.2	100
Unloading and loading friable asbestos-containing products	12.2	–	100	–	100
Working in the tunnels of the buildings that have pipes with fibrous or crumbly lagging or insulation	3.8	–	–	100	100
Disturbing or removing asbestos-containing materials	3.2	-	79.2	20.8	100
Frontline fighting in residential or commercial fires	5.4	37.7	62.3	–	100
Overhaul, clean up, or sifting through the remains of a fire	6.1	38.2	61.8	–	100

This table does not include all exposed workers.

* Percentage of all exposed persons who are exposed in the given exposure circumstance.

** Percentage of persons exposed in the given exposure circumstance who are exposed at this exposure level. Workers could be exposed through more than one activity.

TABLE 6: Main circumstances leading to probable exposure to asbestos

THE USE OF CONTROLS

The use of controls is asked of firefighters. Some 73.5% of frontline firefighters in residential or commercial fires with probable exposure to asbestos report wearing breathing apparatus during frontline firefighting more than 50% of the time. Some 64.4% of firefighters who do overhaul, clean up or sifting through the remains of a fire and are probably exposed to asbestos report using breathing appraratus more than 50% of the time.

BENZENE

Benzene is classified by IARC as a Group 1 carcinogen (carcinogenic to humans). The IARC considers there is sufficient evidence that benzene causes acute myeloid and other acute non-lymphocytic leukaemia, and limited evidence that it causes lung cancer, non-Hodgkin lymphoma, multiple myeloma, chronic myeloid and non-lymphocytic leukaemia (IARC, 2019). Previous studies in New Zealand have found that benzene is commonly used in coal mining and oil and gas extraction; printing, publishing, and recorded media; plastic product manufacturing; machinery and equipment manufacturing; machinery and motor vehicle wholesaling and transport (including road, rail, water, air and space transport; other transport; services to transport; and storage) (t'Manntje, 2011).

In the NZCS, three in ten (30%) New Zealand workers are deemed to be exposed to benzene at any level. Some 8.3% of New Zealand workers are deemed to have probable medium and high exposure to benzene. Extrapolation to the New Zealand working population suggests that approximately 233,000 workers could be occupationally exposed to benzene at a medium and high level.

CIRCUMSTANCES OF EXPOSURE

The main tasks leading to probable exposure to benzene are fuelling vehicles with petrol (56.7%), using petrol to clean hands (12.3%), using mineral turpentine, mineral spirits or white spirit or paint thinner to clean hands (12.3%), refuelling equipment with petrol (11.0%), and using oil or solvent-based primer or undercoat for painting (6.2%). However, when looking at the level of exposure, refuelling equipment with petrol is more likely to result in high level of exposure to benzene.

EXPOSURE CIRCUMSTANCES	EXPOSURE TO BENZENE* (%)	BY LEVEL OF EXPOSURE** (%)			
		Low	Medium	High	Total
Fuelling vehicle with petroL	56.7	69.5	0.8	29.7	100
Refuelling equipment with petrol	11.0	48.5	3.6	47.9	100
Using petrol to clean hands	12.3	71.6	2.8	25.5	100
Using mineral turpentine, mineral spirits or white spirit or paint thinner to clean hands	12.3	73.7	6.9	19.4	100
Using oil or solvent-based primer or undercoat for painting	6.2	42.7	20.2	37.2	100

This table does not include all exposed workers.

* Percentage of all exposed persons who are exposed in the given exposure circumstance.

** Percentage of persons exposed in the given exposure circumstance who are exposed at this exposure level. Workers could be exposed through more than one activity.

TABLE 7: Main circumstances leading to probable exposure to benzene

THE USE OF CONTROLS

In the survey, controls are considered for degreasing and fuel tank cleaning tasks associated with probable exposure to benzene. The use of chemical cartridge or air-supplied respirators is collected for petrol tank cleaning tasks, while information on ventilation or cooling system is gathered for degreasing tasks.

ENVIRONMENTAL TOBACCO SMOKE

Environmental tobacco smoke (ETS) is classified by IARC as a Group 1 carcinogen (carcinogenic to humans). The IARC consider there is sufficient evidence that ETS causes lung cancer (IARC, 2004) and limited evidence that it causes larynx and pharynx cancer (IARC, 2019).

The NZCS shows that about 14.6% of New Zealand workers are probably exposed to ETS at any level. Some 2.9% of New Zealand workers are deemed to have high ETS exposure. Extrapolation to the New Zealand working population suggests that about 81,000 workers are probably exposed to a high level of ETS.

CIRCUMSTANCES OF EXPOSURE

Working in surrounding areas where other workers smoke is the most common circumstance resulting in probable exposure to ETS. Those working indoors close to where their colleagues smoke are deemed exposed to a high level of ETS. People who work in Retail Trade, Public Administration and Safety, and Manufacturing workers are probably exposed to high ETS indoors.

Most people who work outdoors or near the entrances of the building where other workers smoke are probably exposed to ETS at a low level.

EXPOSURE CIRCUMSTANCES	EXPOSURE TO ETS* (%)	BY LEVEL OF EXPOSURE** (%)			
		Low	Medium	High	Total
Working indoors around the areas where other workers smoke	20.1	–	–	100	100
Working outdoors around the areas where other workers smoke	84.7	88.8	–	11.2	100
Working near entrances to the building/work sites around the areas where other workers smoke	26.3	62.7	–	37.3	100

* Percentage of all exposed persons who are exposed in the given exposure circumstance.
** Percentage of persons exposed in the given exposure circumstance who are exposed at this exposure level. Workers could be exposed through more than one activity.

TABLE 8: Main circumstances leading to probable exposure to environmental tobacco smoke

THE USE OF CONTROLS

Workers are asked whether smoking bans are in place at their workplace. Of those with probable exposure to ETS, nearly half (47.4%) report having smoking bans in place for indoor workplaces; 27% report having smoking bans outside near the entrance to the building; and one-fifth (21.4%) of workers mention that smoking is banned in the outdoor areas. Some 13.7% of workers who are probably exposed to ETS report having smoking bans in all workplace areas (indoors, outdoors, and entrance to the building/worksite). About 38.5% of workers with probable exposure to ETS report there is no workplace smoking ban (Table 9).

SMOKING BANS	%
Smoking is banned in indoor areas	47.4
Smoking is banned in outdoor areas	21.4
Smoking is banned outside near the entrance to the building/worksite	27.0
Any smoking bans in the working areas	54.3
Smoking is banned in all workplace areas (indoors, outdoors, and entrance to the building/worksite)	13.7
None of the smoking bans	38.5

Workers could report more than one smoking ban available in their workplace.

TABLE 9: Self-reported information on smoking bans in workers with probable exposure to environmental tobacco smoke

Looking at the individual circumstance of exposure, around 39.3% of workers who are probably exposed to ETS when working indoors report that smoking is banned in indoor workplaces. Nearly one-fourth (23.7%) of people with probable exposure to ETS when working outdoors say a workplace smoking ban is available in outdoor areas. Some 16.9% of workers who are deemed to have probable ETS exposure when working near the entrances of the building/work sites report that smoking is not allowed near the entrances (Table 10).

SMOKING BANS	%
Smoking is banned in indoor areas when the workers work indoors	39.3
Smoking is banned in outdoor areas where the workers work	23.7
Smoking is banned outside near the entrance to the building/work site where the workers work	16.9

TABLE 10: Self-reported information on smoking bans and individual circumstance of exposure

DIESEL ENGINE EXHAUST

Diesel engine exhaust (DEE) is classified by IARC as a Group 1 carcinogen (carcinogenic to humans). DEE is an essential carcinogen in the New Zealand workplace. The IARC considers there is sufficient evidence that DEE causes lung cancer and limited evidence that it causes bladder cancer. DEE is one of a number of significant carcinogens contributing to one-third of the total burden of work-related harm in New Zealand (WorkSafe New Zealand, 2019).

The NZCS shows that about 23.7% of New Zealand workers are probably exposed to DEE. Some 3.7% of New Zealand workers are deemed to be exposed at a high level. Extrapolation to the New Zealand working population suggests that about 99,000 workers are probably exposed to DEE at a high level.

CIRCUMSTANCES OF EXPOSURE

Working in areas where diesel vehicles with engines are running is the most common activity resulting in probable exposure to DEE (61.3%). The level of exposure to DEE depends on the location of the engine (indoors, outdoors, or both), distance from the engine (less than 20m, from 20–50m, and over 50m), and whether the workers can smell the exhaust fumes in the working areas.

Those working indoors and less than 20m from a running diesel vehicle and able to smell exhaust fumes are all assigned to a high level of exposure to DEE. Around half of the workers who work indoors or both indoors and outdoors in areas where diesel vehicle engines are running are deemed to be exposed to a high level of DEE. On the other hand, one-fifth of workers working outdoors are probably exposed to DEE at a high level, and over a third of them are deemed to have low exposure.

Driving or riding diesel vehicles on construction sites or inside the building also contributes to probable exposure to DEE (18.5% and 12.6%, respectively). People performing these tasks are deemed to be exposed to DEE at medium or high levels.

Exposure to DEE is deemed to occur in people working near diesel generators (4.7%) and using or repairing diesel-powered equipment (4.3%).

EXPOSURE CIRCUMSTANCES	EXPOSURE TO DEE* (%)	BY LEVEL OF EXPOSURE** (%)			
		Low	Medium	High	Total
Diesel vehicles with engines running in areas where the workers work	61.3				
– indoors	23.8	0	54.4	45.6	100
- less than 20m from a running diesel vehicle and able to smell exhaust fumes	9.0	–	–	100	100
– outdoors	56.2	34.0	45.9	21.0	100
– both indoors and outdoors	19.4	0	49.8	50.2	100
Driving or riding diesel vehicles on:					
– contruction sites	18.5	–	75.4	24.6	100
– inside the building (for example, warehouse)	12.6	–	56.0	44.0	100
Working near a diesel generator	4.7	18.2	50.4	31.3	100
Using or repairing diesel-powered equipment	4.3	–	53.8	46.2	100

* Percentage of all exposed persons who are exposed in the given exposure circumstance.
** Percentage of persons exposed in the given exposure circumstance who are exposed at this exposure level. Workers could be exposed through more than one activity.

TABLE 11: Main circumstances leading to probable exposure to diesel engine exhaust

THE USE OF CONTROLS

Information on the use of controls is not collected for tasks associated with probable exposure to DEE.

CRYSTALLINE SILICA

Crystalline silica is classified by IARC as a Group 1 carcinogen (carcinogenic to humans). The IARC considers there is sufficient evidence that crystalline silica causes lung cancer (IARC, 2019) and silicosis. It is a risk factor for chronic obstructive pulmonary disease, kidney disease and autoimmune disease. A pilot study on workers performing construction activities found that over 50% of the personal samples exceed the New Zealand Workplace Exposure Standard (McLean *et al*., 2017). It is predicted that approximately 10,000 Australian workers will develop lung cancer in their lifetime because of their occupational exposure to crystalline silica (Carey *et al*., 2021).

Crystalline silica is one of WorkSafe's priority carcinogens. WorkSafe's Carcinogens and Airborne Risks programme is seeking to address the high risk of crystalline silica exposure in the engineered stone industry and to improve risk management of silica in broader industry sectors such as construction.

The NZCS shows that about 10.3% of New Zealand workers are probably exposed to crystalline silica. Some 1.6% and 2.4% of New Zealand workers are deemed to have probable exposure to crystalline silica at a medium and high level, respectively. Extrapolation to the New Zealand working population suggests that approximately 117,600 workers could be occupationally exposed to crystalline silica at a medium and high level.

CIRCUMSTANCES OF EXPOSURE

The most common activities leading to probable exposure to crystalline silica are working with concrete, natural stone, or bricks (13.1%), mixing concrete or cement (11.3%), and demolitions or teardowns (7.5%). All workers mixing concrete or cement, or doing demolitions or tear downs are assigned a high level of exposure.

EXPOSURE CIRCUMSTANCES	EXPOSURE TO CRYSTALLINE SILICA* (%)	BY LEVEL OF EXPOSURE** (%)			
		Low	Medium	High	Total
Working with concrete, natural stone, or bricks	13.1	2.8	–	97.2	100
Mixing concrete or cement	11.3	–	–	100	100
Demolitions or teardowns	7.5	–	–	100	100

This table does not include all exposed workers.

* Percentage of all exposed persons who are exposed in the given exposure circumstance.

** Percentage of persons exposed in the given exposure circumstance who are exposed at this exposure level. Workers could be exposed through more than one activity.

– Working with concrete, natural stone, or bricks includes cuting, drilling, grinding, and polishing.

TABLE 12: Main circumstances leading to probable exposure to crystalline silica

THE USE OF CONTROLS

Controls are considered for working with concrete, natural stone, or bricks. About four in ten (39.0%) report using water suppression. A similar proportion (41.2%) of workers report using on-tool ventilation or dust collection. Over one quarter (27.6%) report using both controls all the time. Nearly half (49.2%) of workers report not using any of these controls.

EXPOSURE CIRCUMSTANCES	USE OF CONTROLS (all the time) (%)			
	Water suppression	On-tool ventilation or dust collection	Both	None
Working with concrete, natural stone, or bricks	39.0	41.2	27.6	49.2

Workers could use more than one control.

TABLE 13: Self-reported information on the use of controls when performing tasks with probable exposure to crystalline silica

OTHER PAHs

Polycyclic aromatic hydrocarbons (PAHs) are a group of chemicals with related structures, which are formed through the incomplete combustion of organic material, and usually occur as complex mixtures. Occupational exposure to PAHs during certain work processes causes lung cancer and non-melanoma skin cancer. There is some evidence that PAHs also cause bladder cancer. One PAH, benzo (a)pyrene is classed by IARC as a Group 1 carcinogen while others are classified as 2A (probably carcinogenic to humans), 2B (possibly carcinogenic to humans) or 3 (not classifiable as to their carcinogenicity to humans).[8] In the OccIDEAS, other PAHs includes benzo(a)pyrene, which is a Group 1 carcinogen (carcinogenic to humans).

[8] There are no epidemiological studies on human exposure to individual PAHs, because these chemicals never occur in isolation in the environment but are present as components of complex chemical mixtures. PAHs are very widespread environmental contaminants, because they are formed during incomplete combustion of materials such as coal, oil, gas, wood, or waste, or during pyrolysis of other organic materials, such as tobacco. Data on the carcinogenicity of PAHs to humans are available primarily from studies in occupational settings where workers are exposed to mixtures containing PAHs. It is difficult to ascertain the carcinogenicity of the component PAHs in these mixtures, because of potential chemical interactions and the presence of other carcinogenic substances.

The NZCS estimates that around 8.1% of New Zealand workers are probably exposed to other PAHs. Some 1.4% of New Zealand workers are deemed to have high other PAHs exposure. Extrapolation to the New Zealand working population suggests approximately 38,000 workers are probably exposed to a high level of other PAHs.

CIRCUMSTANCES OF EXPOSURE

The most common circumstances or tasks resulting in probable exposure to other PAHs are welding metals (30.4%). Among those exposed, nearly seven in ten (68.3%) workers are assigned a low-level exposure, 16.4% medium-level exposure, and 15.3% high-level exposure.

Other important circumstances causing probable exposure to other PAHs include:

- using or reparing fuel-powered equipment indoors (14.2%)
- stripping paint with a heat gun (10.4%)
- burning waste in the open (10.3%)
- frying, barbequing or using a wok during food preparation (8.6%)
- operating diathermy equipment (3.8%)
- overhaul, clean up, and/or sifting through the remains of a fire (3.0%)
- frontline fire fighting (2.8%).

EXPOSURE CIRCUMSTANCES	EXPOSURE TO OTHER PAHs* (%)	BY LEVEL OF EXPOSURE** (%)			
		Low	Medium	High	Total
Welding metals	30.4	68.3	16.4	15.3	100
Using or repairing fuel-powered equipment indoors	14.2	–	83.4	16.6	100
Stripping paint with a heat gun (burning off paint)	10.4	–	83.9	16.1	100
Burning waste or garbage in the open	10.3	–	–	100	100
Frying, barbequing, or using a wok during food preparation	8.6	100	–	–	100
Operating diathermy equipment	3.8	67.0	–	23.0	100
Fire fighter:					
– overhaul, clean up, and/or sifting through the remains of a fire	3.0	–	82.1	17.9	100
– frontline fighting	2.8	–	74.9	25.1	100

This table does not include all exposed workers.

* Percentage of all exposed persons who are exposed in the given exposure circumstance.

** Percentage of persons exposed in the given exposure circumstance who are exposed at this exposure level. Workers could be exposed through more than one activity.

TABLE 14: Main circumstances leading to probable exposure to other PAH

THE USE OF CONTROLS

The use of controls is asked of firefighters. Some 75% of frontline firefighters with probable exposure to other PAHs report using breathing apparatus more than 50% of the time. Over six in ten (64.4%) of firefighters who overhaul, clean up, and/or sift through the remains of a fire report wearing breathing apparatus more than 50% of the time.

CHROMIUM VI

Chromium VI is classified by IARC as a Group 1 carcinogen (carcinogenic to humans). The IARC considers there is sufficient evidence that chromium VI causes lung cancer and limited evidence that it causes nasal cavity and paranasal sinus cancer (IARC, 2019).

Chromium VI compounds are commonly used in the textile industry including printing inks, dyes, and textile finishing products. Previous studies in New Zealand have found a higher risk of bladder cancer in clothing and made-up textile product manufacturing workers, tailors, dressmakers, textile product machine operators, sewing and embroidering machine operators, and sewing machinists (Dryson *et al*., 2008).

The NZCS shows that approximately 6.2% of New Zealand workers are probably exposed to chromium VI at any level. Some 1.2% of New Zealand workers are deemed to have high chromium VI exposure. Extrapolation to the New Zealand working population suggests that approximately 33,600 workers could be occupationally exposed to chromium VI at a high level.

CIRCUMSTANCES OF EXPOSURE

Welding stainless, chromium-plated, or construction steel is the most common task causing probable exposure to chromium VI (34.7%), followed by grinding stainless, chromium-plated, or construction steel (28.7%), stripping old paint which was likely to have been applied before 1990 (25.5%), and using Zinc chromate or other chromate primers before painting (22.7%).

Welding stainless, chromium-plated, or construction steel is assigned a low, medium, or high level of exposure depending on whether an air-supplied welding helmet is worn, the amount of time spent welding outside (more or less than half of the time), or if a ventilation system (welding booth, exhaust hood or local exhaust ventilation) is used (more or less than half of the time, or unknown). Over half of those who weld stainless, chromium-plated, or construction steel using MIG/ gas metal arc, TIG/tungsten arc, and plasma arc (52.1%) are exposed to chromium VI at a high level. Some 66.9% of workers using shielded metal arc, stick or manual arc, flux core to weld stainless, chromium-plated, or construction steel are probably exposed to chromium VI at a high level.

All workers grinding stainless, chromium-plated, or construction steel are assigned medium and high levels of exposure to chromium VI. Over 86% of those machining stainless, chromium-plated, or construction steel are probably exposed to chromium VI at a medium and high level.

Although stripping old paint, which was likely to have been applied before 1990, and using zinc chromate or other chromate primers before painting are among the most common tasks resulting in probable exposure to chromium VI, most of the workers performing these two activities are deemed to be exposed to chromium VI at a low level.

EXPOSURE CIRCUMSTANCES	EXPOSURE TO CHROMIUM VI* (%)	BY LEVEL OF EXPOSURE** (%)			
		Low	Medium	High	Total
Welding stainless, chromium-plated or construction steel:	34.7				
– using MIG/gas metal arc, TIG/tungsten arc, plasma arc	27.7	9.3	38.6	52.1	100
– using shielded metal arc, stick or manual arc, flux core	23.3	5.4	27.6	66.9	100
– using braze of oxyacetylene	15.0	6.8	31.5	61.6	100
Grinding stainless, chromium-plated or construction steel	28.7	–	41.0	59.0	100
Stripping old paint which was likely to have been applied before 1990	25.5	80.4	13.0	6.7	100
Applying zinc chromate or other chromate primers before painting	22.7	79.6	13.3	7.1	100
Mixing concrete or cement (for construction workers)	18.8	40.3	4.9	1.6	100
Machining stainless, chromium-plated or construction steel	11.9	13.6	46.1	40.4	100

This table does not include all exposed workers.
* Percentage of all exposed persons who are exposed in the given exposure circumstance.
** Percentage of persons exposed in the given exposure circumstance who are exposed at this exposure level. Workers could be exposed through more than one activity.

TABLE 15: Main circumstances leading to probable exposure to chromium VI

THE USE OF CONTROLS

Information on the use of controls is collected for welding and machining tasks. Some 23% of workers welding stainless, chromium-plated or construction steel report using an air-supplied welding helmet more than half of the time. Nearly one-quarter of people who weld stainless, chromium-plated or construction steel report working outdoors. About 25.9% of workers who machine stainless, chromium-plated or construction steel report a ventilation system operating on the machines they use to machine metal parts.

EXPOSURE CIRCUMSTANCES	USE OF CONTROLS (more than half of the time) (%)		
	Air-supplied welding helmet	Working outdoor	Ventilation system in place
Welding stainless, chromium-plated or construction steel	23.0	24.7	11.0
Machining stainless, chromium-plated or construction steel	–	–	25.9

Workers could use more than one control.

TABLE 16: Self-reported information on the use of controls when performing tasks with probable exposure to chromium VI

WELDING FUMES

Welding fumes are classified by IARC as a Group 1 carcinogen (carcinogenic to humans). The IARC considers there is sufficient evidence that welding fumes cause lung and pharynx cancer and limited evidence that they cause kidney cancer (IARC, 2019). Welding fumes are one of WorkSafe's priority carcinogens. Welding fumes are also a primary source of exposure to chromium VI, nickel, and cadmium.

The NZCS shows that about 3.6% of New Zealand workers are probably exposed to welding fumes. Some 1.7% and 0.4% of New Zealand workers are assigned medium-level and high-level exposure to welding fumes, respectively. Extrapolation to the New Zealand working population suggests that approximately 64,400 workers could be occupationally exposed to wood dust at a medium and high level.

CIRCUMSTANCES OF EXPOSURE

The most common circumstance resulting in probable exposure to welding fumes is welding, torching, brazing, or cutting metals.

THE USE OF CONTROLS

The level of exposure (high, medium, or low) is assigned depending on whether an air-supplied welding helmet is worn, if a ventilation system (welding booth, exhaust hood or local exhaust ventilation) is used (more or less than half of the time, or unknown), or if workers weld in confined spaces. Of those workers who weld metals and are probably exposed to welding fumes, 39.7% are assigned a low-level exposure because they wear a welding helmet with a separate air supply attached. Those who weld metal and do not wear air-supplied welding helmets are probably exposed to welding fumes at medium and high-level exposure. Workers who often weld in confined spaces and do not wear an air-supplied welding helmet are assigned a high-level exposure to welding fumes.

NICKEL

Nickel is classified by IARC as a Group 1 carcinogen (carcinogenic to human). The IARC considers there is sufficient evidence that nickel causes cancer in lung, nasal cavity, and paranasal sinus (IARC, 2019).

The NZCS shows that about 3.9% of of New Zealand workers are probably exposed to nickel. Some 0.6% of New Zealand workers are deemed to have high nickel exposure. Extrapolation to the New Zealand population suggests that approximately 109,200 workers could be occupationally exposed to nickel at a high level.

CIRCUMSTANCES OF EXPOSURE

The most common circumstances resulting in probable exposure to nickel are stripping old paint which was likely to have been applied before 1990 (40.4%), followed by welding stainless steel or nickel alloy (28.1%), grinding stainless steel or nickel alloy (23.3), and machining stainless steel or nickel alloy (15.0%). The level of exposure (high, medium, or low) is assigned depending on whether an air-supplied welding helmet is worn, if a ventilation system (welding booth, exhaust hood or local exhaust ventilation) is used (more or less than half of the time, or unknown), or if workers weld in confined spaces or outdoor.

EXPOSURE CIRCUMSTANCES	EXPOSURE TO NICKEL* (%)	BY LEVEL OF EXPOSURE** (%)			
		Low	Medium	High	Total
Stripping old paint that is likely to have been applied before 1990	40.4	85.5	9.0	5.5	100
Welding stainless steel or nickel alloy:	28.1				
– using MIG/ gas metal arc, TIG/tungsten arc, plasma arc	24.6	8.0	40.1	58.0	100
– using shielded metal arc, stick or manual arc, flux core	22.0	7.3	34.3	51.9	100
– using oxyacetylene	13.7	4.9	35.9	59.1	100
– using braze	10.8	6.2	33.2	60.6	100
Grinding nickel, nickel alloys and stainless steel	23.3	–	43.0	57.0	100
Machining nickel, nickel alloys and stainless steel	15.0	12.9	49.5	37.5	100

This table does not include all exposed workers.

* Percentage of all exposed persons who are exposed in the given exposure circumstance.

** Percentage of persons exposed in the given exposure circumstance who are exposed at this exposure level. Workers could be exposed through more than one activity.

TABLE 17: Main circumstances leading to probable exposure to nickel

THE USE OF CONTROLS

Information on the use of controls is collected for welding and machining tasks. Nearly one-third (31.2%) of workers welding stainless steel or nickel alloy report using an air-supplied welding helmet more than half of the time. Nearly one-fifth (19.7%) of people who weld stainless steel or nickel alloy report working outdoors. About 26.4% of workers who machine stainless steel and nickel alloy report there is a ventilation system on the machines they use to machine metal parts.

	USE OF CONTROLS (more than half of the time) (%)		
EXPOSURE CIRCUMSTANCES	**Air-supplied welding helmet**	**Working outdoor**	**Ventilation system in place**
Welding stainless steel, nickel or nickel alloy	31.2	19.7	13.3
Machining stainless steel, nickel or nickel alloy	–	–	26.4

Workers could use more than one control.

TABLE 18: Self-reported information on the use of controls when performing tasks with probable exposure to nickel

WOOD DUST

Wood dust is classified by IARC as a Group 1 carcinogen (carcinogenic to human). The IARC considers there is sufficient evidence that wood dust causes cancer in nasopharynx, nasal cavity, and paranasal sinus (IARC, 2019). A series of case-control studies using 5-year data from 1980–1984 of the New Zealand Cancer Registry has found a strong association between lip, nasopharynx, lung, and liver cancers and exposure to wood dust. Sawmillers, foresters, loggers, and carpenters have been at a higher risk of lung, lip, and nasopharynx cancer (Kawachi *et al*., 1989). Wood dust is one of WorkSafe's priority carcinogens.

The NZCS shows that about 8.4% of New Zealand workers are probably exposed to wood dust. Some 4.5% of New Zealand workers are deemed to have high wood dust exposure. Extrapolation to the New Zealand population suggests that approximately 126,000 workers could be occupationally exposed to wood dust at a high level.

CIRCUMSTANCES OF EXPOSURE

The most common circumstances resulting in probable exposure to wood dust are using power tools for carpentry tasks (for example, chopping, cutting, sawing, or sanding wood) (51.4%), followed by sanding wood in preparation for painting with power tools (33.4%) and hand tools (24.8%). Most exposed workers who perform these tasks are assigned a medium or high level of exposure.

Other circumstances causing probable exposure to wood dust include loading/or unloading wood, lumber, or logs (9.3%), demolition (9.2%), and laying wooden floors (7.3%). Almost all workers who do demolition and wooden flooring are deemed to have exposure to wood dust at a high level.

EXPOSURE CIRCUMSTANCES	EXPOSURE TO WOOD DUST* (%)	BY LEVEL OF EXPOSURE** (%)			
		Low	Medium	High	Total
Cutting wood (capentry work):					
– using power tools to chop, cut, saw, or sand wood	51.4	0.5	6.8	92.7	100
Painting work:					
– using power tools to sand wood or chipboard, MDF, plywood, pressed wood or similar	33.4	27.1	30.5	42.4	100
– using hand tools to sand wood or chipboard, MDF, plywood, pressed wood or similar	24.8	23.4	30.4	46.3	100
Loading and/or unloading wood, lumber or logs with hand, handcart, or handtruck	9.3	–	78.9	21.1	100
Demolition or teardowns	9.2	7.3	5.7	87.0	100
Laying wooden floors	7.3	2.6	10.1	87.3	100

This table does not include all exposed workers.
* Percentage of all exposed persons who are exposed in the given exposure circumstance.
** Percentage of persons exposed in the given exposure circumstance who are exposed at this exposure level. Workers could be exposed through more than one activity.
– MDF (Medium Density Fibreboard).

TABLE 19: Main circumstances leading to probable exposure to wood dust

THE USE OF CONTROLS

Of those probably exposed to wood dust from using power sanders in carpentry work, one-fifth (21.2%) report wearing a rubber-half face mask with cartridges. One-fourth report the availability of a local exhaust ventilation system in their work areas. However, over half of the workers probably exposed to wood dust report there are no controls available in their working areas.

Of those probably exposed to wood dust from using a power sander in preparation for painting work, over eight in ten (82.6%) workers report wearing a mask or respirator. Some 45.2% of workers report using a local exhaust ventilation system; a similar proportion (42.7%) report using both masks and ventilation in their work areas.

EXPOSURE CIRCUMSTANCES	USE OF CONTROLS (%)			
	Mask or respirator	Local exhaust ventilation system	Both	None
Using power tools to sand wood in carpentry work	21.2	24.9	9.2	51.4
Using power tools to sand wood in preparation for painting work	82.6	45.2	42.7	12.9

– Workers could report using more than one PPE.
– Workers could perform multiple activities at work.

FIGURE 20: Self-reported information on the use of controls when performing tasks with probable exposure to wood dust

FORMALDEHYDE

Formaldehyde is classified by IARC as a Group 1 carcinogen (carcinogenic to humans). The IARC consider there is sufficient evidence that formaldehyde causes myeloid and non-lymphocytic leukaemia (both acute and chronic) (IARC, 2019). It is widely used in construction, plywood and polymer manufacturing, anatomy and biomedical laboratory, fumigation, painting etc (Protano *et al*., 2022).

The NZCS estimates that around 7.9% of New Zealand workers are probably exposed to formaldehyde at any level. Some 2.3% of New Zealand workers are deemed to have a medium and high formaldehyde exposure (1.7% are assigned medium-level and 0.6% are assigned high-level). Extrapolation to the New Zealand working population suggests that about 64,400 workers could be occupationally exposed to a medium and high level of formaldehyde.

CIRCUMSTANCES OF EXPOSURE

The most common circumstances causing probable exposure to formaldehyde in New Zealand workers are cutting plywood, particle board, marine ply or MDF (33.5%), followed by sanding chipboard, MDF, plywood, pressed wood or similar before painting (23.3%) (exposure is higher in those using power tools), and applying lacquers (19.2%).

Most people who apply lacquers are deemed to have high and medium exposure. Workers who open and enter shipping containers imported from overseas are probably exposed to formaldehyde at a high level.

EXPOSURE CIRCUMSTANCES	EXPOSURE TO FORMALDEHYDE* (%)	BY LEVEL OF EXPOSURE** (%)			
		Low	Medium	High	Total
Cutting plywood, particle board, marine ply, or MDF	33.5	91.8	7.1	1.1	100
The IARC considers sanding chipboard, MDF, plywood, pressed wood or similar before painting	23.3	58.9	39.8	1.3	100
– using a power tool	21.1	60.3	38.2	1.4	100
– using a hand tool	15.3	71.4	26.6	2.0	100
Applying lacquers	19.2	–	99.3	0.7	100
Opening and entering shipping containers imported from overseas	4.1	–	–	100	100
Fire fighting or overhaul, clean up or sifting through the remains of a fire (in firefighters)	3.3	51.9	48.1	–	100
Laying either carpet or vinyl flooring (in construction workers)	2.4	64.8	35.2	–	100

This table does not include all exposed workers.

* Percentage of all exposed persons who are exposed in the given exposure circumstance.

** Percentage of persons exposed in the given exposure circumstance who are exposed at this exposure level. Workers could be exposed through more than one activity.

– Workers could be exposed through more than one activity.

– MDF (Medium Density Fibreboard).

TABLE 21: Main circumstances leading to probable exposure to formaldehyde

THE USE OF CONTROLS

Of those workers who report using power tools to sand chipboard, MDF, plywood, or pressed wood before painting, fewer than half (45.3%) report using a mask/respirator or ventilation. Some 15.3% of them report not using any control at work. However, Australian experts are still considering whether current control measures can reduce formaldehyde exposure (Driscoll *et al*., 2016b; Darcey *et al*., 2016a).

EXPOSURE CIRCUMSTANCES	USE OF CONTROLS (all the time) (%)				
	Local exhaust ventilation system	A mask or respirator	Both	Either	None
Using power tool to sand chipboard, MDF, plywood, pressed wood, or similar before painting	47.7	82.3	45.3	84.7	15.3

MDF (Medium Density Fibreboard).

TABLE 22: Self-reported information on the use of controls when performing tasks with probable exposure to formaldehyde

The use of controls is asked of firefighters who fight fire or overhaul or clean up through the remaining of a fire. The level of exposure to formaldehyde (low or medium) depends on whether firefighters wear breathing apparatus more or less than half of the time during a fire.

SOLAR ULTRAVIOLATE (UV)

Solar UV is classified by IARC as a Group 1 carcinogen (carcinogenic to humans). The IARC consider there is sufficient evidence that solar UV causes melanoma of the skin and limited evidence that it causes cancer in eyes and lips (IARC, 2019). It is estimated that approximately 14.5% of New Zealand workers regularly work outdoors (McCool *et al*., 2009). Melanoma is currently classified as a category B 'disease' (lower priority) based on the National Occupational Health and Safety Advisory Committee (NOHSAC) (WorkSafe New Zealand, 2019).

The NZCS estimates that about 26.8% of New Zealand workers are probably exposed to solar UV at work. Some 6.8% of New Zealand workers are deemed to have high exposure to solar UV. Extrapolation to the New Zealand working population suggests that about 190,400 workers could be occupationally exposed to solar UV at a high level.

CIRCUMSTANCES OF EXPOSURE

New Zealand workers are probably exposed to solar UV through outdoor activities. The level of exposure is identified depending on the amount of working time spent outside and the use of controls. The main circumstances resulting in probable exposure to solar UV are:

- working outdoors for more than four hours per day (46.4%)
- working outdoors between one and four hours per day (43.1%)
- working outdoors for less than one hour per day (10.5%).

Most people working outdoors for more than four hours each day are probably exposed to solar UV at a medium and high level. Those spending less than one hour per day working outdoors are probably exposed to solar UV at a low level.

EXPOSURE CIRCUMSTANCES	EXPOSURE TO OTHER SOLAR UV* (%)	BY LEVEL OF EXPOSURE** (%)			
		Low	Medium	High	Total
Working outdoors for more than 4 hours	46.4	0.2	45.4	54.3	100
Working outdoors between 1 and 4 hours	43.1	39.4	60.6	–	100
Working outdoors for less than 1 hour	10.5	100	–	–	100

* Percentage of all exposed persons who are exposed in the given exposure circumstance.
** Percentage of persons exposed in the given exposure circumstance who are exposed at this exposure level.

TABLE 23: Main circumstances leading to probable exposure to solar UV

THE USE OF CONTROLS

Information on the use of controls is asked for workers working outside during the day. Adequate sun protection is defined as using all four controls (clothing that covers most of the body, sunscreen, hat, and shade) for more than half of the time spent outdoors (Carey *et al*., 2014b).

Wearing clothing covering most of the body (71.1%) and a hat (51.2%) are the most common sun protective controls workers use outdoors. Of those working outside for more than four hours, only 1.7% are considered to have full UV protection. However, some 79.1% of workers report using clothing covering most of their body, 65.1% report using a hat, and almost half (47.3%) report using sunscreen for more than half of the time spent outdoors.

	USE OF CONTROLS (%)				
EXPOSURE CIRCUMSTANCES	**Clothing covering most of the body**	**Sunscreen**	**Hat**	**Shade**	**All controls**
Working outdoors greater than 4 hours	79.1	47.3	65.1	5.8	1.7
Working outdoors between 1 and 4 hours	63.4	35.6	43.2	2.9	0.7
Working outdoors less than 1 hour	51.1	10.3	22.6	8.5	0.9
Total	71.1	38.4	51.2	4.8	1.2

Workers could report using more than one PPE.

TABLE 24: Self-reported information on the use of controls when performing tasks with probable exposure to solar UV

ARTIFICIAL ULTRAVIOLATE (UV)

Artificial UV is classified by IARC as a Group 1 carcinogen (carcinogenic to humans). The IARC considers there is sufficient evidence that artificial UV causes ocular melanoma (IARC, 2006).

The NZCS estimates that approximately 3.7% of New Zealand workers are probably exposed to artificial UV at any level. Some 2.2% of New Zealand workers are deemed to have high artificial UV exposure Extrapolation to the New Zealand working population suggests that approximately 61,600 workers could be occupationally exposed to artificial UV at a high level.

CIRCUMSTANCES OF EXPOSURE

Working in the workplace with other welders is the most common circumstance causing probable exposure to artificial UV. All of such exposures are assigned to a medium and high level of exposure to artificial UV.

		BY LEVEL OF EXPOSURE** (%)			
EXPOSURE CIRCUMSTANCES	**EXPOSURE TO ARTIFICIAL UV* (%)**	**Low**	**Medium**	**High**	**Total**
Other welders in the place where the worker welds	44.1	–	67.8	32.2	100

This table does not include all exposed workers.

* Percentage of all exposed persons who are exposed in the given exposure circumstance.

** Percentage of persons exposed in the given exposure circumstance who are exposed at this exposure level. Workers could be exposed through more than one activity.

TABLE 25: Main circumstances leading to probable exposure to artificial UV

THE USE OF CONTROLS

In the NZCS, the use of air-supplied welding helmet and clothing that completely covers welders' skin while welding is asked for those who do welding. If welders wear air-supplied welding helmets less than half the time, they are deemed to have a probable high exposure to artificial UV.

OCULAR ULTRAVIOLATE (UV)

Ocular UV is classified by IARC as a Group 1 carcinogen (carcinogenic to humans). Ocular damage occurs during exposure to light of shorter wavelengths (UVA – 315–400nm and UVB 280–315nm). Exposure to ocular UV is associated with ocular melanoma, an extremely rare cancer. Ocular melanoma is even less prevalent than melanoma of the skin (National Organization for Rare Disorders, 2022).

Over one-fourth (25.5%) of New Zealand workers are probably exposed to ocular UV. Some 4.1% of New Zealand workers are deemed to have high exposure to ocular UV. Extrapolation to the New Zealand working population suggests that 114,800 workers could be occupationally exposed to ocular UV at a high level.

CIRCUMSTANCES OF EXPOSURE

Working outdoors in the open without any shade is the most common circumstance causing probable exposure to ocular UV (81.9%), followed by working near reflective surfaces (58.5%) and working outdoors under partial shade (44.8%). The level of exposure is determined high, medium, or low depending on the ambient conditions (working under partial shade, in the open with no shade at all or near reflective surfaces) and the use of a control (hats and sunglasses).

EXPOSURE CIRCUMSTANCES	EXPOSURE TO OTHER OCULAR UV* (%)	BY LEVEL OF EXPOSURE** (%)			
		Low	Medium	High	Total
Working outdoors in the open with no shade at all	81.9	57.2	24.3	18.4	100
Working near reflective surfaces (either sand, glass, roofing iron, water, cement, or concrete)	58.5	46.5	37.2	16.4	100
Working outdoors under partial shade (for example, under trees)	44.8	63.5	22.3	14.2	100

* Percentage of all exposed persons who are exposed in the given exposure circumstance.
** Percentage of persons exposed in the given exposure circumstance who are exposed at this exposure level. Workers could be exposed through more than one activity.

TABLE 26: Main circumstances leading to probable exposure to ocular UV

THE USE OF CONTROLS

Controls are considered for workers who work outside during the day. Wearing hats and sunglasses during working outdoors reduces exposure to ocular UV (Rosenthal *et al*., 1988, Backes *et al*., 2019, Behar-Cohen *et al*., 2014). Of those with probable exposure to ocular UV from working in the open without any shade, nearly six in ten (58.6%) workers report wearing hats more than 50% of the time spent outdoors. Some 64.6% of workers report wearing sunglasses when working outside. Four in ten (41.0%) workers report wearing both hats more than half of the time and sunglasses. Some 16% of workers say no controls are used when working outside.

EXPOSURE CIRCUMSTANCES	USE OF CONTROLS (%)			
	Wearing hats more than 50% of the time spent outdoors	Wearing sunglasses	Both	None
Working outdoors in the open without any shade at all	58.6	64.6	41.0	16.0

Workers could report using more than one PPE.

TABLE 27: Self-reported information on the use of controls when performing tasks with probable exposure to ocular UV

GLYPHOSATE

Glyphosate is classified by IARC as a Group 2A carcinogen (probably carcinogenic to humans). The IARC consider there is limited evidence that glyphosate causes non-Hodgkin's lymphoma (IARC, 2019).

Like Australia (Jomichen *et al*., 2017), glyphosate is the most common pesticide used in New Zealand. The NZCS estimates that around 3.4% of New Zealand workers are probably exposed to glyphosate at any level. Some 2.6% of New Zealand workers are assigned high-level exposure. Extrapolation to the New Zealand working populations suggests approximately 70,000 workers could be occupationally exposed to glyphosate at a high level.

CIRCUMSTANCES OF EXPOSURE

Mixing or applying glyphosate/roundup in the last 12 months is the main circumstance resulting in probable exposure to glyphosate (87.8%).

THE USE OF CONTROLS

The use of controls is collected in workers who mixed and applied glyphosate/roundup in the past 12 months. Among exposed people, gloves are most commonly used at 83.1%, followed by boots (79.1%), overall/suits (67.5%), mask or respirator (60.5%), goggles/glasses (56.4%), long trousers (47.6%), and long-sleeved shirt (42.6%). Among people reporting the use of gloves, leather gloves are worn by 8.6% of workers.

When looking at the type of spraying equipment, some 78.1% of workers report using a backpack sprayer, followed by a truck, tractor, or another vehicle with hand-held sprayer (36.7%), and truck, tractor, or another vehicles with a boom in the back (24.3%).

THE USE OF CONTROL		%
Type of PPE	Gloves	83.1
	Boots	79.1
	Overall/suits	67.5
	Mask or respirator	60.5
	Goggles/glasses	56.4
	Long trousers	47.6
	Long-sleeved shirt	42.6
	Short-sleeved shirt	13.5
	Shorts	12.9
	Apron	7.3

THE USE OF CONTROL		%
Day of wearing clothes before washing	1 day	77.1
	2 days	9.5
	3 days and over	9.5
	Don't remember	4.0
Type pf spraying equipment	Backpack sprayer	78.1
	Truck, tractor, or another vehicle with hand-held sprayer	36.7
	Truck, tractor, or another vehicle with a boom in back	24.3
	Truck, tractor, or another vehicle with air-blast sprayer	7.4
	Truck, tractor, or another vehicle with a boom in front	5.4

Workers could report using more than one PPE or spraying equipment.

TABLE 28: Self-reported information on the use of personal protective equipment (PPE) in workers with probable exposure to glyphosate from mixing glyphosate/roundup in the last 12 months

LEAD

Inorganic lead compounds are classified by IARC as a Group 2A carcinogen (probably carcinogenic to human). The IARC consider there is limited evidence that inorganic lead compounds cause stomach cancer (IARC, 2019).

The NZCS estimates that approximately 5% of New Zealand workers are probably exposed to lead at any level. Some 0.6% of New Zealand workers are deemed to have high exposure to lead. Extrapolation to the New Zealand working population suggests that approximately 16,800 workers could be occupationally exposed to lead at a high level.

CIRCUMSTANCES OF EXPOSURE

The main circumstances resulting in probable exposure to lead in New Zealand workers are stripping lead-based or old paint that is likely pre-1990 (38.8%), soldering (38.3%), and grinding welds (30.0%). Other important circumstances leading to probable exposure to lead include welding lead-plated or leaded steel (18.9%), using red lead to undercoat prior painting (12.7%), and machining lead -plated or leaded steel, lead or lead alloys (8.3%).

EXPOSURE CIRCUMSTANCES	EXPOSURE TO LEAD* (%)	BY LEVEL OF EXPOSURE** (%)			
		Low	Medium	High	Total
Stripping lead-based or old paint which was likely to have been applied before 1990	38.8	58.3	36.5	5.2	100
Soldering	38.3	10.8	80.4	8.8	100
Grinding welds	30.0	16.5	58.0	25.5	100
Welding lead -plated or leaded steel, lead or lead alloys	18.9	5.9	53.6	40.4	100
Using red lead to undercoat prior painting	12.7	38.5	48.0	13.4	100
Machining lead -plated or leaded steel, lead or lead alloys	8.3	19.3	51.5	29.3	100

This table does not include all exposed workers.

* Percentage of all exposed persons who are exposed in the given exposure circumstance.

** Percentage of persons exposed in the given exposure circumstance who are exposed at this exposure level. Workers could be exposed through more than one activity and the table does not include all exposed workers.

TABLE 29: Main circumstances leading to probable exposure to lead

THE USE OF CONTROLS

Information on the use of controls is asked for soldering, painting, welding, and machining tasks.

Soldering

Among workers exposed to lead due to soldering, some 38.2% report using a chemical cartridge respirator. About 5.6% report using an air-supplied or SCBA respirator while soldering. Some 45% of workers who often solder report not using any respirator while working.

	USE OF RESPIRATOR WHEN SOLDERING (%)			
EXPOSURE CIRCUMSTANCES	Chemical cartridge respirator	Air-supplied respirator	Simply dust mask	No respirator
Soldering	38.2	5.6	28.2	45.0

Workers report using more than one respirator.

TABLE 30: Self-reported information on the use of controls when soldering

Painting

Among workers exposed to lead due to stripping old or lead-based paint, some 87% report wearing a respirator. However, wearing respirators does not provide adequate protection when solvents are used or when lead-based paintwork is heated (WorkSafe New Zealand, 2017b)). In the NZCS, approximately 37% of workers who wear a respirator report using a heat gun or burning off paint to strip paint. Some 18% of workers who wear respirator report using methylene chloride to strip paint.

Welding

Among people exposed to lead due to welding leaded steel, about 58.1% report using air-supplied welding helmets, 19% report working outdoors and 7.8% report there is a ventilation system (welding booth, exhaust hood, or local exhaust ventilation).

	USE OF CONTROLS (more than half of the time) (%)		
EXPOSURE CIRCUMSTANCES	Air-supplied welding helmet	Working outdoors	Ventilation system in place
Welding	58.1	19.0	7.8

Workers could report using more than one control.

TABLE 31: Self-reported information on the use of controls when welding

Machining

Among people exposed to lead due to machining leaded steel, over one quarter (27.4%) report there is a ventilation system operating on the machines they use to machine metal parts.

STYRENE

Styrene is classified by IARC as a Group 2A carcinogen (probably carcinogenic to humans). The IARC consider there is limited evidence that styrene causes leukaemia and multiple myeloma (IARC, 2019).

The NZCS estimates that approximately 12.2% of New Zealand workers are probably exposed to styrene at any level. Some 0.03% of New Zealand workers are deemed to have high exposure to styrene. Extrapolation to the New Zealand working population suggests that approximately 840 workers could be occupationally exposed to styrene at a high level.

CIRCUMSTANCE OF EXPOSURE

Working indoors less than 20m in the areas where diesel vehicle engines are running is the most common activity resulting in probable exposure to styrene (28.3%), following by driving or riding on a diesel vehicle inside building (24.6%), working indoors less than 20m in the areas where petrol vehicle engines are running (23.0%), and driving or riding on a petrol vehicle inside building (20.5%).

Other important circumstances of exposure include:

- using builder bogs for bogging or gap filling (16.9%)
- using polyester or styrene resin to glue fiberglass or polystyrene (10.4%)
- driving or riding on a petrol vehicle in tunnel or underground in a mine (7.0%)
- driving or riding on a diesel vehicle in tunnel or underground in a mine (5.7%)
- using automotive fillers for bogging or gap filling (5.3%)
- working indoors (less than 20m) from the diesel generators (3.9%)
- using or repairing diesel equipment indoors (2.9%).

EXPOSURE CIRCUMSTANCES	EXPOSURE TO STYRENE* (%)	BY LEVEL OF EXPOSURE** (%)			
		Low	Medium	High	Total
Diesel vehicles with engines running in the working areas					
– indoors less than 20m	28.3	–	100	–	100
– indoors from 20–50m	14.6	96.0	3.1	0.9	100
Petrol vehicles with engines running in the working areas					
– indoors less than 20m	23.0	24.5	75.5	–	100
– indoors from 20–50m	8.6	97.1	1.4	1.5	100
Driving or riding inside building					
– on a diesel vehicle	24.6	54.3	45.7	–	100
– on a petrol vehicle	20.5	69.0	31.0	–	100
Using builder bogs for bogging or gap filling	16.9	78.9	21.1	–	100
Using polyester or styrene resin to glue fiberglass or polystyrene	10.4	80.4	19.6	–	100
Driving or riding in tunnel or underground in a mine					
– on a petrol vehicle	7.0	78.7	21.3	–	100
– on a diesel vehicle	5.7	42.4	57.6	–	100
Using automotive fillers for bogging or gap filling	5.3	60.0	40.0	–	100
Working indoors (less than 20m) from the diesel generators	3.9	17.8	82.2	–	100
Using or repairing diesel equipment indoors	2.9	–	100	–	100

* Percentage of all exposed persons who are exposed in the given exposure circumstance.

** Percentage of persons exposed in the given exposure circumstance who are exposed at this exposure level. Workers could be exposed through more than one activity and the table does not include all exposed workers.

TABLE 32: Main circumstances leading to probable exposure to styrene

THE USE OF CONTROL

Information on the use of controls is not collected for tasks associated with probable exposure to styrene.

SHIFTWORK

Shiftwork is classified by IARC as a Group 2A carcinogen (probably carcinogenic to humans). Shiftwork is 'working time organized to cover more than the usual 8-hour workday, up to a 24-hour period' (CAREX, 2020). Based on IARC, the night shiftwork is 'work during the usual sleeping hours of the general population' (IARC, 2020b). Shiftwork disrupts human circadian rhythms and internal biological 'clock' (CAREX, 2020). Circadian disruptions halt hormone production and affect gene-related cancer. Exposure to shiftwork may increase the risk of breast cancer; however, the duration and dose of exposure is still uncertain (Fritschi *et al*., 2013; Haus and Smolensky, 2013).

Some 8.6% of New Zealand workers are probably exposed to shiftwork. In this context, shiftwork means any of the following shiftwork agents, including graveyard, the light at night, sleep disturbances, phase shift, lack of physical activity, lack of vitamin D, shiftwork and diet, and shiftwork and alcohol.

CIRCUMSTANCES OF EXPOSURE

Working between midnight and 5am or a shift starting between 5am and 7am are the most common circumstances resulting in probable exposure to shiftwork. Similar to AWES (Darcey *et al*., 2016a), exposure is assessed for those working two or more shifts in a row. Some 73.5% of workers who report working graveyard shifts are deemed to have exposure to shiftwork. Over one in three (36.3%) New Zealand workers indicating working in a shift that starts between 5am and 7am are probably exposed to shiftwork.

EXPOSURE CIRCUMSTANCES	PROBABLE EXPOSURE (%)	NO EXPOSURE (%)
Working in a shift between midnight and 5am	73.5	26.5
Working in a shift starting between 5am and 7am	36.3	63.7

Workers could be exposed through more than one activity and the table does not include all exposed workers.

TABLE 33: Main circumstances leading to probable exposure to shiftwork

Further information, including the type of roster, sleep disturbance, physical activity, or diet is collected for those reporting working graveyard shifts between midnight and 5am. This additional information is used for assigning the exposure level (low, medium, and high) of shiftwork (Fristchi *et al*., 2013).

Of those working night shifts, one in three (32.9%) report frequently and always experiencing difficulty falling or staying asleep. Nearly half (47.6%) report sleeping less than six hours or more than nine hours per night. One-fourth (24%) who report experiencing both signs of sleep disturbance (as above) are assigned a high-exposure level.

Of those working graveyard shifts, one in seven (14%) workers report working in backward rotation rosters for more than four nights. Some 7.8% of those who work in graveyard shifts report working in forward rotation rosters for more than three nights. These people are probably exposed to a phase shift at a medium and high level.

More than half (54.6%) of people working between midnight and 5am report that they could easily read at night. These workers are probably exposed to light at work at a high level. One-third (34.6%) of workers who say they could see but not well enough to read at night are deemed to have probable exposure to light at a medium level.

Of those working between midnight and 5am, four in ten (41.1%) report rarely or never doing 20 minutes or more vigorous or moderate physical activity between two consecutive night shifts. A similar proportion (44.5%) of those working

between midnight and 5am report spending less than 30 minutes outdoors. Some 16.4% of workers working night shift report frequently or always drinking alcohol to help them fall asleep. Some 8.7% report having a very unhealthy diet with mostly fatty and sweet foods.

SHIFTWORK RELATED FACTOR	PREVALENCE (%)
Sleep disturbance:	
– frequently and always having difficulty falling or staying asleep	32.9
– sleep less than 6 hours or more than 9 hours	47.6
– both	24.0
Phase shift:	
– working in backward rotation rosters for more than 4 nights	14.0
– working in forward rotation rosters for more than 3 nights	7.8
Light at night:	
– could see but not well enough to read at night at work	34.6
– could easily read at night at work	54.6
Lifestyle factor:	
– rarely or never doing 20 minutes or more vigorous or moderate physical activity	41.1
– spending less than 30 minutes outdoors	44.5
– frequently or always drinking alcohol to help fall asleep	16.4
– having a very unhealthy diet (mostly fatty and sweet foods)	8.7

– Workers could be exposed through more than one activity.
– A backward rotation means that day shifts follow night shifts and then days off. A forward rotation is defined in which night shifts follow day shifts and then days off (Fritschi *et al*., 2013; Haus and Smolensky, 2013).

TABLE 34: Self-reported information on shiftwork related factors

THE USE OF CONTROLS

The use of controls is not asked for shiftwork-related tasks.

5.4 Occupational exposure to carcinogens by industry

Overall exposure by industry

On average, New Zealand workers are probably exposed to 2.6 different carcinogenic agents at any level and 1.3 carcinogens at a medium and high level at work. The highest average number of exposed carcinogens at any level of exposure is found in Agriculture, Forestry and Fishing (6.2), followed by Construction (5.4), Mining (4.8), Transport, Postal and Warehousing (3.2), and Manufacturing (3.1). Agriculture, Forestry and Fishing workers are also exposed to more carcinogenic agents at a medium and high level than other industries.

Overall, the five industries experiencing the highest prevalence of probable exposure to at least one carcinogenic agent at any level are Mining (97.5%), Electricity, Gas Water and Waste Services (92.7%), Agriculture, Forestry and Fishing (88.9%), Construction (76.8%), and Transport, Postal and Warehousing (75.3%).

Exposure to at least one carcinogen at medium and high levels is highest in Mining (92.5%), followed by Agriculture, Forestry and Fishing workers (82.7%), Electricity, Gas Water and Waste Services (80.6%), Construction (63.4%), and Transport, Postal and Warehousing (56.6%).

INDUSTRY	BASE (N)	AT ANY LEVEL OF EXPOSURE		AT MEDIUM AND HIGH LEVEL OF EXPOSURE	
		Exposure to at least one carcinogen* (%)	Average number of exposures	Exposure to at least one carcinogen* (%)	Average number of exposures
All workers	4051	57.5	2.6	39.1	1.3
Accommodation and Food Services	254	45.1	1.5	23.6	0.6
Administrative and Support Services	235	63.0	2.8	46.9	1.5
Agriculture, Forestry and Fishing	303	88.9	6.2	82.7	3.4
Arts and Recreation Services	62	41.6	1.5	25.8	0.6
Construction	356	76.8	5.4	63.4	2.7
Education and Training	159	50.6	1.1	24.8	0.4
Electricity, Gas, Water and Waste Services	154	92.7	4.2	80.6	2.0
Healthcare and Social Assistance	603	54.9	1.9	32.0	0.8
Manufacturing	519	63.7	3.1	44.9	1.6
Mining*	31	97.5	4.8	92.5	2.6
Professional, Scientific and Technical Services	488	45.1	2.2	30.8	1.2
Public Administration and Safety	134	30.8	1.9	23.5	0.8
Retail Trade	440	49.0	1.5	26.8	0.7
Transport, Postal and Warehousing	260	75.3	3.2	56.6	1.6

* Small sample.
– The prevalence of exposure (at any level and by level of exposure) is calculated by dividing the number of exposed people by the total of workers in the given industry.

TABLE 35: Probable exposure to carcinogens by industry

The 10 leading carcinogens probably exposed by industry

The top ten exposed carcinogenic agents at any level of exposure (ordered by prevalence) by industry are presented in Table 36 (refer to Appendix 5 for more details on exposures at any level by industry).

The most frequent exposure at any level across all industries are benzene, diesel engine exhaust, solar UV, and ocular UV. Apart from those carcinogenic agents, there are notable exposure differences by sector.

- Exposure to environmental tobacco smoke is less common in Agriculture, Forestry and Fishing.
- Exposure to crystalline silica, wood dust, and formaldehyde is more common in Construction, and Transport, Postal and Warehousing.
- Glyphosate and other pesticides are common exposures in Agriculture, Forestry and Fishing, and Administrative and Support Services.
- Exposure to chromium VI is more common in Construction, Manufacturing, and Professional, Scientific and Technical Services.
- Lead is among the top ten exposures in Electricity, Gas Water and Waste Services, and Public Administration and Safety.
- Cadmium and nickel are among the ten common exposures in Manufacturing and Mining.

- Other PAHs are one of the ten common exposures in Accommodation and Food Services, Administrative and Support Services, Agriculture, Forestry and Fishing, Manufacturing and Professional, Scientific and Technical Services.
- Exposures to welding fumes and artificial UV are more common in Professional, Scientific and Technical Services.
- Workers in Accommodation and Food Services, Healthcare and Social Assistance, Transport, Postal and Warehousing, Retail Trade, and Public Administration and Safety are more likely to be exposed to shiftwork.
- Exposure to styrene is less common in Healthcare and Social Assistance, and Public Administration and Safety.
- Workers in Healthcare and Social Assistance are more likely to be exposed to ionising radiation.

When looking at the overall levels of exposure to carcinogens, there are some notable differences in exposed carcinogens by industry (Table 37). At medium and high level of exposure, shiftwork is the most common carcinogen in Healthcare and Social Assistance, and Public Administration and Safety. DEE is the most frequent carcinogenic agent in Electricity, Gas Water and Waste Services, Manufacturing, Professional, Scientific and Technical Services, and Mining. Meanwhile, solar UV is the most common carcinogen in the remaining industries. Ocular UV is one of the ten common exposures across all sectors.

Apart from those carcinogens, other important differences in the top ten exposures at a medium and high level by industry are described as below:

- exposure to crystalline silica is more prevalent in Construction, Agriculture, Forestry and Fishing, Administrative and Support Services and Transport, Postal and Warehousing
- exposure to lead is common in Construction, and Professional, Scientific and Technical Services and Electricity, Gas, Water and Waste Services
- exposure to wood dust is common in Agriculture, Forestry and Fishing, Administrative and Support Services, Accommodation and Food Services, Transport, Postal and Warehousing and Manufacturing
- exposure to chromium VI is more common in Manufacturing and Professional, Scientific and Technical Services
- exposure to artificial UV and welding fumes is more common in Manufacturing, and Professional, Scientific and Technical Services. Artificial UV is also a common exposure in Construction
- exposure to glyphosate is more common in Agriculture, Forestry and Fishing, and Administrative and Support Services
- exposure to styrene is more common in Professional, Scientific and Technical Services, and Transport, Postal and Warehousing
- exposure to formaldehyde is more common in Transport, Postal and Warehousing

Please refer to Appendix 7 for the full list of exposures at medium and high levels by industry.

RANK	ALL WORKERS	ACCOMMODATION AND FOOD SERVICES	ADMINISTRATIVE AND SUPPORT SERVICES	AGRICULTURE, FORESTRY AND FISHING	ARTS AND RECREATION SERVICES	CONSTRUCTION	EDUCATION AND TRAINING	ELECTRICITY, GAS WATER AND WASTE SERVICES	HEALTHCARE AND SOCIAL ASSISTANCE	MANUFACTURING	MINING	PROFESSIONAL, SCIENTIFIC AND TECHNICAL SERVICES	PUBLIC ADMINISTRATION AND SAFETY	RETAIL TRADE	TRANSPORT, POSTAL AND WAREHOUSING
	N=4051	N=254	N=235	N=303	N=62	N=356	N=159	N=154	N=603	N=519	N=31	N=488	N=134	N=440	N=260
1	Benzene (30.0%)	Benzene (18.2%)	Solar UV (41.6%)	DEE (73.6%)	Solar UV (36.7%)	DEE (50.6%)	Solar UV (30.4%)	DEE (72.0%)	Benzene (23.6%)	Benzene (33.6%)	DEE (68.4%)	Benzene (26.2%)	Benzene (21.6%)	Benzene (27.9%)	DEE (47.9%)
2	Solar UV (26.8%)	ETS (17.4%)	Benzene (39.2%)	Solar UV (72.7%)	Ocular UV (29.1%)	Solar UV (48.4%)	Ocular UV (28.2%)	Solar UV (56.9%)	Solar UV (18.5%)	DEE (26.7%)	Crystalline silica (65.4%)	DEE (19.7%)	Solar UV (13.8%)	ETS (16.6%)	Solar UV (44.5%)
3	Ocular UV (25.5%)	Solar UV (14.8%)	Ocular UV (36.8%)	Benzene (67.3%)	DEE (17.5%)	Ocular UV (48.3%)	Benzene (20.0%)	Ocular UV (54.5%)	Shiftwork (17.5%)	Ocular UV (23.1%)	Benzene (52.3%)	Ocular UV (18.9%)	Shiftwork (12.8%)	Solar UV (14.6%)	Ocular UV (35.2%)
4	DEE (23.7%)	DEE (13.7%)	DEE (24.6%)	Ocular UV (66.2%)	Styrene (12.8%)	Benzene (45.8%)	ETS (5.4%)	Benzene (47.2%)	Ocular UV (13.4%)	Styrene (18.9%)	Ocular UV (38.4%)	Solar UV (16.7%)	Ocular UV (12.2%)	Ocular UV (13.7%)	Benzene (28.1%)
5	ETS (14.6%)	Other PAHs (12.3%)	Glyphosate (22.5%)	Glyphosate (47.0%)	Benzene (12.2%)	Crystalline Silica (43.9%)	Formaldehyde (5.4%)	Crystalline silica (45.4%)	DEE (9.3%)	ETS (15.5%)	Solar UV (37.5%)	Styrene (14.3%)	DEE (9.9%)	DEE (13.3%)	ETS (27.5%)
6	Styrene (12.2%)	Ocular UV (10.9%)	Wood dust (18.6%)	Wood dust (34.4%)	ETS (9.3%)	Wood dust (38.8%)	DEE (4.1%)	Styrene (20.1%)	Other PAHs (8.6%)	Formaldehyde (14.8%)	Styrene (27.4%)	ETS (9.8%)	ETS (9.1%)	Styrene (8.3%)	Styrene (20.6%)
7	Crystalline Silica (10.3%)	Shiftwork (8.2%)	ETS (12.4%)	Other PAHs (32.7%)	Crystalline Silica (6.4%)	Formaldehyde (31.9%)	Wood dust (2.8%)	ETS (18.1%)	ETS (7.0%)	Other PAHs (14.7%)	Cadmium (23.8%)	Chromium VI (8.5%)	Styrene (7.6%)	Shiftwork (7.6%)	Crystalline Silica (15.0%)
8	Shiftwork (8.6%)	Styrene (8.0%)	Styrene (10.1%)	Crystalline silica (28.3%)	Formaldehyde (5.2%)	Chromium VI (29.3%)	Styrene (2.0%)	Asbestos (8.9%)	Ionising radiation (5.6%)	Chromium VI (14.6%)	ETS (20.5%)	Artificial UV (8.1%)	Lead (7.0%)	Crystalline Silica (4.7%)	Shiftwork (11.4%)
9	Wood dust (8.4%)	Crystalline Silica (5.5%)	Other pesticides (9.9%)	Other pesticides (28.2%)	Asbestos (4.1%)	Styrene (27.4%)	Shiftwork (2.0%)	Shiftwork (8.3%)	Formaldehyde (2.9%)	Nickel (13.2%)	Other PAHs (19.8%)	Welding fumes (8.0%)	Other PAHs (6.1%)	Formaldehyde (2.6%)	Wood dust (9.1%)
10	Other PAHs (8.1%)	Formaldehyde (3.9%)	Other PAHs (8.6%)	Styrene (17.3%)	Shiftwork (3.5%)	ETS (19.7%)	Other PAHs (1.8%)	Lead (8.0%)	Styrene (1.7%)	Solar UV (12.7%)	Shiftwork (17.5%)	Other PAHs (7.5%)	Chromium VI (5.2%)	Ethylene oxide (1.5%)	Formaldehyde (6.9%)

– ETS (Environmental Tobacco Smoke); DEE (Diesel Engine Exhaust); UV (Ultraviolet radiation).
– 'Other PAHs' are polycyclic aromatic hydrocarbons (PAHs) other than vehicle exhaust.
– Shiftwork means any of the following shiftwork agents, including graveyard, light at night, sleep disturbances, phase shift, lack of physical activity, lack of vitamin D, shiftwork and diet, and shiftwork and alcohol.

TABLE 36: The most common carcinogenic agents probably exposed by industry (at any level of exposure)

RANK	ALL WORKERS	ACCOMMODATION AND FOOD SERVICES	ADMINISTRATIVE AND SUPPORT SERVICES	AGRICULTURE, FORESTRY AND FISHING	ARTS AND RECREATION SERVICES	CONSTRUCTION	EDUCATION AND TRAINING	ELECTRICITY, GAS WATER AND WASTE SERVICES	HEALTHCARE AND SOCIAL ASSISTANCE	MANUFACTURING	MINING	PROFESSIONAL, SCIENTIFIC AND TECHNICAL SERVICES	PUBLIC ADMINISTRATION AND SAFETY	RETAIL TRADE	TRANSPORT, POSTAL AND WAREHOUSING
	N=4051	N=254	N=235	N=303	N=62	N=356	N=159	N=154	N=603	N=519	N=31	N=488	N=134	N=440	N=260
1	Solar UV (19.4%)	Solar UV (12.8%)	Solar UV (28.9%)	Solar UV (60.8%)	Solar UV (17.8%)	Solar UV (38.2%)	Solar UV (15.4%)	DEE (50.8%)	Shiftwork (17.5%)	DEE (19.3%)	DEE (60.9%)	DEE (14.3%)	Shiftwork (12.3%)	Solar UV (9.5%)	Solar UV (35.1%)
2	DEE (14.1%)	Shiftwork (8.2%)	Glyphosate (19.2%)	Glyphosate (35.3%)	DEE (12.4%)	DEE (35.6%)	Ocular UV (10.1%)	Solar UV (46.1%)	Solar UV (11.0%)	Ocular UV (14.6%)	Solar UV (34.2%)	Solar UV (12.5%)	Solar UV (11.6%)	DEE (9.1%)	DEE (28.1%)
3	Ocular UV (10.9%)	DEE (7.7%)	Wood dust (17.3%)	Wood dust (33.2%)	Benzene (5.1%)	Crystalline Silica (31.4%)	Shiftwork (2.0%)	Ocular UV (23.7%)	Ocular UV (7.9%)	Benzene (10.9%)	Crystalline silica (27.4%)	Benzene (11.2%)	Benzene (7.8%)	Ocular UV (7.9%)	Benzene (13.4%)
4	Shiftwork (8.5%)	Ocular UV (6.2%)	DEE (11.9%)	Other PAHs (29.6%)	Styrene (4.2%)	Wood dust (30.7%)	Wood dust (1.6%)	Benzene (12.5%)	DEE (2.0%)	Styrene (10.0%)	Cadmium (23.8%)	Ocular UV (10.5%)	Other PAHs (5.7%)	Shiftwork (7.5%)	Ocular UV (12.8%)
5	Benzene (8.3%)	Wood dust (3.7%)	Ocular UV (11.2%)	DEE (26.6%)	Ocular UV (4.1%)	Ocular UV (18.5%)	Lead (1.2%)	Shiftwork (8.3%)	ETS (1.5%)	Artificial UV (9.9%)	Shiftwork (17.5%)	Artificial UV (7.6%)	Ocular UV (4.8%)	Benzene (5.2%)	Shiftwork (11.3%)
6	Wood dust (7.0%)	Crystalline silica (1.6%)	Benzene (9.7%)	Benzene (26.1%)	Shiftwork (3.5%)	Benzene (12.8%)	Formaldehyde (1.2%)	Styrene (5.9%)	Benzene (1.3%)	Solar UV (9.6%)	Other PAHs (17%)	Styrene (7.2%)	DEE (4.7%)	Styrene (3.8%)	Wood dust (9.1%)
7	Styrene (4.4%)	Styrene (1.2%)	Other PAHs (8.2%)	Ocular UV (18.6%)	Wood dust (2.6%)	Other PAHs (10.8%)	ETS (1.2%)	Lead (5.1%)	Formaldehyde (1.1%)	Shiftwork (9.1%)	Styrene (16.6%)	Chromium VI (6.0%)	ETS (3.6%)	ETS (2.6%)	Styrene (8.9%)
8	Crystalline silica (4.0%)	ETS (1.1%)	Crystalline silica (4.2%)	Phenoxy herbicides (12.9%)	Glyphosate (2.3%)	Shiftwork (9.0%)	Benzene (0.7%)	Glyphosate (5.0%)	Other PAHs (0.9%)	Chromium VI (8.3%)	Benzene (14.5%)	Shiftwork (5.9%)	Lead (3.5%)	Wood dust (1.9%)	Crystalline Silica (5.0%)
9	Other PAHs (3.8%)	Formaldehyde (0.2%)	Other pesticides (3.4%)	Crystalline silica (10.5%)	Formaldehyde (0.7%)	Lead (7.8%)	Chromium VI (0.5%)	Asbestos (4.6%)	Ionizing radiation (0.6%)	Wood dust (7.8%)	ETS (11.1%)	Welding fumes (5.5%)	Styrene (2.5%)	Lead (1.5%)	Fomaldehyde (4.3%)
10	Artificial UV (3.3%)	Artificial UV (0.2%)	Shiftwork (3.2%)	Artificial UV (10.2%)	Other PAHs (0.7%)	Artificial UV (7.7%)	DEE (0.3%)	ETS (4.4%)	Ethyleneoxide (0.2%)	Welding fumes (7.5%)	Ocular UV (10%)	Lead (4.5%)	Wood dust (2.4%)	Formaldehyde (1.1%)	Ethyleneoxide (4.0%)

– ETS (Environmental Tobacco Smoke); DEE (Diesel Engine Exhaust); UV (Ultraviolet radiation).
– 'Other PAHs' are polycyclic aromatic hydrocarbons (PAHs) other than vehicle exhaust.

TABLE 37: The most common carcinogenic agents probably exposed by industry (at a medium and high level of exposure)

5.5 Occupational exposure to carcinogens by occupation

In this section, workers' occupations are classified into 30 occupational groups using their job information in the survey. Occupational definitions and categories are made with reference to the paper by Carey *et al*. (2014a) and Athe WES database.[9]

Exposures to carcinogens vary significantly across occupational groups. Construction workers, farmers, emergency workers experience the highest average number of exposures, with each group exposed to more than seven carcinogenic agents. Office workers, teachers, and hospitality workers are among groups experiencing the lowest mean number of exposures (1.3, 1.4, and 0.9, respectively).

The incidence rate ratio is calculated to compare the prevalence of exposure to at least one carcinogen between office workers and other occupational groups. All workers, except those who are hospitality workers and engineers, are more likely than office workers to be exposed to at least one carcinogenic agent at any level. Further analysis will be carried out to identify exposure to carcinogens by socio-demographic characteristics (such as gender, age, ethnicity, education, etc), and occupational group.

OCCUPATIONAL GROUP	BASE (N=)	AVERAGE NUMBER OF EXPOSURES	INCIDENCE RATE RATIO (95% CI)
Office workers	**746**	**1.3**	**1.0**
Animal/horticultural workers	234	4.9	2.5 (2.1,3.0)
Automobile drivers	111	2.9	2.2 (1.7,2.8)
Carpenters	79	6.7	2.5 (1.8,3.4)
Cleaners	100	1.8	1.5 (1.1,2.1)
Construction workers	154	7.6	2.3 (1.9,2.9)
Electrical workers	99	6.4	2.6 (1.9,3.4)
Emergency workers	80	7.4	2.5 (1.8,3.3)
Engineers	63	1.8	1.2 (0.9,1.6)
Farmers	170	7.5	2.5 (2.0,3.1)
Food factory workers	114	2.9	1.7 (1.2,2.3)
Food service workers	203	1.9	1.7 (1.3,2.1)
Handypersons*	19	5.9	2.5 (1.2,4.6)
Health and personal support workers	245	1.8	1.6 (1.3,1.9)
Heavy vehicle drivers	79	5.7	2.6 (1.9,3.5)
Hospitality workers	77	0.9	0.8 (0.5,1.2)
Machine operators	168	4.1	2.1 (1.6,2.6)
Metal workers	159	5.7	2.1 (1.6.2.7)
Miners*	15	5.3	2.6 (1.2,4.9)
Nurses	259	2.5	1.6 (1.3,2.1)
Health professionals	110	1.8	1.4 (1.0,1.9)

[9] The database is confidentially shared with WorkSafe for reference only.

OCCUPATIONAL GROUP	BASE (N=)	AVERAGE NUMBER OF EXPOSURES	INCIDENCE RATE RATIO (95% CI)
Outdoor work NEC	56	3.7	2.4 (1.8,3.1)
Painters	32	5.7	2.6 (1.6.3.9)
Passenger transport workers	30	2.8	2.0 (1.2,3.3)
Plumbers	79	4.6	2.6 (1.8.3.5)
Printers	37	3.2	2.4 (1.5,3.5)
Scientists	112	2.3	1.9 (1.4,2.5)
Teachers	102	1.4	1.5 (1.3,1.8)
Vehicle trades	169	6.3	2.6 (1.9,3.4)
Warehousing workers	142	4.1	2.0 (1.5,2.5)

TABLE 38:
Exposures to carcinogenic agents by occupational group

* Due to a small sample, results are indicative only.

– CI = Confidence Interval; Incidence rate ratio is used to compare the prevalence of exposure to at least one carcinogen at any level between office workers and other occupational groups. This is non-adjusted incidence rate ratio which does not take into account surveyed workers age and gender in relation to the total working population.

Table 39 shows the most common exposures at any level by occupation. Over eight in ten (85.4%) farmers and seven in ten (72.6%) animal/horticultural workers are exposed to solar UV, making it the most considerable exposure for these two occupational groups. Solar UV is also among the top twelve common exposures across all occupations.

Wood dust is carpenters' most common carcinogenic agent (90.2%). It is also more prevalent among horticultural workers, farmers, handypersons, and construction workers.

Over one-third (35.3%) of nurses are exposed to shiftwork, making it the largest exposure in this occupational group. Shiftwork is also one of the top ten common carcinogens among health professionals, emergency workers, health and support workers, machine operators, hospitality workers, heavy vehicle drivers, warehousing workers, food factory workers, and passenger transport workers.

Benzene is the most frequent exposure among automobile workers, cleaners, emergency workers, engineers, food service workers, hospitality workers, health professionals and workers, printers, and painters. It is the second most common carcinogen among animal/horticultural workers, farmers, food factory workers, machine operators, nurses, vehicle trades, and scientists.

DEE is the most common exposure among electrical workers, heavy vehicle drivers, food factory workers, machine operators, warehousing workers, miners, plumbers, vehicle trades, and passenger transport workers. It is also among top five frequent carcinogenic agents among farmers, automobile workers, carpenters, emergency workers, engineers, handypersons, animal/horticultural workers, cleaners, construction workers, printers, and scientists.

Ocular UV is the most common carcinogen experienced by construction, metal, and outdoor NEC workers. Nearly one in three (32.3%) scientists are exposed to formaldehyde, making it the most common exposure in the occupation.

OCCUPATIONAL GROUP	MOST COMMON EXPOSURES (%)											
	1	2	3	4	5	6	7	8	9	10	11	12
Animal/horticultural workers (n=234)	Solar UV (72.6)	Benzene (65.1)	Ocular UV (64.1)	DEE (58.7)	Glyphosate (46.5)	Wood dust (41.7)	Other pesticides (23.0)	Styrene (18.3)	Other PAHs (17.5)	ETS (15.0)	Crystalline silica (10.8)	Other herbicides (9.3)
Automobile drivers (n=111)	Benzene (56.7)	Solar UV (53.7)	DEE (38.2)	Ocular UV (35.1)	ETS (15.8)	Styrene (14.4)	Crystalline silica (11.0)	Formaldehyde* (8.4)	Shiftwork* (6.6)	Wood dust* (4.8)	Asbestos* (4.5)	Artificial UV* (1.6)
Carpenters (n=79)	Wood dust (90.2)	Formaldehyde (74.9)	DEE (60.3)	Benzene (53.8)	Solar UV (50.6)	Ocular UV (50.3)	Crystalline silica (45.6)	Chromium VI (44.8)	Styrene (44.2)	Arsenic (24.5)	Shiftwork* (10.0)	Cadmium* (9.2)
Cleaners (n=100)	Benzene (47.1)	ETS (21.5)	Solar UV (19.0)	Mineral oils (17.7)	DEE (13.4)	Crystalline silica (11.4)	Ocular UV (9.8)	Styrene* (7.0)	Other PAHs* (4.9)	Asbestos* (3.8)	Tetrachloroethylene* (3.4)	Trichloroethylene* (3.0)
Construction workers (n=154)	Ocular UV (66.5)	Crystalline silica (64.8)	Solar UV (61.6)	DEE (55.5)	Wood dust (54.2)	Benzene (52.4)	Formaldehyde (45.3)	Chromium VI (45.1)	ETS (35.3)	Styrene (33.9)	Lead (27.0)	Other PAHs (19.6)
Electrical workers (n=99)	DEE (83.6)	Ocular UV (68.0)	Crystalline silica (65.5)	Solar UV (65.2)	Benzene (57.2)	Styrene (35.8)	ETS (27.2)	Lead (22.4)	Mineral oils (22.0)	Asbestos (19.5)	Chromium VI (12.6)	Cadmium (11.8)
Emergency workers (n=80)	Benzene (72.4)	Solar UV (68.5)	Shiftwork (50.5)	Ocular UV (48.7)	DEE (48.1)	Styrene (39.3)	Lead (31.0)	Other PAHs (25.1)	Formaldehyde (24.9)	Asbestos (22.1)	1,3 Butadiene (21.3)	Chromium VI (21.3)
Engineers (n=63)	Benzene (23.4)	Ocular UV (16.4)	Formaldehyde (16.3)	DEE (15.0)	Solar UV (10.8)	Lead (10.3)	Crystalline silica (9.6)	Styrene (26.4)	Other PAHs (8.7)	Artificial UV (8.3)	Welding fumes (8.3)	Chromium VI (5.6)
Farmers (n=170)	Solar UV (85.4)	Benzene (84.0)	DEE (83.9)	Ocular UV (80.2)	Glyphosate (57.6)	Other PAHs (44.1)	Crystalline silica (41.9)	Wood dust (40.3)	Other pesticides (38.6)	Phenoxy herbicides (28.9)	Welding fumes (17.5)	Artificial UV (17.5)
Food factory workers (n=114)	DEE (29.5)	Benzene (25.3)	ETS (25.0)	Styrene (21.5)	Shiftwork (20.4)	Other PAHs (15.1)	Solar UV (14.3)	Ocular UV (14.0)	Lead (8.8)	Formaldehyde* (6.9)	Crystalline silica* (5.2)	Glyphosate* (3.2)
Food service workers (n= 203)	Benzene (23.6)	ETS (22.4)	Other PAHs (21.6)	Shiftwork (15.5)	DEE (12.4)	Solar UV (11.2)	Ocular UV (8.7)	Styrene (6.3)	Asbestos* (2.7)	Crystalline silica* (2.7)	Formaldehyde* (0.7)	Ethylene oxide* (0.3)
Handypersons* (n=19)	Solar UV (82.0)	Ocular UV (71.2)	DEE (63.2)	Benzene (59.9)	Wood dust (57.5)	Formaldehyde (35.1)	Glyphosate (33.3)	Chromium VI (27.5)	Styrene (27.4)	Crystalline silica (16.7)	Other PAHs (15.5)	Lead (15.5) Nickel (15.5)

OCCUPATIONAL GROUP	MOST COMMON EXPOSURES (%)											
	1	2	3	4	5	6	7	8	9	10	11	12
Health and personal support workers (n=245)	Benzene (27.9)	Solar UV (27.5)	Ocular UV (19.5)	ETS (14.4)	Other PAHs (12.4)	DEE (11.9)	Shiftwork (10.3)	Formaldehyde (5.3)	Asbestos (3.3)	Styrene (2.5)	Crystalline silica* (1.4)	Lead* (0.7)
Heavy vehicle drivers (n=79)	DEE (88.2)	Solar UV (74.1)	Ocular UV (61.3)	Crystalline silica (43.2)	Styrene (42.5)	Benzene (38.0)	ETS (23.8)	Shiftwork (19.1)	Wood dust (18.8)	Formaldehyde (17.5)	Other PAHs (13.9)	Asbestos (6.4)
Hospitality workers (n=77)	Benzene (18.5)	ETS (9.8)	Solar UV (7.1)	Shiftwork (6.4)	Ocular UV (5.4)	DEE (4.8)	Styrene (3.2)	Other PAHs (3.1)	Asbestos (2.5)	Formaldehyde (1.6)	Lead* (0.8)	Wood dust* (0.8)
Machine operators (n=168)	DEE (40.8)	Benzene (39.0)	Styrene (30.4)	Ocular UV (20.2)	Shiftwork (19.7)	Crystalline silica (18.9)	ETS (18.8)	Formaldehyde (14.6)	Nickel (14.0)	Other PAHs (13.9)	Chromium VI (12.8)	Solar UV (12.3)
Metal workers (n=159)	Ocular UV (58.6)	Artificial UV (52.2)	Welding fumes (52.2)	Chromium VI (52.1)	Benzene (43.8)	Nickel (43.2)	Other PAHs (40.7)	DEE (37.8)	Mineral oils (35.5)	Lead (27.7)	Styrene (22.1)	Wood dust (17.3)
Miners* (n=15)	DEE (93.8)	Crystalline silica (86.3)	Benzene (42.8)	Styrene (42.1)	ETS (35.0)	Ocular UV (32.3)	Solar UV (32.3)	Other PAHs (25.5)	Ionising radiation (18.9)	Mineral oils (16.0)	Formaldehyde (16.0)	Asbestos (14.7)
Nurses (n=259)	Shiftwork (35.3)	Benzene (22.0)	Other PAHs (8.5)	Ionising radiation (8.5)	Solar UV (6.9)	Ocular UV (5.9)	DEE (3.6)	ETS (1.9)	Formaldehyde (1.8)	Artificial UV (1.2)	Styrene* (0.5)	Mineral oils* (0.1)
Office workers (n=746)	Benzene (18.3)	Solar UV (14.9)	Ocular UV (13.6)	ETS (13.5)	DEE (11.4)	Styrene (6.4)	Shiftwork (5.6)	Crystalline silica (4.5)	Wood dust (3.3)	Asbestos (3.1)	Formaldehyde (3.0)	Lead (2.4)
Health professionals (n=110)	Benzene (25.1)	Shiftwork (19.6)	Ionising radiation (15.6)	Solar UV (9.8)	Ocular UV (8.7)	Other PAHs (8.2)	DEE (7.6)	Formaldehyde (2.3)	Styrene (2.1)	Crystalline silica (2.1)	ETS* (0.8)	Artificial UV* (0.5)
Outdoor work NEC (n=56)	Ocular UV (56.3)	Solar UV (54.2)	Benzene (49.3)	DEE (29.3)	ETS (26.6)	Styrene (21.1)	Lead (18.9)	Other PAHs^ (13.6)	Chromium VI^ (13.3)	Nickel* (11.9)	Artificial UV* (11.2)	Welding fumes* (11.2)
Painters (n=32)	Benzene (89.0)	Solar UV (57.0)	Wood dust (52.0)	Ocular UV (49.0)	DEE (47.3)	Formaldehyde (43.2)	Cadmium (40.7)	Chromium VI (34.6)	Nickel (33.8)	Crystalline silica (31.4)	Styrene* (20.9)	Other PAHs* (20.4)
Passenger transport workers* (n=30)	DEE (66.3)	ETS (33.5%)	Solar UV (29.9%)	Benzene (18.3)	Ocular UV (16.5)	Shiftwork (16.4)	Styrene (12.1)	Other PAH (3.2)	Crystalline silica (2.0)	–	–	–

OCCUPATIONAL GROUP	MOST COMMON EXPOSURES (%)											
	1	2	3	4	5	6	7	8	9	10	11	12
Plumbers (n=79)	DEE NEC (91.0)	Solar UV (87.7)	Ocular UV (86.1)	Crystalline silica (57.2)	Benzene (46.1)	ETS (23.3)	Styrene (20.7)	Glyphosate* (7.7)	Other pesticides* (4.9)	Asbestos* (4.8)	Shiftwork* (4.0)	Artificial UV* (3.7)
Printers (n=37)	Benzene (56.0)	Other PAHs (52.0)	Mineral oils (44.9)	DEE (35.2)	Styrene (25.7)	Ocular UV (21.8)	Solar UV (21.8)	ETS (20.3)	Dichloromethane* (8.3)	Wood dust* (3.7)	Lead* (3.7)	Nickel* (3.7)
Scientists (n=112)	Formaldehyde (32.3)	Benzene (27.6)	Ocular UV (27.3)	Solar UV (25.8)	DEE (21.7)	ETS (10.9)	Crystalline silica (10.0)	Ionising radiation (7.5)	Glyphosate (6.9)	Other pesticides (6.8)	Shiftwork (5.4)	Styrene (5.2)
Teachers (n=102)	Solar UV (37.9)	Ocular UV (33.5)	Benzene (21.1)	ETS* (6.3)	Formaldehyde* (6.2)	DEE* (4.5)	Wood dust (3.9)	Shiftwork* (3.2)	Other PAHs* (2.4)	Styrene* (2.4)	Acid mist* (1.8)	Lead* (1.8)
Vehicle trades (n=169)	DEE (86.1)	Benzene (69.9)	Ocular UV (64.3)	Styrene (59.6)	Solar UV (47.7)	Asbestos (32.8)	Other PAHs (32.2)	Chromium VI (31.7)	Welding fumes (31.6)	Artificial UV (31.6)	Mineral oils (18.5)	Crystalline silica (17.5)
Warehousing workers (n=142)	DEE (44.7)	Styrene (40.1)	Benzene (39.5)	Solar UV (39.1)	Ocular UV (30.8)	ETS (24.1)	Shiftwork (18.2)	Formaldehyde (17.1)	Ethylene oxide (9.6)	Crystalline silica (7.6)	Nickel (6.9)	Cadmium (6.4)

* Due to a small sample, results are indicative only.

– Not available.

– DEE (Diesel Engine Exhaust); ETS (Environmental Tobacco Smoke); 'Other PAHs' are polycyclic aromatic hydrocarbons (PAHs) other than vehicle exhaust; NEC (Not elsewhere classified).

– Shiftwork means any of the following shiftwork agents, including graveyard, light at night, sleep disturbances, phase shift, lack of physical activity, lack of vitamin D, shiftwork and diet, and shiftwork and alcohol.

TABLE 39: Proportion of workers exposed to at least one carcinogen at any level by occupational group

There are other notable exposure differences to consider:

- construction workers, miners, plumbers, farmers, electrical workers, and carpenters are more likely to be exposed to crystalline silica
- emergency workers, carpenters, machine operators, construction workers, and miners are more likely to be exposed to styrene
- exposure to chromium VI is more prevalent among construction workers, painters, vehicle trades, metal workers, and carpenters
- construction workers, handypersons, emergency workers, and carpenters are more likely to be exposed to formaldehyde
- exposure to lead is more common in electrical, construction, emergency, and metal workers
- farmers and metal workers are more likely to be exposed to other PAHs
- exposures to artificial UV, welding fumes, and nickel are more prevalent in metal workers.

5.6 Occupational exposure to carcinogens by demographic characteristics[10]

By gender

Approximately 57.5% of New Zealand workers are probably exposed to at least one carcinogen through their work, while 23.3% are exposed to five or more carcinogens at any level. On the other hand, 39.1% of workers are exposed to at least one carcinogen at medium and high levels.

When broken down by gender, males are more likely than females to be exposed at any level to at least one carcinogen (67.1% compared to 46.8%) and five or more carcinogenic agents (32.5% compared to 13.1%). Furthermore, 51.5% of male workers are exposed to at least one carcinogen at medium and high levels. This proportion is almost twice as high as that of females (25.1%).

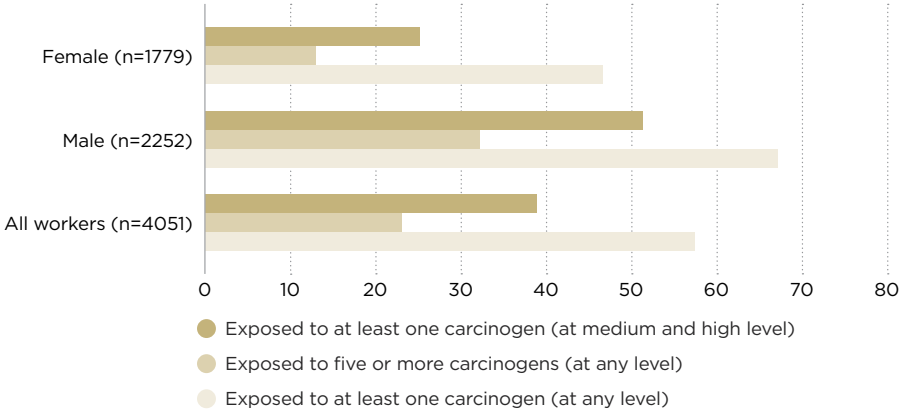


FIGURE 3: Occupational exposure to carcinogenic agents by gender

The top twenty-five exposed carcinogenic agents at any level of exposure (ordered by prevalence) for male and female workers are presented in Table 40.

Benzene is the most common carcinogenic agent exposed by male and female workers. In addition to benzene, exposures to ocular UV, solar UV, DEE, styrene, environmental tobacco smoke, wood dust, formaldehyde, and other PAHs are also common for both genders. However, compared to women, men experience significantly higher exposure proportionally across all carcinogens.

[10] WorkSafe will be conducting further analysis to identify exposure differences by industry, occupation stratified by demographic characteristics.

	MALE (N=2252)		FEMALE (N=1779)	
RANK	**CARCINOGEN**	**PROPORTION (%)**	**CARCINOGEN**	**PROPORTION (%)**
	Exposure to at least one	**67.1**	**Exposure to at least one**	**46.8**
1	Benzene	38.6	Benzene	20.2
2	Diesel engine exhaust	36.1	Solar UV	17.0
3	Solar UV	35.8	ETS	15.3
4	Ocular UV	35.3	Ocular UV	14.8
5	Styrene	18.8	Diesel engine exhaust	10.0
6	Crystalline silica	16.7	Shiftwork	8.7
7	ETS	13.8	Styrene	4.6
8	Wood dust	12.8	Formaldehyde	4.4
9	Other PAHs	11.6	Other PAHs	4.2
10	Formaldehyde	11.1	Wood dust	3.6
11	Chromium VI	10.6	Crystalline silica	3.2
12	Shiftwork	8.6	Glyphosate	2.0
13	Lead	8.2	Asbestos	1.5
14	Artificial UV	6.5	Lead	1.4
15	Welding fumes	6.5	Chromium VI	1.3
16	Nickel	6.4	Other pesticides	1.2
17	Asbestos	6.3	Nickel	1.1
18	Glyphosate	4.6	Ionising radiation	1.0
19	Cadmium	4.3	Cadmium	0.8
20	Mineral oils	4.3	Dichloromethane	0.6
21	Other pesticides	2.7	Mineral oils	0.5
22	Dichloromethane	1.9	Artificial UV	0.5
23	Arsenic	1.7	Welding fumes	0.5
24	Phenoxy herbicides	1.4	Other herbicides*	0.3
25	Cobalt	1.2	Phenoxy herbicides*	0.3

* Due to a small number of exposed workers, results are indicative only.
Dichloromethane can be called Methylene Chloride. Tetrachloroethylene can be called perchloroethylene (perc).

- 'Other PAHs' are polycyclic aromatic hydrocarbons (PAHs) other than vehicle exhaust.
- ETS (Environmental tobacco smoke).
- Shiftwork means any of the following shiftwork agents, including graveyard, light at night, sleep disturbances, phase shift, lack of physical activity, lack of vitamin D, shiftwork and diet, and shiftwork and alcohol.

TABLE 40: Proportion of workers exposed to carcinogenic agents at any level of exposure by gender

When looking at overall exposure to carcinogens, exposure to solar UV at medium and high level is the highest for both male and female workers. In addition, exposures to DEE, ocular UV, benzene, wood dust and shiftwork at medium and high levels are also common in both genders. Proportionally, men appear to experience significantly higher medium and high levels of exposures across all carcinogens than do women.

	MALE (N=2252)		FEMALE (N=1779)	
RANK	**CARCINOGEN**	**PROPORTION (%)**	**CARCINOGEN**	**PROPORTION (%)**
	Exposure to at least one	**51.5**	**Exposure to at least one**	**25.4**
1	Solar UV	26.7	Solar UV	11.5
2	Diesel engine exhaust	23.4	Shiftwork	8.7
3	Ocular UV	15.8	Ocular UV	5.6
4	Benzene	12.6	Diesel engine exhaust	3.8
5	Wood dust	10.7	Benzene	3.3
6	Shiftwork	8.5	Wood dust	3.0
7	Styrene	7.6	ETS	2.1
8	Crystalline silica	6.2	Glyphosate	1.7
9	Other PAHs	6.0	Crystalline silica	1.5
10	Artificial UV	6.0	Formaldehyde	1.5
11	Lead	4.6	Other PAHs	1.4
12	Chromium VI	4.5	Lead	1.0
13	Welding fumes	4.0	Styrene	0.7
14	ETS	3.7	Artificial UV*	0.3
15	Glyphosate	3.5	Chromium VI*	0.3
16	Mineral oils	3.3	Nickel*	0.3
17	Formaldehyde	3.0	Cadmium*	0.3
18	Nickel	2.5	Other pesticides*	0.2
19	Asbestos	2.0	Dichloromethane*	0.2
20	Cadmium	1.7	Mineral oils*	0.2

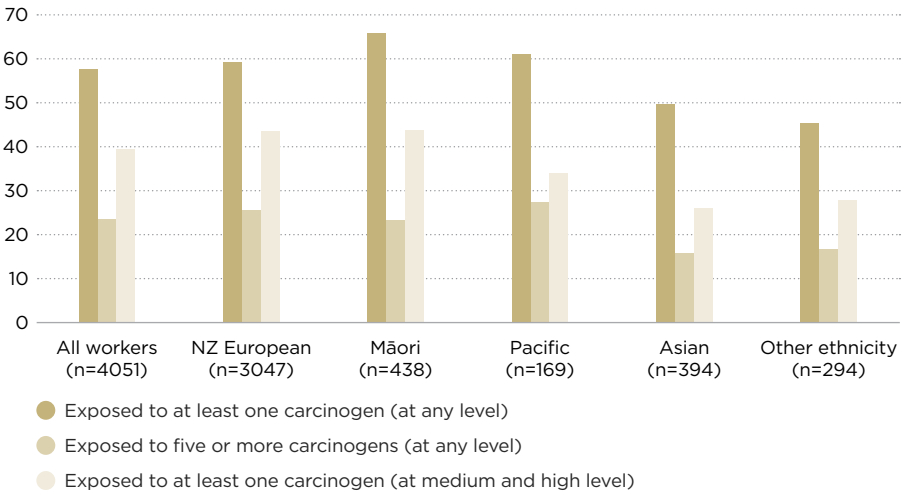
* Due to a small number of exposed workers, results are indicative only.
– Dichloromethane can be called Methylene Chloride.
– ‘Other PAHs’ are polycyclic aromatic hydrocarbons (PAHs) other than vehicle exhaust.
– Shiftwork means any of the following shiftwork agents, including light at night, sleep disturbances, phase shift, lack of physical activity, lack of vitamin D, shiftwork and diet, and shiftwork and alcohol.

TABLE 41: Proportion of New Zealand workers exposed to carcinogenic agents at medium and high level of exposure by gender

By ethnicity

Exposures are not spread evenly across all ethnicities. Over six in ten (65.6%) Māori workers are exposed to at least one carcinogen at work, the highest among all ethnic groups. The prevalence of exposure to five or more carcinogenic agents among Asian workers is 15.5%, significantly lower than that of Māori, Pacific, and NZ European workers (23.0%, 27.1%, and 25.3%, respectively).

Overall, Māori and NZ European workers are more likely than Asian and other ethnic workers to be exposed to at least one carcinogen at medium and high levels (43.4% and 43.2% compared to 26.0% and 27.6%, respectively).



Workers can identify with multiple ethnicities.

FIGURE 4: Occupational exposure to carcinogenic agents at any level, by ethnicity

The top twenty exposed carcinogenic agents at any level of exposure (ordered by prevalence) by ethnicities are presented in Table 42. The most common exposures across all ethnicities are benzene, DEE, solar UV, environmental tobacco smoke, styrene, and ocular UV.

There are notable differences in carcinogen exposure among ethnicities. Māori and Pacific workers are more likely to be exposed to environmental tobacco smoke and shiftwork. NZ European and Māori workers are more likely to be exposed to styrene and wood dust. Asian and other ethnic workers are less likely than NZ European and Māori workers to be exposed to crystalline silica (6.5% and 6.9% compared to 11.2% and 11.5%, respectively).

RANK	NZ EUROPEAN (N=3047)		MĀORI (N=438)		PACIFIC (N=169)		ASIAN (N=394)		OTHER (N=294)	
	CARCINOGEN	PROPORTION (%)	CARCINOGEN	PROPORTION (%)	CARCINOGEN	PROPORTION (%)	CARCINOGEN	PROPORTION (%)	CARCINOGEN	PROPORTION (%)
	Exposure to at least one	**59.1**	**Exposure to at least one**	**65.6**	**Exposure to at least one**	**60.8**	**Exposure to at least one**	**49.4**	**Exposure to at least one**	**45.0**
1	Solar UV	31.8	Benzene	31.0	ETS	24.6	Benzene	28.9	Solar UV	23.8
2	Benzene	31.5	Solar UV	27.6	Benzene	22.7	ETS	18.6	Benzene	22.5
3	Ocular UV	30.4	ETS	25.3	DEE	22.3	DEE	12.0	Ocular UV	21.9
4	DEE	27.1	Ocular UV	23.4	Solar UV	19.0	Solar UV	12.0	DEE	14.4
5	Styrene	13.0	DEE	23.3	Ocular UV	15.4	Ocular UV	11.2	ETS	9.0
6	ETS	12.2	Styrene	13.9	Shiftwork	13.8	Styrene	8.6	Styrene	7.1
7	Crystalline silica	11.2	Shiftwork	11.9	Crystalline silica	10.5	Shiftwork	8.5	Crystalline silica	6.9
8	Wood dust	9.6	Crystalline silica	11.5	Styrene	8.7	Crystalline silica	6.5	Wood dust	6.5
9	Other PAHs	9.2	Wood dust	10.2	Other PAHs	7.5	Other PAHs	4.8	Other PAHs	6.3
10	Formaldehyde	9.0	Formaldehyde	8.3	Wood dust	6.4	Asbestos	4.6	Formaldehyde	6.2
11	Shiftwork	8.0	Other PAHs	6.6	Formaldehyde	6.2	Formaldehyde	4.4	Shiftwork	4.8
12	Chromium VI	7.5	Lead	4.8	Chromium VI*	3.3	Wood dust	3.2	Chromium VI*	3.0
13	Lead	5.8	Chromium VI	4.5	Asbestos*	3.1	Lead	3.2	Asbestos*	2.8
14	Artificial UV	4.6	Asbestos	3.7	Lead*	2.6	Chromium VI*	1.7	Artificial UV*	2.1
15	Welding fumes	4.5	Nickel	3.3	Mineral oils*	1.9	Nickel*	1.6	Welding fumes*	2.0
16	Nickel	4.5	Mineral oils	2.9	Nickel*	1.6	Artificial UV*	1.3	Mineral oils*	1.7
17	Glyphosate	4.5	Artificial UV	2.8	Artificial UV*	1.6	Welding fumes*	1.3	Lead*	1.4
18	Asbestos	4.1	Welding fumes	2.8	Welding fumes*	1.6	Cadmium*	1.3	Nickel*	1.2
19	Mineral oils	3.1	Cadmium	2.8	Glyphosate*	1.2	Ionising radiation*	1.3	Cadmium*	1.1
20	Cadmium	2.8	Glyphosate	2.1	Cadmium*	1.1	Glyphosate*	1.2	Ionising radiation*	0.9

* Due to a small number of exposed workers, results are indicative only.
– Workers can identify with multiple ethnicities.
– 'Other PAHs' are polycyclic aromatic hydrocarbons (PAHs) other than vehicle exhaust.
– ETS (Environmental Tobacco Smoke); DEE (Diesel Engine Exhaust).
– Shiftwork means any of the shiftwork agents, including graveyard, light at night, sleep disturbances, phase shift, lack of physical activity, lack of vitamin D, shiftwork and diet, and shiftwork and alcohol.

TABLE 42: The most common carcinogenic agents exposed by ethnicity, at any level of exposure

By age group

There is no significant difference in exposures to at least one carcinogen either at any level or medium and high level across age groups. The prevalence of exposure to five or more carcinogens at any level also appears to be the same in all age groups.

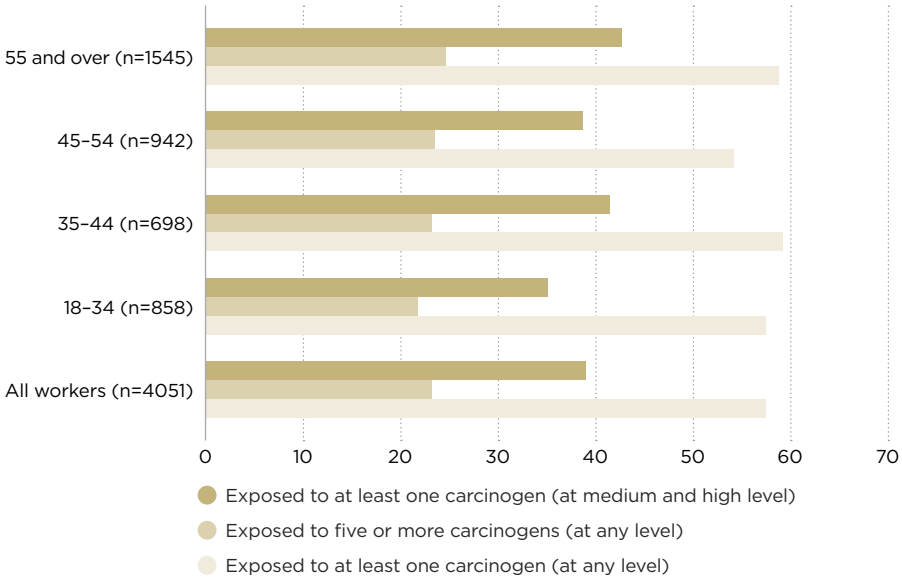


FIGURE 5: Occupational exposure to carcinogenic agents at any level, by age group

The top twenty exposed carcinogenic agents at any level of exposure (ordered by prevalence) by different age groups are presented in Table 43. Benzene and solar UV are the most common exposures at any level across all age groups. Workers in the age group 18–34 and 35–44 are more likely than the age groups 45–54 and 55 and over to be exposed to environmental tobacco smoke (20.9% and 18.0% compared to 9.4% and 7.6%, respectively).

Young workers under 35 years of age are less likely than other age groups to be exposed to other PAHs (5.6% in the age group 18–34 compared to 9.5%, 9.6%, and 9.2% in the age group 35–44, 45–54, and 55 and over, respectively). Exposure to wood dust is less common in this group than in the age groups 45–54 and 55 and over (6.4% compared to 9.6% and 9.8%, respectively).

RANK	18–34 (N= 858)		35–44 (N=698)		45–54 (N=942)		55 AND OVER (N=1545)	
	CARCINOGEN	PROPORTION (%)	CARCINOGEN	PROPORTION (%)	CARCINOGEN	PROPORTION (%)	CARCINOGEN	PROPORTION (%)
	Exposure to at least one	**57.6**	**Exposure to at least one**	**59.3**	**Exposure to at least one**	**54.3**	**Exposure to at least one**	**58.8**
1	Benzene	29.0	Solar UV	31.1	Benzene	29.3	Benzene	31.4
2	Solar UV	21.6	Benzene	30.6	Solar UV	26.8	Solar UV	30.9
3	ETS	20.9	Ocular UV	30.5	DEE	26.1	Ocular UV	28.4
4	DEE	20.3	DEE	23.2	Ocular UV	26.1	DEE	26.5
5	Ocular UV	20.2	ETS	18.0	Styrene	11.9	Styrene	11.1
6	Styrene	13.0	Styrene	12.3	Crystalline silica	10.2	Crystalline silica	10.9
7	Crystalline silica	9.1	Crystalline silica	11.6	Other PAHs	9.6	Wood dust	9.8
8	Shiftwork	9.1	Other PAHs	9.5	Wood dust	9.6	Other PAHs	9.2
9	Formaldehyde	8.0	Shiftwork	9.4	ETS	9.4	Formaldehyde	8.3
10	Wood dust	6.4	Wood dust	8.8	Shiftwork	8.3	Chromium VI	7.7
11	Other PAHs	5.6	Formaldehyde	8.0	Formaldehyde	7.2	ETS	7.6
12	Lead	5.2	Chromium VI	6.1	Chromium VI	6.5	Shiftwork	7.6
13	Chromium VI	4.8	Artificial UV	5.0	Lead	4.9	Glyphosate	5.3
14	Asbestos	4.5	Asbestos	4.9	Glyphosate	4.1	Lead	5.0
15	Nickel	3.3	Welding fumes	4.9	Artificial UV	4.0	Nickel	4.9
16	Cadmium	2.6	Nickel	4.7	Welding fumes	3.9	Artificial UV	4.3
17	Artificial UV	2.3	Lead	4.6	Asbestos	3.0	Welding fumes	4.1
18	Welding fumes	2.2	Cadmium	4.3	Mineral oils	2.9	Mineral oils	3.6
19	Mineral oils	1.8	Glyphosate	3.9	Nickel	2.9	Asbestos	3.5
20	Dichloromethane	1.4	Dichloromethane	2.5	Other pesticides	2.8	Other pesticides	3.3

– 'Other PAHs' are polycyclic aromatic hydrocarbons (PAHs) other than vehicle exhaust.
– ETS (Environmental Tobacco Smoke); DEE (Diesel Engine Exhaust).
– Shiftwork means any of the following shiftwork agents, including graveyard, light at night, sleep disturbances, phase shift, lack of physical activity, lack of vitamin D, shiftwork and diet, and shiftwork and alcohol.

TABLE 43: The most common carcinogenic agents exposed by age group, at any level of exposure

5.7 Occupational exposures to carcinogens by regions[11]

Information on the regions where the workers mostly work is collected in the survey. The prevalence of probable exposure to at least one carcinogen at any level is highest in Waikato and Bay of Plenty (83.0%), followed by Marlborough (78.0%), Southland (77.4%), and Northland (77.0%). Probable exposure at any level in Auckland, Manawatu-Wanganui, Wellington-Wairarapa, Nelson, and Otago is lower than or similar to the overall exposure (57.5%).

When looking at the exposure level, probable medium and high exposures are more prevalent in Marlborough and Tasman (71.3%), followed by Waikato (66.8%), West Coast (65.8%), and Southland (65.2%). Probable medium and high exposures are less prevalent in Wellington-Wairarapa (33.2%) and Auckland (31.5%).

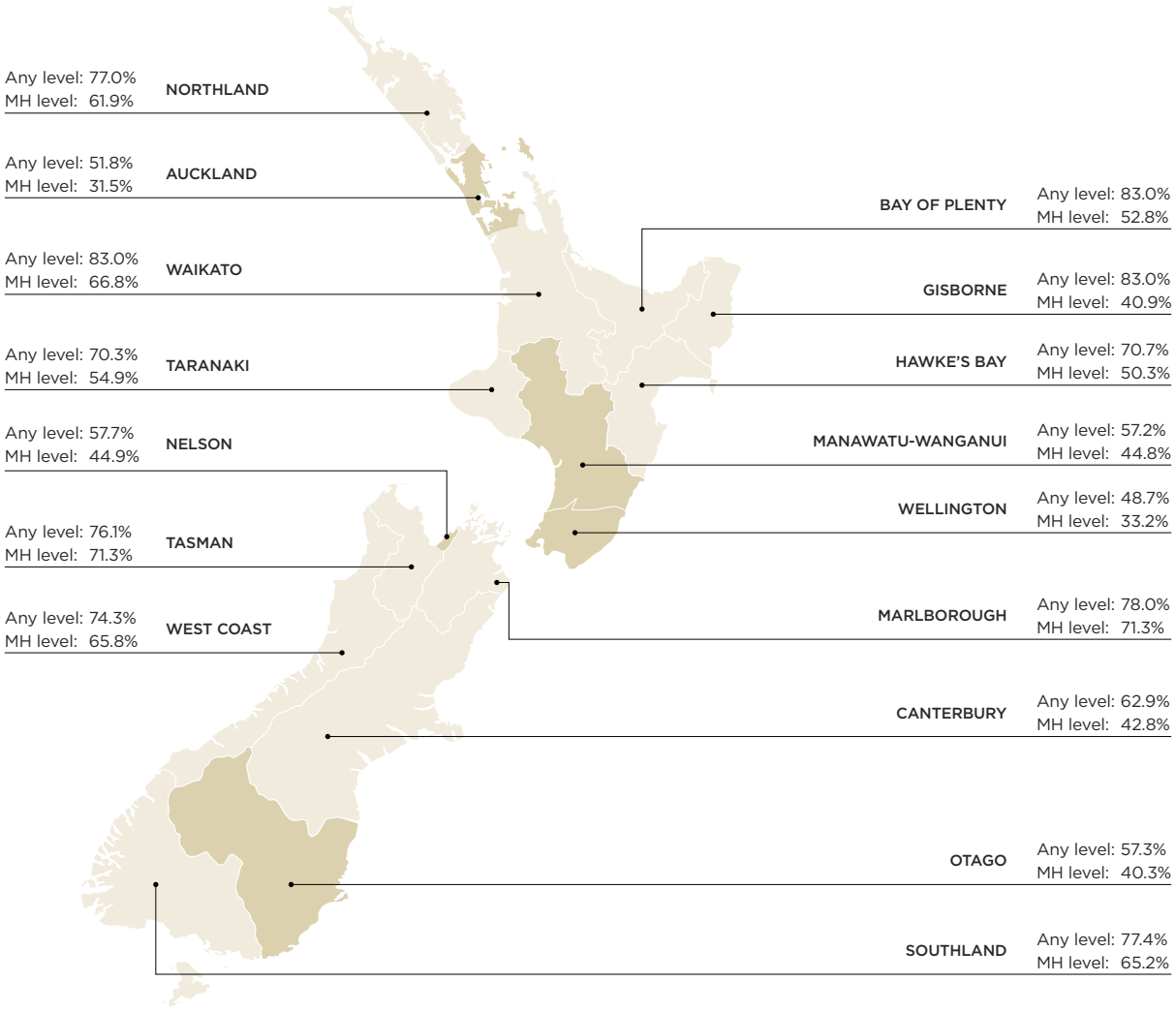


FIGURE 6: Occupational exposure to any carcinogen by regions

[11] WorkSafe will be conducting further analysis to identify exposure differences by industry, occupation, socioeconomic characteristics stratified by regions.

5.8 WorkSafe's Strategic Outcome Framework

WorkSafe's Strategic Outcomes Framework sets out the relationship between the work it does and its goals for work health and safety in Aotearoa New Zealand. The three goals or outcomes are:

- **Healthy work**: work is healthy for workers and those affected by work
- **Safe work**: work is safe for workers and those affected by workers
- **Equitable outcomes**: work is healthy and safe for all in Aotearoa.

Each outcome has indicators which track progress towards the goal. The indicators are included in WorkSafe's Te Tauākī Whakamaunga atu (Statement of Intent) 2021/2022–2024/2025. The NZCS is the source for the outcome indicator 1.2, fewer people are exposed to carcinogens through their work. The level of exposure to carcinogens is a strong proxy for future health outcomes and, therefore, an appropriate 'lead' indicator for WorkSafe's goal of healthy mahi (work). Reducing the proportion of workers with current exposure to carcinogens will reduce the excess risk of cancer and other related diseases. The indicator has two measures:

1. **The proportion of workers who are exposed to any carcinogen at a medium or high level, with the exception of solar UV and shift work factors**.[12] This reflects WorkSafe's focus on addressing airborne carcinogens, most of which are also risk factors for non-malignant respiratory disease and/or other diseases. Some 26.3% of workers have probable medium/high exposure to at least one carcinogenic agent. WorkSafe's target is for this level to trend down over time as carcinogenic exposures are eliminated or controls are improved.
2. **The proportion of workers with any exposure to asbestos**. This reflects the contribution of asbestos to the current burden of harm, with 200–250 deaths per annum attributed to historical asbestos exposure, and the need to manage ongoing risks from exposure to asbestos. Some 4% of New Zealand workers are probably exposed to asbestos at any level.

More information on the Te Tauākī Whakamaunga atu 2021/2022–2024/2025 is available elsewhere on WorkSafe's website.

[12] Although there is a high prevalence of exposure to solar UV among New Zealand workers (26.8%), scientists have recently discussed whether the up-to-date evidence is robust enough to influence the use of protective controls. Additionally, the exposure risk threshold for solar UV is unclear (Gies *et al*., 2018). Melanoma caused by solar UV exposure is currently classified as a category B 'disease' (lower priority) by the National Occupational Health and Safety Advisory Committee of New Zealand (WorkSafe New Zealand, 2019). Similarly, exposure to ocular UV is associated with ocular cancer, which is a sporadic cancer. Shiftwork is another everyday exposure among New Zealand workers, but the individual shift factor captured in the NZCS (for example, shiftwork and physical activity, shiftwork and diet, or shiftwork and vitamin D) have not been fully assessed for their carcinogenicity by the IARC. There is uncertainty about the shiftwork exposure dose and the likelihood of cancer.

5.9 New Zealand and Australia compared

This section explores the exposure prevalence of carcinogenic agents in New Zealand and Australia. It also compares the exposures in Agriculture, Forestry and Fishing, Construction, Healthcare and Social assistance, and Manufacturing sectors between the two countries (where possible). Further work will be conducted to identify the most common circumstances resulting in probable exposure in prioritised sectors[13] in New Zealand.

Carcinogen exposures in New Zealand and Australia

The prevalence of exposure to at least one carcinogen in New Zealand is higher than that reported in Australia (57.5% compared to 37.6%). The AWES covers 38 carcinogenic agents, which might not capture all exposed workers in Australia. Also, the addition of some exposures (for example, erionite, ocular UV and herbicides/pesticides) that were not in AWES might drive the exposure prevalence differences between New Zealand and Australia.

The proportion of probable exposure to DEE, solar UV, crystalline silica, other PAHs, and formaldehyde is higher in New Zealand compared to Australia. The prevalence of exposure to lead is lower in New Zealand than Australia (5.0% compared to 6.1%). Exposure to pesticides is similar in both countries (4.0% exposed). When looking at the level of exposure, except for formaldehyde and DEE, the probable high exposure to these carcinogens in New Zealand is lower than that reported in Australia.

EXPOSURE		NEW ZEALAND	AUSTRALIA
At least one carcinogen		57.5%	37.6%
Solar UV			
	At any level of exposure	26.8%	22.0%
	High exposure	6.8%	12.6%
DEE			
	At any level of exposure	23.7%	13.8%
	High exposure	3.7%	1.8%
Crystalline silica			
	At any level of exposure	10.3%	6.6%
	High exposure	2.4%	3.7%
Formaldehyde			
	At any level of exposure	7.9%	2.6%
	High exposure	0.6%	0.1%
Other PAHs			
	At any level of exposure	8.1%	5.9%
	High exposure	1.4%	2.5%
Lead			
	At any level of exposure	5.0%	6.1%
	High exposure	0.6%	2.7%
Pesticides			
	At any level of exposure	4.0%	4.0%

- Exposure data in Australia is obtained from Carey *et al*. (2014a), Carey *et al*. (2014b), Si *et al* (2016), Jomichen *et al*. (2016), Driscoll *et al*. (2016a), and Driscoll *et al*. (2016c).
- Proportion of high (and medium) exposure is calculated for those exposed to the given carcinogen.
- The table only captures some common carcinogens (where data is available) in New Zealand and Australia.

TABLE 44: Carcinogen exposure in New Zealand and Australia – a comparison snapshot

[13] WorkSafe's prioritised sectors include Agriculture, Forestry, Manufacturing, Construction, Healthcare and Social assistance, and Transport, Postal and Warehousing. The selection of prioritised sectors is initially based on the number of ACC acute injury claims.

Agriculture

Some 88.9% of workers in Agriculture, Forestry and Fishing in New Zealand are probably exposed to at least one carcinogen. The top three common exposures are DEE, solar UV, and benzene which are the same as those found in Australia. The AWES reports a much higher prevalence of exposure in Agriculture in Australia than the NZCS, with 99% exposed (Darcey *et al*., 2016b). However, the analysis presented in the AWES is restricted to the Agricultural industry ANZSIC code 'A01', which does not cover the forestry and fishing sectors.

Except for crystalline silica, nickel, and chromium VI, the probable exposure to individual carcinogens is lower among Agriculture workers in New Zealand compared to Australia.

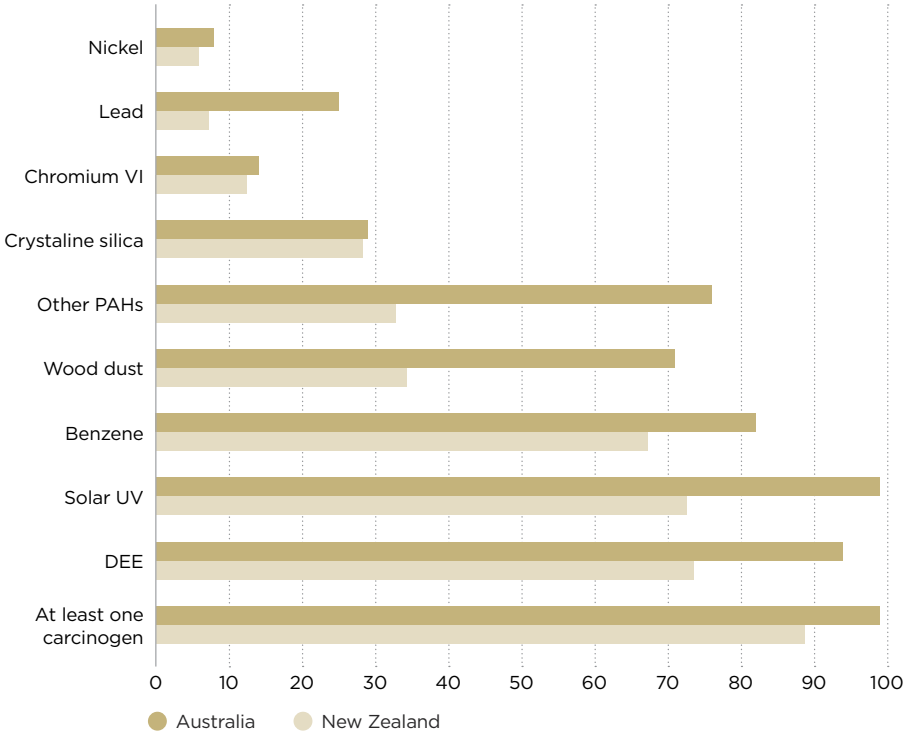


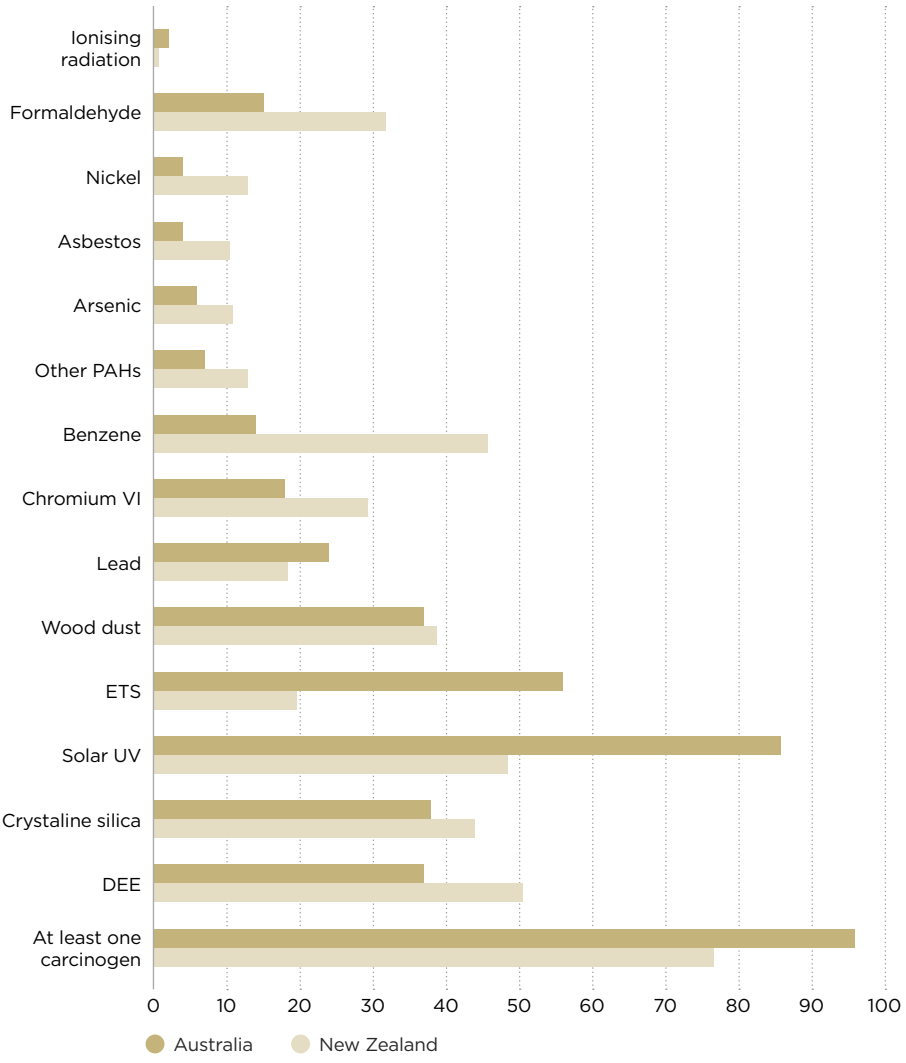
FIGURE 7: Exposure to carcinogens in Agriculture sector in New Zealand and Australia (%)

- Exposure data in the Agriculture sector in Australia is obtained from the AWES (Darcey *et al*., 2016b). In the AWES, Agriculture sector does not include fishing and forestry.
- DEE (Diesel Engine Exhaust); 'Other PAHs' (for benzo (a) pyrene) are polycyclic aromatic hydrocarbons (PAHs) other than vehicle exhaust.
- The chart only captures the most common carcinogens (at any level of exposure) in Agriculture sector in New Zealand and Australia.

Construction

Nearly eight in ten (76.8%) workers in Construction in New Zealand are probably exposed to at least one carcinogen, which is significantly lower than that reported in Australia (with 96% exposed).

Construction workers in New Zealand experience significantly higher exposure to DEE, benzene, chromium VI, formaldehyde, asbestos, nickel, arsenic, and other PAHs than in Australia. On the other hand, exposure to solar UV and ETS are more common in Construction sector in Australia than in New Zealand.



- Exposure data in the Construction sector in Australia is obtained from the AWES (Driscoll *et al*., 2016b).
- DEE (Diesel Engine Exhaust); ETS (Environmental Tobacco Smoke).
- 'Other PAHs' are polycyclic aromatic hydrocarbons (PAHs) other than vehicle exhaust.
- The chart only captures the most common carcinogens (at any level of exposure) in Construction sector in New Zealand and Australia.

FIGURE 8: Exposure to carcinogens in Construction sector in New Zealand and Australia (%)

Manufacturing

Some 64% of workers in manufacturing sector in New Zealand are deemed to be exposed to at least one carcinogen, which is slightly lower than that reported in Australia (with 67% exposed).

Benzene, DEE, solar UV, ocular UV (not reported in AWES), formaldehyde, and other PAHs are the most prevalent exposures in manufacturing sector in New Zealand. While benzene is the biggest exposure in Manufacturing in New Zealand (with 33.6% exposed), only 2% of workers in this industry in Australia are probably exposed to it. Manufacturing workers in New Zealand are less likely than Australia to be exposed to chromium VI, nickel, and wood dust. The type of manufacturing activities undertaken in Australia and New Zealand might drive the exposure differences in the two countries.

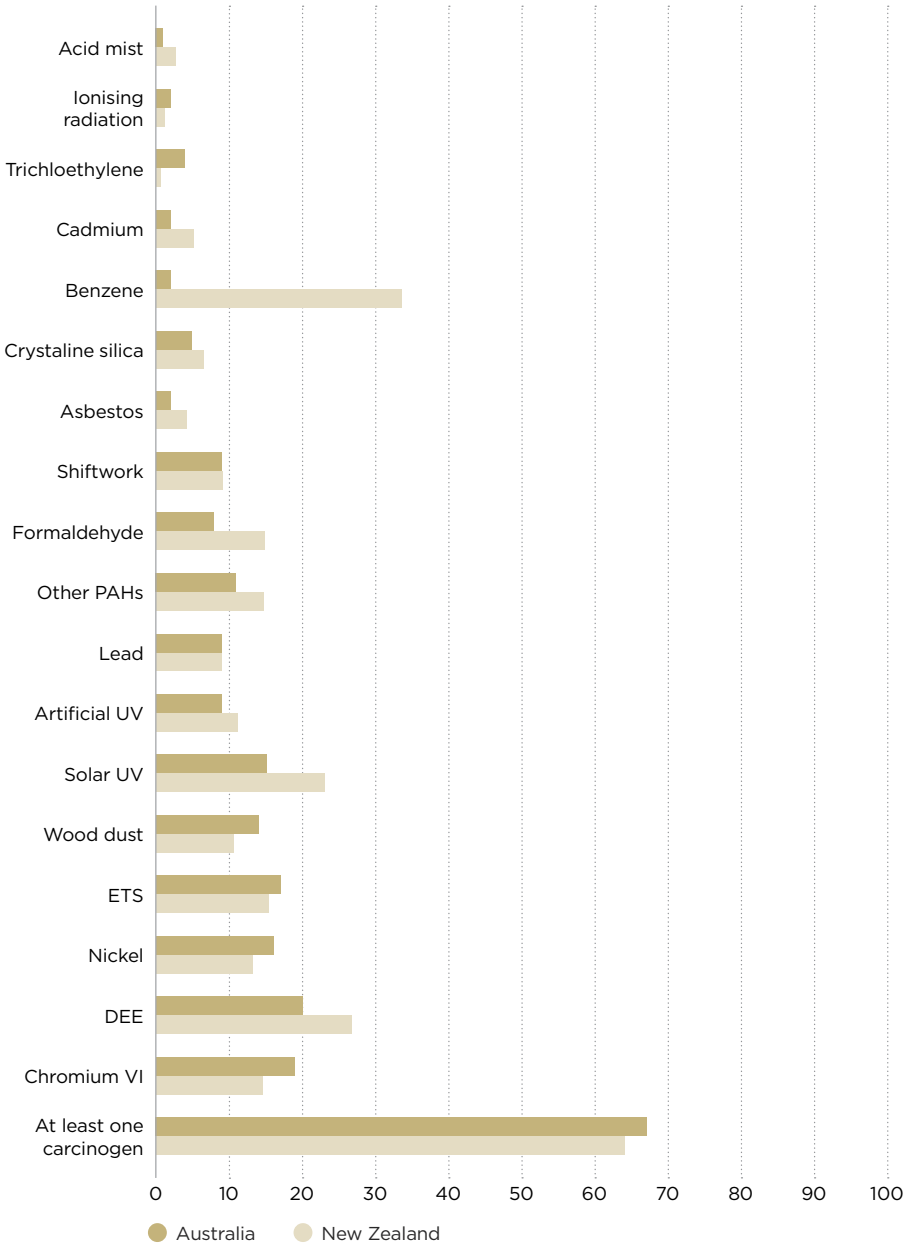


FIGURE 9: Exposure to carcinogens in Manufacturing sector in New Zealand and Australia (%)

- Exposure data in the Manufacturing sector in Australia is obtained from the AWES (Darcey *et al.*, 2016a).
- DEE (Diesel Engine Exhaust); ETS (Environmental Tobacco Smoke).
- 'Other PAHs' are polycyclic aromatic hydrocarbons (PAHs) other than vehicle exhaust.
- The chart only captures the most common carcinogens (at any level of exposure) in Manufacturing sector in New Zealand and Australia.

Healthcare and social assistance

Some 54.9% of New Zealand Healthcare and Social assistance (HCSA) workers are probably exposed to at least one carcinogen, which is slightly higher than that found in Australia (with 50% exposed).

Shiftwork is the most common carcinogenic exposure in HCSA in Australia (with nearly 24% of workers exposed). In New Zealand, with 17.5% of workers exposed, shiftwork is the third most common exposure in HCSA, just behind benzene and solar UV. Although benzene is the most significant exposure in Healthcare and Social assistance in New Zealand, over 94% of those exposed are assigned low-level exposure. The most common circumstance resulting in probable exposure to benzene in the HCSA sector is refuelling vehicles with petrol (85%). Over 70% of the HCSA workers with probable exposure to benzene are health and personal support workers and nurses.

Similarly, exposure to solar UV is more common among HCSA workers in New Zealand than in Australia. The most common circumstance resulting in probable exposure to solar UV in the HCSA sector in New Zealand is working outdoors with no shade. Over half of the HCSA workers with probable solar UV exposure are health and personal support workers.

Exposure to other PAHs is expected in Healthcare and Social assistance in both New Zealand and Australia (8.6% and 9.6%, respectively). Operating diathermy equipment is the main circumstance resulting in probable exposure to other PAHs in this industry. The heating process of diathermy for controlling bleeding or tissue dissection in surgery generates other PAHs (Rai *et al*., 2019).

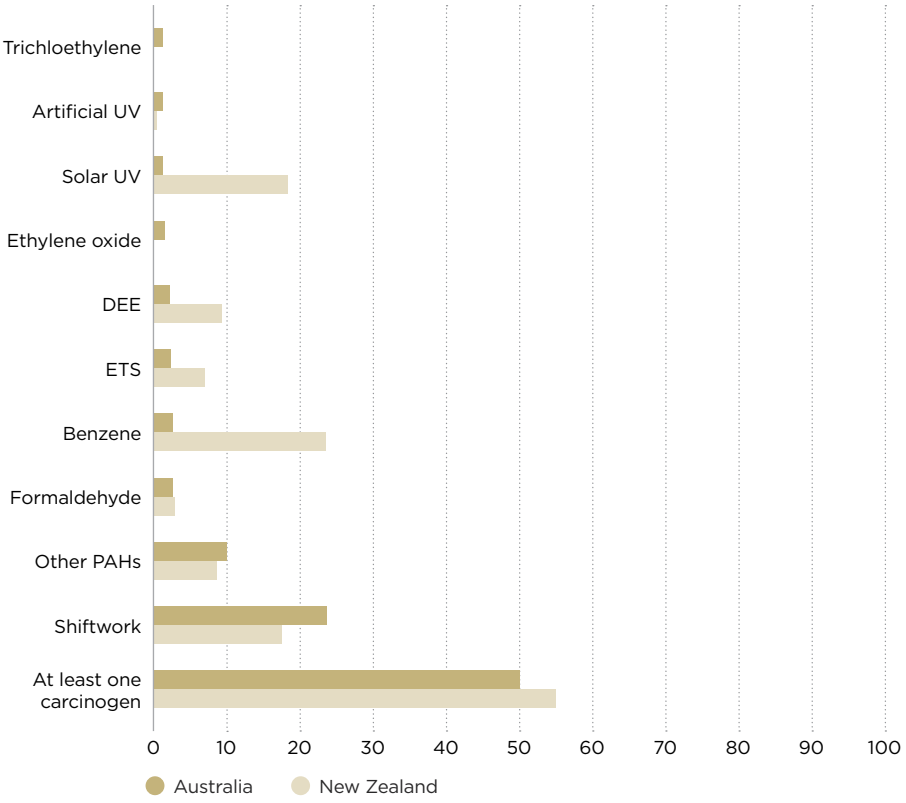


FIGURE 10: Exposure to carcinogens in Healthcare and Social assistance sector in New Zealand and Australia (%)

- Exposure data in the Healthcare and Social assistance sector in Australia is obtained from the AWES (Rai *et al*., 2020).
- DEE (Diesel Engine Exhaust); ETS (Environmental Tobacco Smoke).
- 'Other PAHs' are polycyclic aromatic hydrocarbons (PAHs) other than vehicle exhaust.
- The chart only captures the most common carcinogens (at any level of exposure) in Healthcare and Social assistance sector in New Zealand and Australia.

6.0 Summary

IN THIS SECTION:

Applying the OccIDEAS approach, the NZCS aims to estimate a baseline prevalence of exposure to occupational carcinogens in New Zealand workers.

Over half (57.5%) of workers in New Zealand are probably exposed to at least one carcinogen at any level. The proportion is higher than the exposure prevalence in Australia (37.6%). The AWES narrows down 38 carcinogenic agents, which might not include all workers who are probably exposed to carcinogens in Australia (Carey *et al*., 2014a), while the NZCS covers 44 carcinogens. The addition of some circumstances of exposures and carcinogens (for example, ocular UV, erionite and some pesticides/herbicides) and changes of frequency of tasks that were not in the AWES might contribute to exposure differences between Australia and New Zealand. Compared to AWES, the NZCS has a more diverse and extensive sample of Manufacturing, Construction, Healthcare and Social assistance, and Agriculture workers. For instance, the achieved sample for Healthcare and Social assistance in the NZCS is almost double AWES (603 compared to 369, respectively).

New Zealand workers experience a higher average number of exposures per worker than do workers in Canada and the EU (2.6 carcinogens compared to 0.4 and 1.3 carcinogens in Canada and the EU, respectively) (Peters *et al*., 2015; Kauppinen *et al*., 2000). Like AWES, the NZCS relies on data on workers' tasks at an individual level deemed not included in the CAREX Canada and EU, which might explain the difference.

6.1 Exposures and controls

New Zealand's most common carcinogenic agents are benzene, solar UV, ocular UV, diesel engine exhaust (DEE), environmental tobacco smoke (ETS), styrene, crystalline silica, shiftwork, wood dust, and other PAHs. Probable high exposures are common for benzene, solar UV, shiftwork, wood dust, ocular UV, DEE, ETS, glyphosate, crystalline silica, artificial UV, other PAHs, and chromium VI.

With 30.0% of workers exposed, benzene is the most common exposure in New Zealand. The main tasks leading to probable exposure to benzene are fuelling vehicles with petrol, using petrol to clean hands, refuelling equipment with petrol, and using oil or solvent-based primer or undercoat for painting. Some 7.3% of New Zealand workers are deemed to be exposed to benzene at a high level. Refuelling equipment with petrol is the main task leading to probable high exposure to benzene in New Zealand. Using overseas data, Fowlers and Silver (2015) estimated that refuelling a lawn mower with petrol

twice per month yearly for 50 years could contribute to a cancer risk range of 4/1,000,000 to 50/1,000,000. When looking at the industry, the prevalence of probable exposure to benzene is significantly higher in Agriculture in Australia than in New Zealand (82% compared to 67%, respectively). The AWES also reports that refuelling equipment with petrol is the most common circumstance resulting in benzene exposure in Agriculture in Australia. There is limited information about the potential controls to eliminate and minimise occupational exposure to benzene (Darcey *et al*., 2016b). Safe Work New South Wales suggest that substituting vehicles with safer engines and cleaner fuels, regularly maintaining vehicles and plants, and having adequate ventilation could reduce benzene exposure in agriculture (Safe Work New South Wales, 2022).

Over one-fourth of New Zealand workers are exposed to solar UV or ocular UV, making them the second and third most common carcinogens. The proportion of solar UV exposure is slightly higher than that found in Australia, with 22%; however, the prevalence of probable high exposure to solar UV of those exposed is much lower in New Zealand compared to Australia (25.2% and 57.2%, respectively). The AWES reports that nearly 60% of those exposed to solar UV in Australia work outdoors for more than four hours per day (compared to 46% in New Zealand), which might likely explain a higher prevalence of probably high exposure (Carey *et al*., 2014b). Like Safe Work Australia, WorkSafe has developed a quick guide to help PCBUs (a PCBU- a Person Conducting a Business or Undertaking) choose the most effective sun protection measures using the hierarchy of controls (WorkSafe New Zealand, 2018). Of those exposed to solar UV in New Zealand, about 19% report working under dense shade. Only 1.7% of workers who spend more than four hours working outside are considered to have complete UV protection (full clothes, hat, sunscreen, and shade).

Some 4.0% of New Zealand workers are probably exposed to asbestos at any level. Approximately 1.1% of New Zealand workers are deemed to have high and medium probable exposure to this carcinogenic agent. Asbestos is one of WorkSafe's priority carcinogens. WorkSafe's current focus is on addressing the risks of asbestos exposure. In WorkSafe's Strategic Outcomes Framework, the carcinogen indicator measures the proportion of New Zealand workers exposed to asbestos (as described in section 5.8). The NZCS reports that the main circumstance leading to probable exposure to asbestos in New Zealand is servicing, reparing, or replacing brakes or clutches on vehicles built before 2003.

Some 8.4% of New Zealand workers are probably exposed to wood dust. Of those exposed, over half of them (53.8%) experience high exposure. Sanding is the most common circumstance resulting in wood dust exposure. WorkSafe has recently released a quick guide to advise PCBUs on the health risks of inhaling wood dust and the most effective control measures (WorkSafe New Zealand, 2022b). The NZCS has found that about 9.2% of workers sanding during carpentry and 42.7% of people who report sanding before painting report using both respiratory protective equipment and local exhaust ventilation.

Some 14.6% of New Zealand workers are deemed to be exposed to ETS. Of those exposed, around 20.1% experience probable high exposure. In New Zealand, the Smokefree Environments and Regulated Products Act 1990 requires all internal areas of workplaces to be smokefree (Ministry of Health, 2021a). However, as described in Table 10, only 39.3% of New Zealand workers who are probably exposed to ETS when working indoors report that smoking is banned in their indoor workplaces.

Some 4% of New Zealand workers are probably exposed to any pesticides, similar to that found in the AWES (Jomichen *et al*., 2016). According to the New Zealand Worker Exposure Survey 2004–2006, about 10% of New Zealand workers report using pesticides at work. However, there needs to be more information on how

many people are deemed to be exposed to pesticides from their use (Eng *et al*., 2010). Glyphosate is the most common exposure for New Zealand workers. Various controls to protect workers from glyphosate exposure are used, including gloves, clothing, and eye protector. WorkSafe has designed a factsheet to provide employers and workers working with organophosphates information on health effects, health checks, and first aid (WorkSafe New Zealand, 2017a).

The NZCS has found a higher prevalence of crystalline silica exposure in New Zealand than in Australia (10.3% compared to 6.6%). When looking at those exposed, however, New Zealand has a lower prevalence of probable high exposure to crystalline silica (2.4% in New Zealand compared to 3.7% in Australia). Workers in New Zealand are less likely than Australian workers to mix cement or concrete; or cut, grind, and sand concrete, which are the most common circumstances resulting in high exposure to crystalline silica (Si *et al*., 2016). WorkSafe has set up guidance to advise PCBUs to protect their workers and how to eliminate and minimise respirable crystalline silica dust at work (WorkSafe New Zealand, 2022a).

Welding tasks and machining parts cause exposure to artificial UV, chromium VI, welding fumes, nickel and cadmium. WorkSafe has developed guidance on health risks associated with welding and how to eliminate or reduce them. Local exhaust ventilation is suggested as a practical engineering measure to control the exposures (WorkSafe New Zealand, 2022c). The NZCS has found that, over one fourth of workers who do machining stainless, chromium-plated, or construction steel report a ventilation system operating more than half of the time on plant and equipment they use to machine metal parts.

Formaldehyde is classified by IARC as a Group 1 carcinogen (carcinogenic to humans). Some 7.9% of New Zealand workers are deemed to have probable exposure to formaldehyde. This prevalence is significantly higher than in Australia, with 2.5% exposed. About 7.4% of exposed workers in New Zealand are deemed to have high exposure to formaldehyde, which is nearly 1.5 times higher than that reported in the AWES (Driscoll *et al*., 2016a). Like Australia, cutting or sanding plywood or particle board through carpentry and painting are the most common circumstances resulting in probable exposure to formaldehyde in New Zealand. About 45% of New Zealand workers exposed through power tools to sand plywood report using ventilation and a respirator. However, there is insufficient evidence on using controls to change the level of formaldehyde exposure (Driscoll *et al*., 2016b; Darcey *et al*., 2016a). Further studies are needed to identify practical measures to reduce formaldehyde exposure in New Zealand.

Similarly, although workers in New Zealand have a higher prevalence of probable exposure to diesel engine exhaust and other PAHs, they are less likely to be exposed to these carcinogenic agents at a high level compared to Australia (Driscoll *et al*., 2016c; Peters *et al*., 2015). The Hazardous Substances Calculator is helpful in identifying the most appropriate control measures for combustion products like DEE and other PAHs (Hazardous Substances Toolbox, 2022). More analysis will be conducted to understand better the exposure difference, exposure circumstances and the use of controls in Australia and New Zealand.

Approximately 5% of New Zealand workers are probably exposed to lead at any level. New Zealand workers are deemed to have a lower prevalence of lead exposure than Australia, with 6.1% exposed. While soldering is the main circumstance resulting in lead exposure in Australia (Driscoll *et al*., 2016d), painting is the most common task leading to probable exposure to lead among New Zealand workers. Like Australia (Driscoll *et al*., 2016d), construction in New Zealand has the highest prevalence of lead exposure, with 18.3% exposed. Since April 2021, the notification level of lead has been reduced from 0.48 micromoles per litre of blood (µmol/l) to 0.24 µmol/l (Ministry of Health,

2021b). The new notification level might help better health risk management. WorkSafe has developed a range of guidelines for lead-based paint management (WorkSafe New Zealand, 2017b), suggesting businesses take all reasonable steps to ensure that their work activities do not harm their employees or other people.

About 12.2% of New Zealand workers are probably exposed to styrene at any level. Probable exposure to styrene is more common in Construction; Mining; Transport, Postal and Warehousing; Electricity, Gas, Water and Waste Services; and Manufacturing. The Composites Association of New Zealand (2021), in collaboration with Massey University Centre for Public Health Research, will be conducting a Styrene Exposure Monitoring Study to measure the actual level of exposure among workers in the composites industry. According to WorkSafe New Zealand (2022d), the workplace short-term exposure limit and time-weighted average exposures for styrene are 40ppm and 20ppm, respectively.

6.2 Exposures by industry and occupation

There are noteworthy exposure differences when breaking down carcinogens by industry. Compared to Australia, the prevalence of exposure to at least one carcinogen in New Zealand is similar for Manufacturing, lower for Construction and Agriculture, Forestry and Fishing, but higher for Healthcare and Social Assistance. New Zealand workers are more likely than the EU and Canada to be exposed to at least one carcinogenic agent. Additionally, the top exposures by industries are different across countries. For instance, while shiftwork is experienced by 9.1% of Manufacturing workers in New Zealand, it is the most frequent exposure in the Canadian Manufacturing sector (with 21%) (Peters *et al*., 2015). However, different definitions of shiftwork rosters and related factors such as light at night, vitamin D or sleep disturbance might contribute to the exposure difference (Lin *et al*., 2013; CAREX, 2020). Benzene is the most common exposure in Manufacturing in New Zealand (with 33.6% of workers being exposed to it); however, only 2% of Australian Manufacturing workers are exposed to it (Darcey *et al*., 2016a). About 10.2% of New Zealand Construction workers are probably exposed to asbestos, which is higher than that reported in Australia, with 4% exposed (Driscoll *et al*., 2016b) and slightly lower than that found in the construction of buildings in Canada, with 12% exposed (CAREX, 2022). Crystalline silica is an everyday exposure in Construction, with over four in ten (43.9%) New Zealand workers deemed exposed. This is relatively similar to Australia (38% exposed). The heterogeneity of industry definitions and distributions is expected to contribute to most of the exposure by country (Darcey *et al*., 2016a; Darcey *et al*., 2016b; Driscoll *et al*., 2016b).

Consistent with the findings from Australia (Carey *et al*., 2014a; McKenzie *et al*., 2013), occupation is a significant factor in exposure prevalence among New Zealand workers. Office and hospitality workers are less likely than other occupational groups to be exposed to carcinogenic agents. On the other hand, construction workers, farmers, and emergency workers experience the highest average number of exposures. Some occupations appear to experience greater exposure to specific carcinogenic agents. For example, diesel engine exhaust is the most frequent exposure among electrical workers, heavy vehicle drivers, food factory workers, machine operators, warehousing workers, miners, plumbers, vehicle trades, and passenger transport workers. Exposure to wood dust is more common among carpenters, horticultural workers, farmers, handypersons, and construction workers. Benzene is a frequent exposure not only among automobile workers but also among cleaners, emergency workers, engineers, food service workers, hospitality workers, health professionals and workers, printers, and painters. Exposure to crystalline silica is common among construction workers, miners, plumbers, farmers, electrical workers, and carpenters.

6.3 Exposures by demographics

Exposures to carcinogenic agents are distributed unevenly across ethnicity. Māori workers are the most likely group to be exposed to at least one carcinogen at any level. When looking at the overall exposure level, Māori and NZ European workers are more likely than Asian and other ethnic workers to be exposed to at least one carcinogen at medium and high levels. On the other hand, Asian workers are less likely than Māori, Pacific, and NZ European workers to be exposed to five or more carcinogenic agents. When exposures stratified by ethnicity are examined, NZ European and Māori workers are more likely to be exposed to styrene and wood dust. Asian and other ethnic workers are less likely than NZ European and Māori workers to be exposed to crystalline silica. Diesel engine exhaust exposure is more common in Māori, Pacific, and NZ European workers. Māori and Pacific workers are more likely to be exposed to environmental tobacco smoke and shiftwork. A recent study on New Zealand migrants to Australia has found that nearly 80% of Māori and Pacific workers are exposed to at least one carcinogen, which is significantly higher than that in New Zealand Europeans, with 67% exposed. Exposure to environmental tobacco smoke, wood dust, and lead is more common for Māori and Pacific workers who migrate to Australia (Carey *et al*., 2021).

In addition to ethnicity, gender and age significantly contribute to carcinogen exposure in New Zealand. These two factors should not be overlooked in developing healthy work plans. Compared to females, male workers experience a higher prevalence of exposure across all carcinogenic agents at any level or medium and high levels. Among men, exposures to at least one carcinogen at any level are most elevated in handypersons, painters, heavy vehicle drivers, miners, and electrical workers. In contrast, among women, construction workers, plumbers, vehicle workers, and emergency workers are most likely exposed to carcinogens. This is consistent with AWES, where exposure prevalence is significantly higher among men, especially among farmers, heavy vehicle drivers, and miners (Carey *et al*., 2014). Eng *et al*. (2017) have also found that male workers in New Zealand are two to four times more likely to report exposure to dust and chemical substances that might include carcinogenic and non-carcinogenic agents. However, a study in Italy has found that in specific industries such as fabricated metal manufacturing or construction females are more likely than males to have high carcinogen exposure levels (Scarselli *et al*., 2018).

In the NZCS, workers aged 18–34 and 35–44 are more likely to be exposed to environmental tobacco smoke than those aged 45–54 and 55 and over. Young workers under 35 are less likely to be exposed to other PAHs. They are also less likely than those aged 45–54 and 55 and over to be exposed to wood dust. These findings suggest potential opportunities for targeted groups to improve occupational health and safety.

6.4 Limitations

There are some limitations when interpreting the survey findings.

The OccIDEAS has developed the rules for exposure assessment based on the occupational exposure limits (or workplace exposure standards) (as described in sections 3.3 and 4.1) for many years. Unfortunately, the rules still need to be updated based on recent changes in evidence for some carcinogens. For example, in Australia, the workplace exposure standard for respirable crystalline silica has been reduced from 0.1 mg/m^3 to 0.05 mg/m^3 since 2020 (Safe Work Australia, 2022). Similarly, the workplace exposure standard for benzene in New Zealand has recently been halved from 1ppm to 0.5ppm (WorkSafe New Zealand,

2022d). The European Commission has urgently called to set up a general occupational exposure limits of welding fumes to have adequate protection of workers' health (Sjögren *et al*., 2022). Therefore, the prevalence of probable exposure is subject to change in light of the new occupational exposure limits.

It is not possible to estimate the risk of developing cancer from a single exposure or multiple exposures within OccIDEAS. Carcinogens are classified into two groups based on their carcinogenic effect: threshold and non-threshold. The carcinogenicity is usually associated with a dose, which equals level multiplied by duration. OccIDEAS surveys provide limited information on how many hours each day or week a worker spent on the task, which is essential to assess the duration of exposure. In OccIDEAS, only the tasks on exposure to solar UV and ocular UV include some information on number of working hours but this could be more granular (for example, working more than four hours, between one and four hours, and less than one hour). It is also not plausible to include these questions in every single task in the OccIDEAS questionnaire because it might double the length of the survey, causing a significant response burden to the respondents. However, OccIDEAS is able to perform exposure assessment for individual agents in a specific occupation or industry to better understand the potential health risks of exposure.

Information on the use of controls is only gathered for some exposure circumstances, therefore, it is likely to affect the probability and level of exposure to carcinogen. Respiratory protective equipment and ventilation are the most common measures of control collected in the OccIDEAS (Darcey *et al*., 2016a; Darcey *et al*., 2016b; Driscoll *et al*., 2016b).

Like the AWES (Darcey *et al*., 2016a; Darcey *et al*., 2016b; Driscoll *et al*., 2016b), although the NZCS survey includes potential exposures, there need to be more questions on any exposure circumstances in a sub-sector. It is challenging to ask people to provide information that allows researchers to assign ANZSIC codes for a sub-sector. This is particularly true for some industries with complicated sub-sectors like manufacturing, agriculture, transport, postal and warehousing. OccIDEAS job modules have a range of questions on specific sectors; however, there are a few cases where workers in New Zealand might not fit into any of the categories. For future surveys, it might be worth adding some sub-industries and additional occupations, or job titles into OccIDEAS. Additionally, information on less common sub-industries or occupations might not be well captured in the OccIDEAS. It would be helpful to conduct targeted surveys to estimate carcinogen exposure in a specific sub-sector in New Zealand.

Some exposure circumstances cannot be obtainable from the NZCS. The OccIDEAS questionnaire charts only respondents' current jobs and tasks, not those performed in the past. Additionally, information on the length and frequency of exposure is limited. The NZCS was conducted during the height of COVID-19 in New Zealand when the economy witnessed the loss of jobs in many industries like accommodation and food services, or transport, postal and warehousing, and the opportunities for workers to participate in other sectors such as agriculture, forestry, construction, or some manufacturing sub-sectors may have been negatively impacted (Kiernan, 2020). The labour redeployment during COVID-19 might drive the exposure circumstances in the short or medium term. These points should be considered when comparing occupational exposure to carcinogenic agents between New Zealand and other economies.

Unlike the AWES with telephone-based interviews, the NZCS used web-based interviews to collect data that might be problematic for some respondents' ability to complete the survey. To minimise such issues, the survey supplier conducted cognitive testing and pilot pre-fieldwork to test the length of an interview and identify any questions associated with highly technical words or jargon. However, due to the nature of a web-based interview, we inevitably received some incomplete responses that have been excluded from the final sample after the data cleaning phase.

7.0
Conclusion

The NZCS is the first New Zealand study estimating the current occupational exposure to carcinogenic agents in the workplace.

The survey used the OccIDEAS job-specific questionnaire which has been successfully conducted and validated in Australia and Malaysia. OccIDEAS has created job modules around the kind of exposures that people probably have at work. In OccIDEAS, the questionnaire is also structured to avoid people's perspectives on the risk because some workers might be aware of more risks or fewer risks than others on the same tasks or jobs. A combination of self-reported information from respondents and assessments from Australian occupational epidemiologists and hygienists allows WorkSafe to obtain reliable data on the current carcinogen exposure in New Zealand workers.

The NZCS provides information on how many workers are potentially exposed to at least one carcinogen, either at any level or low, medium, and high levels. It also describes the current exposure to carcinogenic agents by industry and occupation, identifies the common occupational carcinogens in each sector, and explores the use of control measures. These results are essential for developing sector harm profiles and determining the burden of occupational cancer in each industry. Future study could extend to improve the attitudes and behaviours toward using protective measures among workers and employers.

Because OccIDEAS can identify the possibility and level of exposure to a single carcinogen in OccIDEAS, the NZCS helps better understand the circumstances resulting in exposure and the potential health risks. For example, past exposure surveys could only capture 'dust' or 'solvent' in general (Eng *et al*., 2010), while the NZCS can identify the hazards of crystalline silica dust or benzene to which the workers are exposed.

The survey found an uneven distribution of occupational carcinogens by demographic characteristics. Male, Māori, and Pacific workers are more likely to be potentially exposed to occupational carcinogens than others. Some workers also experience a higher probability of exposure to specific carcinogens. For example, environmental tobacco smoke and shiftwork exposure are more common in Māori and Pacific workers. The survey results could help inform development of healthy work programmes and address the inequities in work-related health outcomes in New Zealand.

The survey identifies the gaps in occupational exposure across regions where workers primarily work. Some regions, such as the Bay of Plenty or Waikato, experience a significantly higher prevalence of probable exposure (at any level or medium and high levels) than other regions, for example, Auckland or Wellington-Wairarapa. These findings will add some value to WorkSafe's Maruiti Safe Haven Strategy 2027 and the Regional Focus, which includes the Harm Prevention planning and Te Ao Māori Capability Uplift.

The NZCS provides a baseline picture of carcinogen exposure in the New Zealand working environment. Findings from the survey will support WorkSafe's Hoe Nuku (priority) on carcinogen and airborne risk programme and the Government Health and Safety at Work Strategy 2018–2028. These results could be used to estimate the future burden of occupational cancer from the current exposure to carcinogens, develop the New Zealand profiles on occupational and environmental exposure for known and probable carcinogenic agents, and prioritise which agents to focus on. The different trends of work-related cancers and exposure to carcinogens at work will allow WorkSafe to evaluate the effectiveness of the Carcinogen and Airborne Risk Programme.

The next step is to undertake a deep dive analysis of carcinogen exposure by tasks performed by workers that might be useful for validating the data collected from the NZCS and developing specific interventions for WorkSafe's prioritised sectors.[14] WorkSafe will also be conducting further analysis to identify exposure differences by industry and occupation stratified by demographic characteristics.

[14] WorkSafe's prioritised sectors include Agriculture, Forestry, Manufacturing, Construction, Healthcare and Social assistance, and Transport, Postal and Warehousing. The selection of priorotised sectors is initially based on the number of ACC acute injury claims.

Appendices

IN THIS SECTION:

Appendix 1: Acronyms

ANZSIC	Australia and New Zealand Standard Industrial Classification
AWES	Australian Work Exposures Survey
CAREX	Carcinogen Exposure
DEE	Diesel Engine Exhaust
EPA	Environmental Protection Authority
EU	European Union
ETS	Environmental Tobacco Smoke
IARC	International Agency for Research on Cancer
ICD	International Classification of Diseases
MDF	Medium Density Fiberboard
MH	Medium and high
NOHSAC	National Occupational Health and Safety Advisory Committee
NZ	New Zealand
NZCS	New Zealand Carcinogens Survey
OccIDEAS	Occupational Integrated Database Exposure Assessment System
OEL	Occupational Exposure Limit
PAHs	Polycyclic aromatic hydrocarbons
PCBU	Person Conducting a Business or Undertaking
PCBs	Polychlorinated biphenyls
ppm	Parts of vapour or gas per million
UV	Ultraviolet
WES	Workplace Exposure Standards

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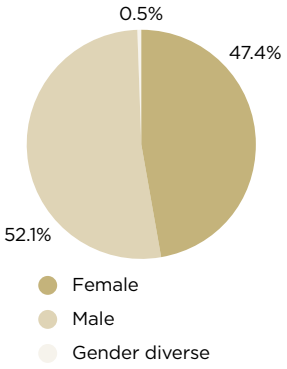
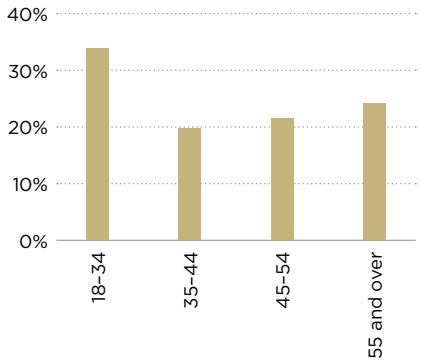
Appendix 3: Demographic characteristics of the survey population (part 1)

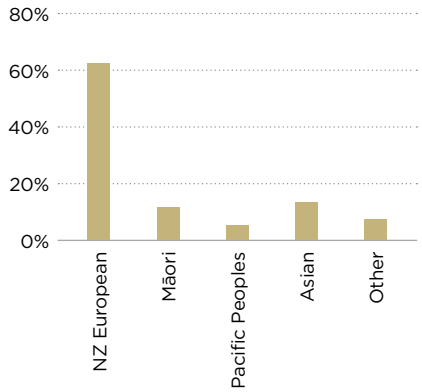
GENDER



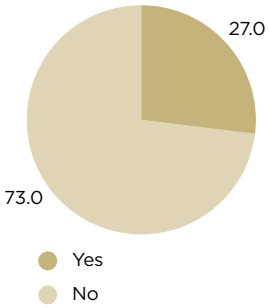
AGE



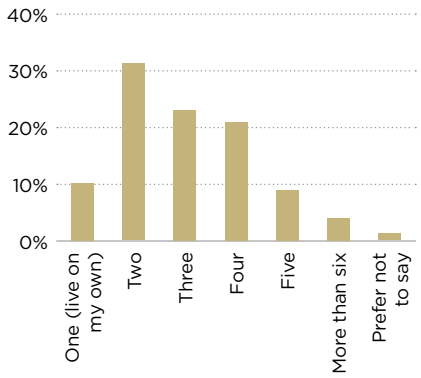
ETHNICITY**



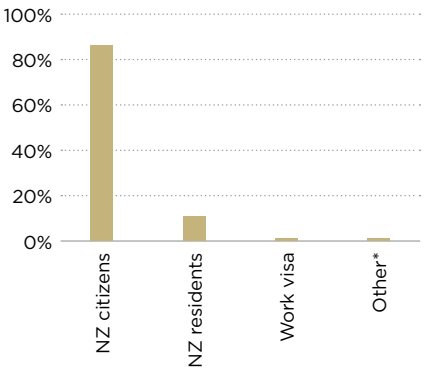
BORN IN NZ



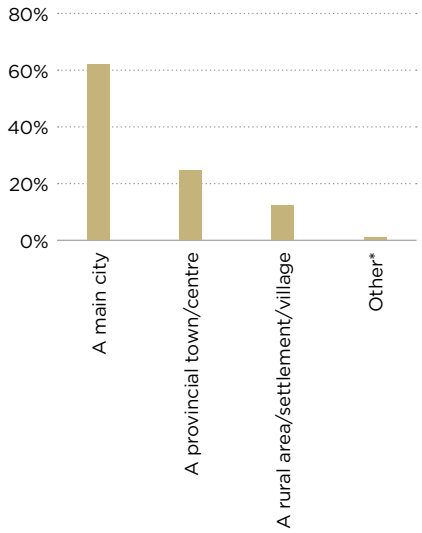
NUMBER OF PEOPLE IN THE FAMILY



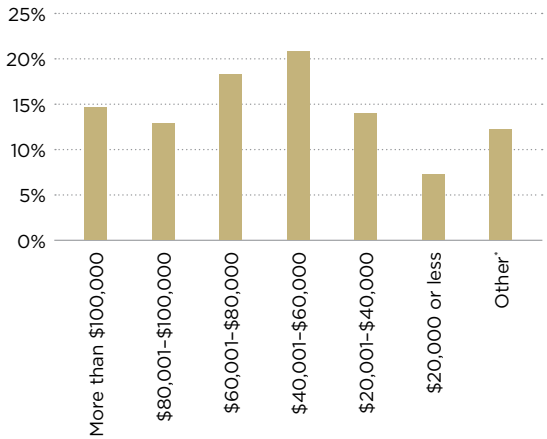
MIGRANT STATUS



LIVING AREAS



HOUSEHOLD INCOME

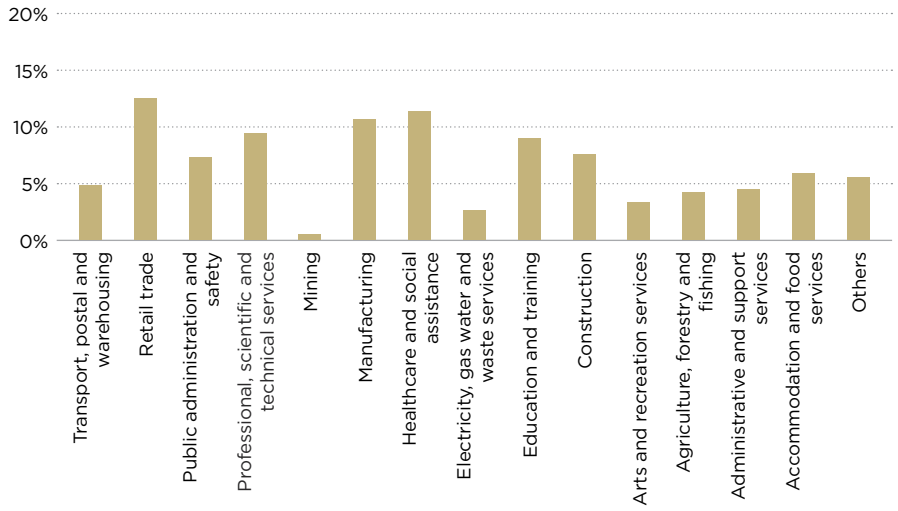


* Other includes 'Don't know', 'Prefer not to say', and other options with a small number of responses.

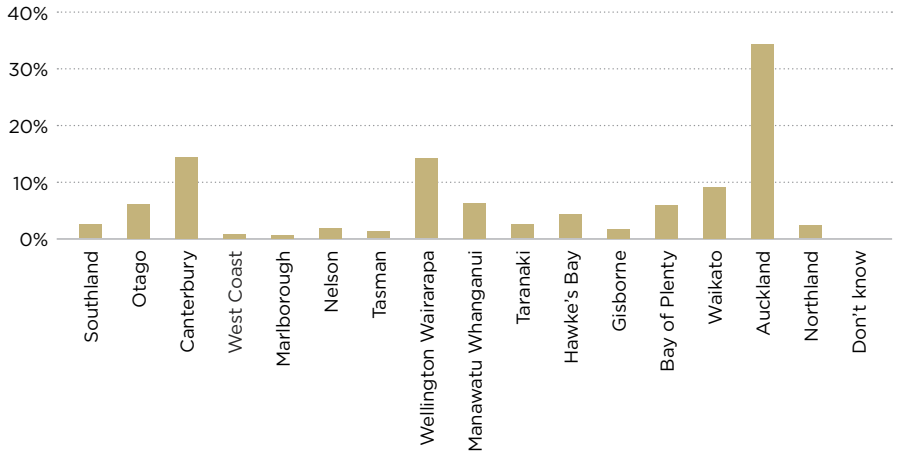
** Workers can identify with multiple ethnicities.

Appendix 4: Demographic characteristics of the survey population (part 2)

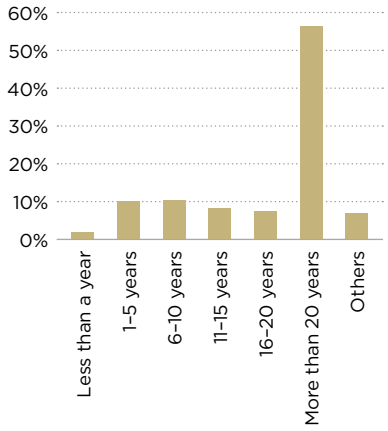
INDUSTRY



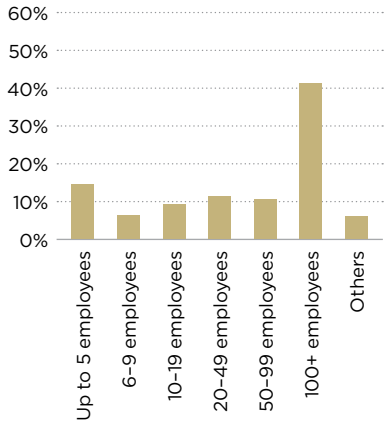
LOCATIONS OF WORK†



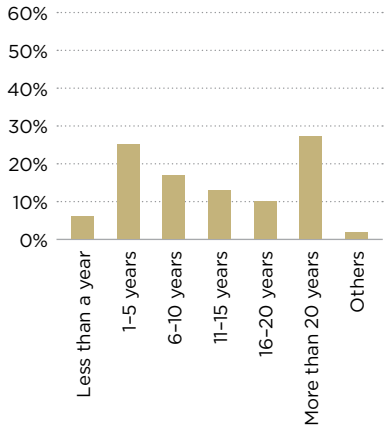
LENGTH OF BUSINESS OPERATING TIME



SIZE OF EMPLOYER



LENGTH OF TIME IN THE INDUSTRY



† Workers can indicate more than one location of work.

Appendix 5: Carcinogen exposures at any level by industry (%)

	ACCOMMODATION AND FOOD SERVICES	ADMINISTRATIVE AND SUPPORT SERVICES	AGRICULTURE, FORESTRY AND FISHING	ARTS AND RECREATION SERVICES	CONSTRUCTION	EDUCATION AND TRAINING	ELECTRICITY, GAS WATER AND WASTE SERVICES	HEALTHCARE AND SOCIAL ASSISTANCE	MANUFACTURING	MINING	PROFESSIONAL, SCIENTIFIC AND TECHNICAL SERVICES	PUBLIC ADMINISTRATION AND SAFETY	RETAIL TRADE	TRANSPORT, POSTAL AND WAREHOUSING
Benzene	18.2	39.2	67.3	12.2	45.8	20.0	47.2	23.6	33.6	52.3	26.2	21.6	27.9	28.1
Solar UV	14.8	41.6	72.7	36.7	48.4	30.4	56.9	18.5	12.7	37.5	16.7	13.8	14.6	44.5
Ocular UV	10.9	36.8	66.2	29.1	48.3	28.2	54.5	13.4	23.1	36.4	18.9	12.2	13.7	35.2
DEE	13.7	24.6	73.6	17.5	50.6	4.1	72.0	9.3	26.7	68.4	19.7	9.9	13.3	47.9
ETS	17.4	12.4	15.9	9.3	19.7	5.4	18.1	7.0	15.5	20.5	9.8	9.1	16.6	27.5
Styrene	8.0	10.1	17.3	12.8	27.4	2.0	20.1	1.7	18.9	27.4	14.3	7.6	8.3	20.6
Crystalline silica	5.5	7.9	28.3	6.4	43.9	0.1	45.4	1.0	6.5	65.4	6.7	1.2	4.7	15.0
Shiftwork	8.2	3.2	4.3	3.5	9.0	2.0	8.3	17.5	9.1	17.5	6.5	12.8	7.6	11.4
Wood dust	3.7	18.6	34.4	3.2	38.8	2.8	1.4	0	10.5	0	4.1	2.8	2.0	9.1
Other PAHs	12.3	8.6	32.7	0.7	13.0	1.8	6.1	8.6	14.7	19.8	7.5	6.1	1.4	2.3
Formaldehyde	3.9	2.6	10.5	5.2	31.9	5.4	1.0	2.9	14.8	9.2	7.3	4.3	2.6	6.9
Chromium VI	0	1.6	12.6	1.0	29.3	0.5	3.7	0	14.6	0	8.5	5.2	0.1	2.3
Lead	0.2	0.7	7.3	0	18.3	1.2	8.0	0	9.0	5.5	6.8	7.0	1.6	1.4
Asbestos	2.8	1.9	5.2	4.1	10.4	0.1	8.9	1.4	4.2	14.0	6.5	4.8	1.5	3.6
Nickel	1.4	1.4	5.9	0.7	12.9	0.3	3.3	0	13.2	0	5.2	2.1	0.8	2.1
Artificial UV	0.2	1.4	12.5	0.3	8.0	0.2	4.1	0.4	11.1	0	8.1	0.2	0.9	1.3
Welding fumes	0.2	1.4	12.5	0.3	8.0	0.2	4.1	0	10.8	0	8.0	0.2	0.9	1.3
Glyphosate	1.4	22.5	47.0	2.7	0	0	6.0	0.1	0.2	0	0.2	0.4	0	0
Cadmium	0	0.2	4.2	0	10.3	0.2	3.9	0	5.2	23.8	4.7	1.9	0.9	0.5
Mineral oils	0	6.4	3.1	0	6.8	0.1	2.4	0.1	9.1	6.2	3.0	0	0.1	3.5
Other pesticides	0	9.9	28.2	0.6	0.9	0	4.3	0.6	0.3	0	0.2	0.2	0	0
Dichloromethane	0.2	0.2	2.6	0.4	6.9	0	0.6	0	3.0	0	0.8	0	0.2	0.6
Ionising Radiation	0	0.3	0	0	0.7	0	2.7	5.6	1.1	11.5	0.5	0	0	0
Arsenic	0	0.2	1.2	0	10.8	0	1.4	0	0.2	0	0	0	0	0

	ACCOMMODATION AND FOOD SERVICES	ADMINISTRATIVE AND SUPPORT SERVICES	AGRICULTURE, FORESTRY AND FISHING	ARTS AND RECREATION SERVICES	CONSTRUCTION	EDUCATION AND TRAINING	ELECTRICITY, GAS WATER AND WASTE SERVICES	HEALTHCARE AND SOCIAL ASSISTANCE	MANUFACTURING	MINING	PROFESSIONAL, SCIENTIFIC AND TECHNICAL SERVICES	PUBLIC ADMINISTRATION AND SAFETY	RETAIL TRADE	TRANSPORT, POSTAL AND WAREHOUSING
Phenoxy herbicides	0	2.0	17.1	0.4	0	0	0.5	0	0	0	0	0	0	0
Cobalt	0	0	1.6	0	2.6	0.1	2.2	0	1.6	2.5	2.1	0	0	0
Other herbicides	0	3.1	9.2	0.4	0	0	0	0	0	0	0.1	0	0	0
Acid mists	0	0	0.3	0.5	0	1.3	0	0.1	2.7	2.8	0.5	0	0	0.3
Ethylene oxide	0	0	0.3	0	0	0	0	0.2	0.2	0	0.1	0	1.5	4.9
1,3 Butadiene	0	0	0	0	0	0	0	0	1.7	0	0	3.5	0	0
Organophosphates	0	0.5	7.1	0.4	0	0	1.4	0.1	0	0	0	0	0	0
Vinyl Chloride	0	0	0	0	0	0	0	0	0.1	0	0	3.3	0	0
Tetrachloroethylene	0	0.9	0.6	0	0.3	0.2	0	0	0.9	2.8	0.5	0	0.1	0.2
Trichloroethylene	0	1.3	0.9	0.4	0.1	0.2	0	0	0.6	2.8	0.3	0	0.1	0.2
PCBs	0	0	0	0	0	0	5.2	0	0	0	0	1.5	0	0
Beryllium	0	0.3	0.6	0	0.5	0	2.7	0	0.2	0	0.1	0.2	0	0
Organochlorines	0	0	0	0	1.5	0	0	0	0.1	0	0	0	0	0
Leather dust	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0
Erionite	0	0	0	0	0.2	0	0.6	0	0	5.5	0	0	0	0
Nitrosamines	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0
Acrylamide	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Epichlorhydrin	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ortho-toluidine	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MOCA	0	0	0	0	0	0	0	0	0	0	0	0	0	0

- MOCA is 4,4'-Methylenebis. PCBs are Polychlorinated biphenyls. Dichloromethane can be called Methylene Chloride. Tetrachloroethylene can be called perchloroethylene (perc).
- 'Other PAHs' are polycyclic aromatic hydrocarbons (PAHs) other than vehicle exhaust.
- ETS (Environmental tobacco smoke); DEE (Diesel engine exhaust).
- Shiftwork means any of the following shiftwork agents, including graveyard, light at night, sleep disturbances, phase shift, lack of physical activity, lack of vitamin D, shiftwork and diet, and shiftwork and alcohol.

Appendix 6: Carcinogen exposures at a low level by industry (%)

	ACCOMMODATION AND FOOD SERVICES	ADMINISTRATIVE AND SUPPORT SERVICES	AGRICULTURE, FORESTRY AND FISHING	ARTS AND RECREATION SERVICES	CONSTRUCTION	EDUCATION AND TRAINING	ELECTRICITY, GAS WATER AND WASTE SERVICES	HEALTHCARE AND SOCIAL ASSISTANCE	MANUFACTURING	MINING	PROFESSIONAL, SCIENTIFIC AND TECHNICAL SERVICES	PUBLIC ADMINISTRATION AND SAFETY	RETAIL TRADE	TRANSPORT, POSTAL AND WAREHOUSING
Benzene	13.9	29.5	41.1	7.1	33.0	19.3	34.7	22.3	22.7	37.8	15.1	13.8	22.7	14.8
Solar UV	2.0	12.7	12.0	18.9	10.2	15.0	10.8	7.5	3.1	3.3	4.2	2.1	5.1	9.4
Ocular UV	4.8	25.6	47.7	25.0	30.0	18.2	30.8	5.5	8.5	28.4	8.4	7.5	5.8	22.3
DEE	6.0	12.8	47.0	5.1	15.0	3.8	21.2	7.3	7.4	7.5	5.4	5.3	4.3	19.8
ETS	16.3	10.3	11.5	9.0	14.2	4.2	13.7	5.5	13.3	9.5	8.8	5.4	14.0	23.8
Styrene	6.9	7.2	7.2	8.6	22.5	1.8	14.3	1.6	8.8	10.8	7.1	5.2	4.5	11.7
Crystalline silica	3.9	3.6	17.8	6.0	12.5	0.1	44.0	1.0	5.2	37.9	4.3	1.2	4.4	10.0
Shiftwork	5.8	0.6	3.5	0	7.1	1.1	2.8	11.9	6.9	15.0	5.2	12.4	3.3	9.7
Wood dust	0	1.4	1.2	0.6	8.1	1.2	0	0	2.7	0	2.1	0.4	0.1	0
Other PAHs	12.3	0.5	3.1	0	2.2	1.6	1.8	7.7	13.1	2.8	4.9	0.4	1.3	1.9
Formaldehyde	3.7	2.6	7.8	4.5	25.9	4.2	0.4	1.8	9.5	2.9	4.9	2.3	1.5	2.6
Chromium VI	0	0.6	2.5	0.7	24.7	0	2.3	0	6.3	0	2.5	4.4	0.1	0.8
Lead	0	0.2	1.7	0	10.5	0	2.9	0	3.0	0	2.2	3.5	0.1	1.1
Asbestos	2.8	1.9	5.2	4.1	3.0	0.1	4.3	1.4	2.4	11.2	6.5	2.4	1.5	3.6
Nickel	1.4	0.9	2.2	0.3	10.2	0	2.7	0	7.0	0	2.8	2.1	0.1	1.4
Artificial UV	0	0.3	2.3	0.3	0.3	0	1.2	0.4	1.1	0	0.5	0	0	0.5
Welding fumes	0	0.3	4.1	0.3	5.4	0	2.3	0	3.3	0	2.5	0.2	0	0.5
Glyphosate	1.4	3.3	11.7	0.4	0	0	0.9	0	0	0	0	0	0	0
Cadmium	0	0.2	1.9	0	6.7	0	3.3	0	2.8	0	2.7	1.7	0.8	0.5
Mineral oils	0	5.6	0	0	0	0	0.5	0.1	2.2	6.2	0.6	0	0	1.7
Other pesticides	0	6.4	23.8	0.3	0.3	0	4.3	0.6	0	0	0.2	0.2	0	0
Dichloromethane	0.2	0.2	1.4	0	4.4	0	0.6	0	0.1	0	0.1	0	0	0.3
Ionising Radiation	0	0.3	0	0	0.4	0	2.1	4.9	0.5	11.5	0.4	0	0	0
Arsenic	0	0	0	0	8.6	0	0	0	0.2	0	0	0	0	0

	ACCOMMODATION AND FOOD SERVICES	ADMINISTRATIVE AND SUPPORT SERVICES	AGRICULTURE, FORESTRY AND FISHING	ARTS AND RECREATION SERVICES	CONSTRUCTION	EDUCATION AND TRAINING	ELECTRICITY, GAS WATER AND WASTE SERVICES	HEALTHCARE AND SOCIAL ASSISTANCE	MANUFACTURING	MINING	PROFESSIONAL, SCIENTIFIC AND TECHNICAL SERVICES	PUBLIC ADMINISTRATION AND SAFETY	RETAIL TRADE	TRANSPORT, POSTAL AND WAREHOUSING
Phenoxy herbicides	0	0.6	4.2	0	0	0	0	0	0	0	0	0	0	0
Cobalt	0	0	0	0	0	0	1.7	0	0.7	2.5	0.2	0	0	0
Other herbicides	0	1.0	2.3	0	0	0	0	0	0	0	0	0	0	0
Acid mists	0	0	0	0.5	0	1.3	0	0.1	1.2	0	0.4	0	0	0
Ethylene oxide	0	0	0	0	0	0	0	0	0.2	0	0	0	0.5	0.9
1,3 Butadiene	0	0	0	0	0	0	0	0	1.4	0	0	1.8	0	0
Organophosphates	0	0	2.8	0	0	0	0	0	0	0	0	0	0	0
Vinyl Chloride	0	0	0	0	0	0	0	0	0.1	0	0	3.3	0	0
Tetrachloroethylene	0	0	0	0	0	0.2	0	0	0.1	0	0	0	0	0
Trichloroethylene	0	1.0	0	0	0	0.1	0	0	0	0	0.2	0	0	0
PCBs	0	0	0	0	0	0	5.2	0	0	0	0	1.5	0	0
Beryllium	0	0.3	0	0	0	0	2.2	0	0.1	0	0.1	0	0	0
Organochlorines	0	0	0	0	1.1	0	0	0	0.1	0	0	0	0	0
Leather dust	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0
Erionite	0	0	0	0	0.2	0	0.6	0	0	5.5	0	0	0	0
Nitrosamines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acrylamide	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Epichlorhydrin	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ortho-toluidine	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MOCA	0	0	0	0	0	0	0	0	0	0	0	0	0	0

- MOCA is 4,4'-Methylenebis. PCBs are Polychlorinated biphenyls. Dichloromethane can be called Methylene Chloride. Tetrachloroethylene can be called perchloroethylene (perc).
- 'Other PAHs' are polycyclic aromatic hydrocarbons (PAHs) other than vehicle exhaust.
- ETS (Environmental tobacco smoke); DEE (Diesel engine exhaust).
- Shiftwork means any of the following shiftwork agents, including graveyard, light at night, sleep disturbances, phase shift, lack of physical activity, lack of vitamin D, shiftwork and diet, and shiftwork and alcohol.

Appendix 7: Carcinogen exposures at medium and high levels by industry (%)

	ACCOMMODATION AND FOOD SERVICES	ADMINISTRATIVE AND SUPPORT SERVICES	AGRICULTURE, FORESTRY AND FISHING	ARTS AND RECREATION SERVICES	CONSTRUCTION	EDUCATION AND TRAINING	ELECTRICITY, GAS WATER AND WASTE SERVICES	HEALTHCARE AND SOCIAL ASSISTANCE	MANUFACTURING	MINING	PROFESSIONAL, SCIENTIFIC AND TECHNICAL SERVICES	PUBLIC ADMINISTRATION AND SAFETY	RETAIL TRADE	TRANSPORT, POSTAL AND WAREHOUSING
Benzene	4.3	9.7	26.1	5.1	12.8	0.7	12.5	1.3	10.9	14.5	11.2	7.8	5.2	13.4
Solar UV	12.8	28.9	60.8	17.8	38.2	15.4	46.1	11.0	9.6	34.2	12.5	11.6	9.5	35.1
Ocular UV	6.2	11.2	18.6	4.1	18.5	10.1	23.7	7.9	14.6	10.0	10.5	4.8	7.9	12.8
DEE	7.7	11.9	26.6	12.4	35.6	0.3	50.8	2.0	19.3	60.9	14.3	4.7	9.1	28.1
ETS	1.1	2.1	4.5	0.4	5.4	1.2	4.4	1.5	2.2	11.1	1.0	3.6	2.6	3.7
Styrene	1.2	2.9	10.1	4.2	4.9	0.2	5.9	0.1	10.0	16.6	7.2	2.5	3.8	8.9
Crystalline silica	1.6	4.2	10.5	0.4	31.4	0	1.5	0	1.3	27.4	2.4	0	0.3	5.0
Shiftwork	8.2	3.2	4.3	3.5	9.0	2.0	8.3	17.5	9.1	17.5	5.9	12.3	7.6	11.4
Wood dust	3.7	17.3	33.2	2.6	30.7	1.6	1.4	0	7.8	0	2.0	2.4	1.9	9.1
Other PAHs	0	8.2	29.6	0.7	10.8	0.2	4.3	0.9	1.6	17.0	2.6	5.7	0.1	0.4
Formaldehyde	0.2	0	2.7	0.7	6.0	1.2	0.6	1.1	5.3	6.2	2.4	2.0	1.1	4.3
Chromium VI	0	1.1	10.2	0.3	4.6	0.5	1.4	0	8.3	0	6.0	0.8	0	1.5
Lead	0.2	0.5	5.7	0	7.8	1.2	5.1	0	6.0	0	4.5	3.5	1.5	0.3
Asbestos	0	0	0	0	7.4	0	4.6	0	1.8	2.8	0	2.4	0	0
Nickel	0	0.5	3.7	0.4	2.6	0.3	0.5	0	6.2	0	2.4	0	0.7	0.7
Artificial UV	0.2	1.1	10.2	0	7.7	0.2	2.9	0	9.9	0	7.6	0.2	0.9	0.7
Welding fumes	0.2	1.1	8.4	0	2.7	0.2	1.8	0	7.5	0	5.5	0	0.9	0.7
Glyphosate	0	19.2	35.3	2.3	0	0	5.0	0.1	0.2	0	0.2	0.4	0	0
Cadmium	0	0	2.4	0	3.6	0.2	0.5	0	2.4	23.8	2.0	0.2	0.1	0
Mineral oils	0	0.9	3.1	0	6.8	0.1	1.9	0	6.9	0	2.4	0	0.1	1.8
Other pesticides	0	3.4	4.4	0.3	0.7	0	0	0	0.3	0	0	0	0	0
Dichloromethane	0	0	1.2	0.4	2.5	0	0	0	2.8	0	0.7	0	0.2	0.3
Ionising Radiation	0	0	0	0	0.3	0	0.6	0.7	0	0.1	0	0	0	0

	ACCOMMODATION AND FOOD SERVICES	ADMINISTRATIVE AND SUPPORT SERVICES	AGRICULTURE, FORESTRY AND FISHING	ARTS AND RECREATION SERVICES	CONSTRUCTION	EDUCATION AND TRAINING	ELECTRICITY, GAS WATER AND WASTE SERVICES	HEALTHCARE AND SOCIAL ASSISTANCE	MANUFACTURING	MINING	PROFESSIONAL, SCIENTIFIC AND TECHNICAL SERVICES	PUBLIC ADMINISTRATION AND SAFETY	RETAIL TRADE	TRANSPORT, POSTAL AND WAREHOUSING
Arsenic	0	0.2	1.2	0	2.2	0	1.4	0	0	0	0	0	0	0
Phenoxy herbicides	0	1.4	12.9	0.4	0	0	0.5	0	0	0	0	0	0	0
Cobalt	0	0	1.6	0	2.6	0.1	0.5	0	0.9	0	1.9	0	0	0
Other herbicides	0	2.1	6.8	0.4	0	0	0	0	0	0	0.1	0	0	0
Acid mists	0	0	0.3	0	0	0	0	0	1.4	2.8	0	0	0	0.3
Ethylene oxide	0	0	0.3	0	0	0	0	0.2	0	0	0.1	0	0.9	4.0
1,3 Butadiene	0	0	0	0	0	0	0	0	0.3	0	0	1.7	0	0
Organophosphates	0	0.5	4.3	0.4	0	0	1.4	0.1	0	0	0	0	0	0
Vinyl Chloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tetrachloroethylene	0	0.9	0.6	0	0.3	0	0	0	0.8	2.8	0.5	0	0.1	0.2
Trichloroethylene	0	0.2	0.9	0.4	0.1	0.1	0	0	0.6	2.8	0	0	0.1	0.2
PCBs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beryllium	0	0	0.6	0	0.5	0	0.5	0	0.1	0	0	0.2	0	0
Organochlorines	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0
Leather dust	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Erionite	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrosamines	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0
Acrylamide	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Epichlorhydrin	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ortho-toluidine	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MOCA	0	0	0	0	0	0	0	0	0	0	0	0	0	0

- MOCA is 4,4'-Methylenebis. PCBs are Polychlorinated biphenyls. Dichloromethane can be called Methylene Chloride. Tetrachloroethylene can be called perchloroethylene (perc).
- 'Other PAHs' are polycyclic aromatic hydrocarbons (PAHs) other than vehicle exhaust.
- ETS (Environmental tobacco smoke); DEE (Diesel engine exhaust).
- Shiftwork means any of the following shiftwork agents, including light at night, sleep disturbances, phase shift, lack of physical activity, lack of vitamin D, shiftwork and diet, and shiftwork and alcohol.

Appendix 8: List of potentially exposed jobs by industry created in the survey[15]

Agriculture, Forestry and Fishing

- Fruit, vegetable and crop farming (FARM)
- Sheep, beef cattle and grain farming (FARM)
- Dairy Cattle Farming (FARM)
- Poultry Farming (FARM)
- Deer Farming (FARM)
- Other Livestock Farming (FARM)
- Commercial Fishing (including charter services) (SHIP)
- Forestry and Logging (FORE)

Mining

- Coal mining (MINE)
- Oil and gas extraction (OPET)
- Metal ore mining (MINE)
- Non-metallic mineral mining and quarrying (MINE)
- Exploration and other mining support services (MINE)

Manufacturing

- Food and beverage product manufacturing (FOOD)
- Textile, leather clothing and footwear manufacturing
  - Textile or textile product manufacturing (including clothing and knitted products) (TEXT)
  - Leather tanning, fur dressing and leather product manufacturing (LEAT)
  - Footwear manufacturing (SHOE)
- Wood Manufacturing (FORE)
- Pulp and paper manufacturing (IMAR)
- Printing (including the Reproduction of Recorded Media) (PRIN)
- Petroleum and Coal Product Manufacturing
  - Basic Chemical and Chemical Product Manufacturing (IMAR)
  - Basic polymer manufacturing (IMAR)
  - Fertiliser and pesticide manufacturing (IMAR)
  - Pharmaceutical and medicinal product manufacturing (IMAR)
  - Cleaning compound and toiletry preparation manufacturing (IMAR)
  - Other basic chemical product manufacturing (IMAR)
- Polymer Product and Rubber Product Manufacturing
  - Polymer product manufacturing (IMAR)
  - Natural rubber product manufacturing (RUBB)
  - Non-Metallic Mineral Product Manufacturing (IMAR)
  - Ceramic product manufacturing (CERA)
  - Cement, lime, plaster and concrete product manufacturing (CERA)
  - Other non-metallic mineral product manufacturing (CERA)

[15] The list of potentially exposed occupations is based on the Australian Worker Exposure Survey Interviewer Training Manual, Procedure Manual, Carey *et al*. (2013) paper and discussions with Professor Lin Fritschi (Curtin University).

- Primary Metal and Metal Product Manufacturing/smelting
  - Basic ferrous/non-ferrous metal manufacturing (PRMM)
  - Fabricated Metal Product Manufacturing (PRMM)
  - Iron and steel forging (FOUN)
  - Metal smelting (PRMM)
  - Structural metal product manufacturing (MACH)
  - Metal container manufacturing (FOUN)
  - Sheet metal product manufacturing (PRMM)
  - Metal coatings services (MFAC)
- Transport Equipment Manufacturing (IMAR)
- Machinery and Equipment Manufacturing (MACH)
- Upholstery and Other Manufacturing
  - Furniture upholstery (UPHO)
  - Vehicle upholstery (UPHO)
  - Other manufacturing (IMAR)

Electricity, Water and Waste Services

- Electricity generation, transmission and distribution (LINE)
- Water Supply, Sewerage and Drainage Services (including plumbers) (SEWG)
- Waste Collection, Treatment and Disposal Services (WAMA)

Construction

- Building construction (excluding plumbers) (CONS)
- Road/bridge Construction (ROAD)

Retail trade

- Motor vehicle and motor vehicle parts retailing (RETA)
- Petrol station worker/attendant (PESA)
- Food retailing (FOOD)
- Other store-based retailing (RETA)
- Non-store retailing and retail commission-based buying and/or selling (RETA)
- Jewellery services (MFAC) (Manufacturing quota)

Accommodation and Food Services

- Cafes, restaurants, bakery, butchery and takeaway food services (FOOD)
- Catering services (FOOD)
- Pubs, taverns and bars (FOOD)

Transport, Postal and Warehousing

- Road transport (including freight or passenger) (DRIV)
- Train driver (DRIV)
- Train maintenance and repair (RAIL)
- Water transport (including freight or passenger) (SHIP)
- Air transport (AIRT)
- Aircraft repair and maintenance (AIRT)
- Postal and courier pick-up and delivery services (DRIV)
- Parking/carpark services (RDSD)

- Transport support services
  - Road transport support services (RDSD)
  - Railway transport support services (RAIL)
  - Water transport support services (SHIP)
  - Airport operations and other air transport services (AIRT)
- Warehousing and storage services, including forklift drivers (STOR)

Newspaper, periodical, book, directory and sign printing (PRIN) (Manufacturing quota)

Real Estate Services (DRIV) (Retail Trade quota)

Professional, Scientific and Technical Services

- Welder/boiler maker (WELD)
- Chemistry laboratory services (LABC)
- Surveying (RDSD)
- Veterinary services (HLTH)
- Automotive repair and maintenance (MECH)
- Health and beauty services (HAIR)

Administration and Support Services

- Building/industrial/residential cleaning services (CLNR)
- Laundry services (CLNR)
- Dry cleaning services (DRYC)
- Pest control services (PEST)
- Gardening/groundskeeping services (GARD)
- Janitorial/caretaking/handyman services (JANI)
- General building/factory/hospital maintenance (FAMM)
- Animal services
  - Veterinary services (HLTH)
  - Animal handling and grooming services (ANIM)
  - Animal riding services (ANIM)
  - Animal breeding services (ANIM)
  - Animal support services (ANIM)

Public Administration and Safety

- Security guard (OFFW)
- Police (POLI)
- Military (MLTY)
- Firefighting (FIRE)

Education and training

- Science teacher (TEAC)
- Chemistry teacher (TEAC)
- Biology teacher (TEAC)
- Art/craft teacher (TEAC)
- Trades/vocational teacher (TEAC)
- Biology lecturer/professor (TEAC)
- Art lecturer/professor (TEAC)
- Trades lecturer/professor (TEAC)
- Chemistry lecturer/professor (TEAC)

Health Care and Social Assistance

- Medical laboratories (LABC)
- Hospital medical services (HLTH)
- Medical and other health care services
  - Medical services (HLTH)
  - Pathology and diagnostic imaging services (HLTH)
  - Allied health services (HLTH)
- Residential care services (HLTH)
- Funeral services (FUNR)

Arts and Recreation Services

- Parks, gardens and DOC operation (GARD)
- Artist/Painter (ARTF)
- Zoo operation (ANIM)
- Photography and film processing (ARTF)
- Horse and dog racing activities (ANIM)

None of these (TERMINATE)

Appendix 9: Survey weighting

The data have been weighted, so the overall sample is representative of the population of interest based on age, gender, risk group of occupation, and industry, according to Statistics New Zealand population counts in Census 2018. The weighted data allows WorkSafe to estimate how many New Zealand workers are probably exposed to at least one carcinogen or a specific carcinogenic agent.

Dichotomy variables, including risk-group with value, high and low/other/unknown were coded from occupation in the control dataset while all cases in the main dataset were coded as the high risk-group.

The first around of weighting (raking) is based on age, gender, risk-group. The proportion of the high risk-group in the population is much lower than that in the sample but is an essential variable for weighting to make the sample representative of the population. To mitigate the design effect, age group was collapsed into slightly broader categories, 18 to 34, 35–44, 45–54 and 55+.

The second round of weighting is based on industry. The industry category 'Professional, Scientific and Technical Services' comprises 9% of the industry population. However, the initial weighing made this stratum 19% of the sample while other industries looked fair. Therefore, this industry category was also included as a weighing variable. Due to the great number of strata used for weighting, which resulted in some large weights and a high design effect, 'Industry' was collapsed into two groups: 'Professional, Scientific and Technical Services' and 'other industry'.

Weights for the stratum which belongs to 18–34 years, male, low risk group and other industry was capped at 5. The Design effect due to weighing is 1.2. Weight was set as '1' for those respondents who answered the demographic questions as other/prefer not to say or did not answer the demographic question at all (missing value). The margin of error is +/- 2.5% while design effect is 1.62.

	POPULATION	UNWEIGHTED	WEIGHTED
Risk-group			
High	38%	83%	39%
Low other don't know	62%	17%	61%
Age			
18–34	34%	21%	34%
35–44	20%	17%	20%
45–54	22%	23%	22%
55 and over	24%	38%	24%
Gender			
Male	53%	56%	52%
Female	47%	44%	47%
Another gender	–	0%	0%
Prefer not to say	–	0%	0%
Industry			
Accommodation and Food Services	9%	6%	6%
Administrative and Support Services	6%	6%	5%
Agriculture, Forestry and Fishing	6%	8%	4%
Arts and Recreation Services	2%	2%	3%
Construction	9%	9%	8%
Education and Training	10%	4%	9%
Electricity, Gas Water and Waste Services	1%	4%	3%
Healthcare and Social Assistance	13%	15%	11%
Manufacturing	12%	13%	11%
Mining	0%	1%	1%
Professional, Scientific and Technical Services	9%	12%	10%
Public Administration and Safety	7%	3%	7%
Retail Trade	11%	11%	13%
Transport, Postal and Warehousing	5%	6%	5%
Other/unspecified	–	1%	2%
Prefer not to say	–	1%	3%
Total	**100.0%**	**100.0%**	**100.0%**

Appendix 10: Job specific and task modules in the OccIDEAS[16]

Job specific modules

JOB SPECIFIC MODULES (JSM)	DESCRIPTION
Air transport workers	Air transport including airport ground staff, flight attendant, pilot etc.
Animal worker	Work with animals as part of their jobs: zookeeper, farrier, horse rider, wildlife, pet shop etc **does not** include veterinarians or vet nurses or farm workers.
Artist/film processing	Professional artists, photographers, or process film.
Caretaker/janitor	Janitors, handymen, building maintenance. Those who perform tasks in addition to cleaning, such as painting and grounds maintenance, should use this JSM. For those who identify solely as cleaners and do not perform other tasks, the cleaner JSM may be more appropriate.
Ceramics	Ceramics industry including brick, tile and pipe making, glass, pottery, and sanitary ware.
Cleaner	Domestic, commercial, and industrial cleaners, on-site supervisor.
Construction trades	Construction trade workers including electricians, painters, carpenters, plumbers, plasterers, labourers. Other possible job titles include bricklayer, ceiling fixer, concrete cutter, or tradesperson.
Driver	Drivers and transport workers. Possible job titles that this JSM should be used for include backhoe operators, bulldozer operators, bus drivers, couriers, delivery drivers, dump truck drivers, freight drivers, mail carriers, pizza delivery, postal delivery, rubbish collectors, taxi drivers, truck drivers, and unloaders. This JSM can also be used for those who drive as part of their job on a more than average basis, such as real estate agents.
Dry cleaner	Retail dry cleaning and dry-cleaning plant workers. It includes dry cleaners, ironers, launderers, and pressers.
Farmer	Crop and livestock farm workers, horticulture workers. Possible job titles to be included in this JSM include agronomist, agriculture worker, farm assistant, farm hand, farm labourer, on-farm manager, stockman, shepherd, station hand, and viticulturalist.
Firefighter	Firefighters.
Fitter and maintenance mechanic	Maintenance tradesperson in factories, hospitals etc.
Food workers	All food related jobs including, chef/cooks, bakers, butchers, food processing plants or food retail outlet.
Forestry timbermill	Forestry workers and timbermill workers. Possible job titles include forestry worker, timber cutter, timbermill worker, wood cutter, and wood chopper.
Foundry	Production workers in the foundry or metal casting industry. This does not include machining, metal finishing or mining, and should be distinguished from primary metal manufacture.
Gardener groundskeeper	Gardeners, landscapers, sports ground maintenance. Possible job titles that fit under this JSM include DOC field workers, council ranger, lawnmower man, and plant nurseryman.
Generic	For jobs that don't have a specific module.

[16] For more details on job specific module, please refer to website www.occideas.org

JOB SPECIFIC MODULES (JSM)	DESCRIPTION
Hairdresser/beauty therapist	Hair salon workers/beauty therapists. Possible job titles that fit under this JSM include beautician, beauty salon assistant, beauty therapist, cosmetician, hair stylist, nail technician, and salon assistant, as well as barber and hairdresser.
Health workers	Health professionals, includes veterinarians, vet nurses, dentists, dental assistants, nurses, home care, doctors, surgeons. Possible job titles include anaesthetic technician, clinical coder, counsellor, dental assistant, dental therapist, dentist, doctor, GP, health information manager, intern, medical imaging technologist, medical laboratory technician, medical scientist, nurse, occupational therapist, oncologist, optometrist, pharmacist, physiotherapist, podiatrist, radiation therapist, speech pathologist, and veterinarian. Paramedics and ambulance officers may be more suited to the driver JSM, unless their job does not involve frequent driving. All nurses should be given this JSM.
Industrial manufacturing, assembly and repair	Manufacture, assembly, or repair items.
Lab worker chemist	Workers/researchers in all types of scientific laboratories. Clinical, biological, and metallurgical laboratories are all included here.
Leather tanning	Leather tanning, including beamhouse operations and tanyard processes. This JSM should be used where people indicate that they work with leather. This includes the manufacture of leather, tanneries, and industries in which products are made from leather. This does not include the manufacture of footwear, which has its own JSM (shoes and leather goods).
Line worker/power station worker	Power station or power line workers.
Machinist	Machining parts, fabrication, forging, fitter, and turner.
Mechanic/panel beater	Mechanics and panel beaters. The mechanic JSM should be used for those who work in vehicle repairs and similar occupations, performing any of a variety of tasks including brake repairs, body work, hydraulics, and air conditioning work.
Metal finishing and coating	Metal plating, coating, or other finishing. Please note there are separate JSMs for the manufacture, refining, and casting of metals.
Military	Army, navy, airforce troops **not** tradesworkers.
Miners/quarrymen	Miners or quarrymen.
Oil/petroleum industry	Oil or petroleum industry.
Pesticide users	Main task is to use pesticides including crop sprayers, pest control workers.
Petrol station attendant	Petrol and gas station attendant.
Police	Police officers.
Primary metal manufacturing	Production workers in metal smelters and refineries or rolling and drawing mills.
Printing	Printers and printing workers. The printing JSM is for all those who have worked in the printing industry, including printing books, art reproductions, textiles, and plastic. Lithography, letterpress, flexography, and screen printing are all included here.
Railway	Rail station, depot, signal box, train repair facility, track maintenance.
Retail workers	Retail stores other than food retail.

JOB SPECIFIC MODULES (JSM)	DESCRIPTION
Road construction	Constructing and maintaining roads. Possible job titles include paver operator, screedman, and roadside labourer, machine operator (for example, excavator roller).
Roadside worker	Work alongside roads but **not** in road construction (for example, toll booth, street vendors, traffic controller). Possible job titles include roadside labourer and parking warden. Those who perform roadside work unrelated to construction should use the Roadside Worker JSM
Rubber industry	Rubber manufacture or rubber goods manufacture.
Sewage and water worker	Sewage plant and water workers.
Shipping/fishing	Shipping industry workers, merchant seamen and fishermen.
Shoes and leather goods	Manufacture and repair of shoes or finished leather goods.
Store person	Store person and forklift drivers.
Textiles	Manufacture of natural or synthetic textiles, fabric, yarn, or finished goods such as clothes. This does not include upholsterers, who have their own JSM.
Upholstery	Upholstery industry including auto and furniture. This does not include the manufacture of textiles to be used in upholstery (see textiles JSM).
Waste management	Tip/landfill site workers, waste truck drivers, recycling workers/runners.
Welder	Welders, boiler makers.

Task modules

TASK MODULE	DESCRIPTION
Animal workers	Come into contact with animals. Caretaker/janitor, health workers, lab worker/chemist, retail workers and teacher.
Asbestos removal	Remove asbestos. Caretaker/janitor, construction trades, fitter and maintenance, mechanic.
Back burning	Burn areas of forest or farm. Caretaker/janitor, farmer, forestry/timbermill and gardener/groundskeeper.
Burn waste	Burn waste or garbage. Caretaker/janitor, farmer, forestry/timbermill, gardener/groundskeeper and waste management.
Cleaning	Those who do general cleaning as part of their work. In most job modules.
Cleaning hands	Use chemicals to clean hands. In all jsms excluding cleaners, dry cleaners, firefighter, florist, food worker, generic, line worker, musician/entertainer, office worker, retail workers, roadside worker and store person.
Cutting oils	Use cutting or cooling oils. Artist/film processing, caretaker/janitor, construction trades, driver, farmer, fitter and maintenance mechanic, foundry, gardener/groundskeeper, industrial manufacturing, assembly and repair, machinist, mechanic/panel beater, oil/petroleum industry, printing, teacher, and welder.
Cutting wood	Those who cut, sand and saw wood. Artist/film processing, caretaker/janitor, construction trades, farmer, forestry/timbermill, gardener/groundskeeper, industrial manufacturing, assembly and repair, oil/petroleum industry, railway, teacher, upholstery and waste management.

TASK MODULE	DESCRIPTION
Degreaser	Degreasing, mainly metal air transport workers, caretaker/janitor, construction trades, driver, farmer, fitter and maintenance mechanic, foundry, industrial manufacturing, assembly and repair, machinist, mechanic/panel beater, metal finishing and coating, petrol station attendant, printing, teacher and welder.
Driving/maintenance	Drive or maintain vehicles as part of their work. Air transport workers, animal workers, caretaker/janitor, cleaner, construction trades, driver, dry cleaner, farmer, firefighter, fitter and maintenance mechanic, florist, food workers, forestry/timbermill, gardener/groundskeeper, generic, health worker, line worker, mechanic/panel beater, military, miners/quarrymen, oil/petroleum industry, pesticide user, petrol station attendant, police, railway, road construction, sewage and water worker, shipping, store person and waste management.
Electrical	Electricians, power line workers and other electrical work construction trades, line worker, mechanic/panel beater and teacher.
Environmental tobacco smoke	Exposure to environmental tobacco smoke (second hand or passive tobacco smoke) in the workplace. All JSMs.
Fabric cleaning	Clean fabrics. Cleaners, dry cleaners, hairdresser/beauty therapist, textiles and upholstery.
Fertiliser	Apply fertilisers. Caretaker/janitor, farmer, forestry/timbermill, gardener/groundskeeper, lab worker/chemist.
Frequent flyer	Travel frequently for work office workers.
Flowers	Contact with flowers. Caretaker/janitor, farmer, florist, food workers, gardener/groundskeeper, health worker and lab worker/chemist.
Flux	Use of soldering, welding and radiator fluxes. Artist/film processing, caretaker/janitor, construction trades, farmer, fitter and maintenance mechanic, foundry, gardener/groundskeeper, industrial manufacturing, assembly and repair, line worker, machinist, mechanic/panel beater, oil/petroleum industry, teacher, upholstery and welder.
Fuel-powered equipment	Use fuel powered equipment other than vehicles (for example, lawn mowers, chainsaws etc). Artist/film processing, caretaker/janitor, cleaners, construction trades, farmer, forestry/timbermill, gardener/groundskeeper, line worker, military, miners/quarrymen, road construction, teacher, upholstery and waste management.
Food preparation	Prepare food for meals. Health worker, military, shipping/fishing and teacher.
Fuel tank cleaning	Clean fuel tanks. Air transport workers, cleaner, driver, fitter and maintenance mechanic, farmer, gardener groundskeeper, caretaker/janitor, mechanic/panel beater, military, oil/petroleum industry, petrol station attendant, railway, shipping/fishing.
Furnace cleaning, installation and maintenance	Ceramics, fitter and maintenance mechanic, foundry, machinist, primary metal manufacturing.
Generator exhaust	Work near generators. Caretaker/janitor, construction trades, farmer, fitter and maintenance mechanic, forestry/timbermill, industrial manufacturing, assembly and repair, line worker, machinist, mechain/panel beater, metal finishing and coating, military, miners/quarrymen, railway, shipping/fishing, teacher, upholstery, waste management and welding.
Glues	Use glues, adhesives, bogs, or gap fillers. Artist/film processing, caretaker/janitor, ceramics, construction trades, farmer, fitter and maintenance mechanic, gardener/groundskeeper, industrial manufacturing, assembly and repair, mechanic/panel beater, oil/petroleum industry, rubber industry, shipping/fishing, shoes and leather goods, teacher, textiles and upholstery.
Latex gloves	For those who wear gloves. In all except following JSMs: driver, leather tanning, line worker, musician/entertainer, office worker, petrol station attendant, road construction, roadside worker, and welder.
Machining parts	Machine wood, metal, or plastic parts. Farmer, fitter and maintenance mechanic, industrial manufacturing, assembly and repair, machinist and teacher.
Material handling	Truck loading/unloading, transport and handling of material. Must be with driving task module.

TASK MODULE	DESCRIPTION
Painting	Painting artist/film processing, caretaker/janitor, ceramics, construction trades, farmer, fitter and maintenance mechanic, forestry/timbermill, gardener/groundskeeper, industrial manufacturing, assembly and repair, printing, road construction, teacher and upholstery.
Pesticides	Mix or apply herbicides, insecticides, fungicides, fumigants, or rodenticides. Animal workers, caretakers/janitors, farmers, forestry/timbermill, gardeners/groundskeepers, health worker, lab worker/chemist, military, pesticide user, railway, sewage and water worker and waste management.
Reactive dyes	Work with reactive dyes. Industrial manufacturing, assembly and repair, leather tanning, printing, shoes and leather goods and textiles.
Rodents	Clean up rat and/or mice infestations. Animal workers, caretakers/janitors, cleaners, construction trades, farmers, food workers, forestry/timbermill, gardener/groundskeeper, health worker, pesticide user, railway, sewage and water worker, shipping/fishing, teacher, waste management.
Respiratory protection	Questions about use of masks and respirators in most job modules.
Sanding	Artist/film processing, caretaker/janitor, ceramics, construction trades, farmer, fitter and maintenance mechanic, forestry/timbermill, gardener/groundskeeper, industrial manufacturing, assembly and repair, teacher and upholstery.
Seafood handling	Catch or prepare seafood. Animal workers, farmer, food workers, lab worker/chemist and shipping/fishing.
Shiftworker	Scheduled work out of office hours, especially at night in most job modules.
Shipping	Work on boats or ships but had another job/trade. Construction trades, military, oil and petroleum industry and shipping/fishing.
Soldering	Soldering air transport workers, artist/film processing, caretaker/janitor, construction trades, farmer, fitter and maintenance mechanic, foundry, gardener/groundskeeper, industrial manufacturing, assembly and repair, line worker, machinist, mechanic/panel beater, oil/petroleum industry, railway worker, shipping/fishing, teacher, upholstery and welder.
Sterilising	For those who sterilise equipment. Health worker, lab worker/chemist.
Stripping paint	For those who strip paint. Artist/film processing, caretaker/janitor, ceramics, construction trades, farmer, fitter and maintenance mechanic, gardener/groundskeeper, industrial manufacturing, assembly and repair, mechanic/panel beater, teacher, and upholstery.
Solar uv	For those who work outside during the day. Air transport workers, animal workers, artist/film processing, caretaker/janitor, construction trades, driver, farmer, firefighter, florist, food workers, forestry/timbermill, gardener/groundskeeper, generic, lab worker/chemist, line worker, mechanic/panel beater, military, miners/quarrymen, musician/entertainer, office worker, oil/petroleum industry, pesticide user, petrol station attendant, police, railway, retail workers, road construction, roadside worker, sewage and water worker, shipping/fishing, store person, teacher and waste management.
Ventilation	Questions about ventilation in the area worked. In most job modules.
Vehicle exhausts	Work near running vehicles in most job modules.
Welding	For those who weld. Artist/film processing, caretaker/janitor, construction trades, farmer, fitter and maintenance mechanic, foundry, gardener/groundskeeper, industrial manufacturing, assembly and repair, line worker, machinist, mechanic/panel beater, oil/petroleum industry, teacher, upholstery and welder.
Wood dust	Work with wood construction trades, farmer, forestry timbermill, foundry, gardener groundskeeper, industrial manufacturing, assembly and repair, caretaker/janitor, lab worker chemist, railway, upholstery.
Xray use	Use xrays for quality assurance (not medical imagining). Construction trades, industrial manufacturing, assembly and repair, line worker, rubber industry, shipping/fishing and welder.

WORKSAFE
Mahi Haumaru Aotearoa

QUESTIONNAIRE

Appendix 11:

The survey

1. About your job

The next few questions will ask you about your current job situation, as well as the business where you are working.

1. First of all, are you still working as a(n): (insert job from pre-calling/registration) ○ Yes ○ No

2. (if Q1=2, ask) Are you currently working in paid employment: (hover over 'Paid employment includes full time, part time, casual, contract or self-employed work') ○ Yes ○ No (no = terminate)
   Termination message: Unfortunately, we need to hear from people who are currently working in paid employment. Thank you for your time.

3. (if Q2=1, ask) Please choose the industry and occupation you are currently working in from the list below. If you have more than one job, please choose the industry and occupation of your main job; that is, the one you spend most of your time doing.
   (insert from ANZSIC industry list – select one option)

   ○ None of these

   If respondent selects 'None of these', terminate.
   Termination message: Unfortunately, you are not working in a job that is of interest for this survey. Thank you for your time.

4. (if Q3=industry of interest, ask) What is your current occupation:

   ○ Prefer not to say

5. Are you working:
   - ○ In a full-time permanent role (full-time permanent employees are those who work 30 hours or more per week)
   - ○ In a part-time permanent role (part-time permanent employees are those who work less than 30 hours per week)
   - ○ On a fixed-term contract (staff on fixed term agreements are hired as an employee by the business to work until a specified date or when a particular event occurs)
   - ○ As a casual employee (casual staff usually refers to a situation where the employee has no regular pattern or guaranteed hours of work and no ongoing expectation of employment)
   - ○ As a seasonal worker (seasonal employment is generally a type of fixed-term employment where the employment agreement says that the work will finish at the end of the season)
   - ○ As a contractor (contractors are self-employed people brought in to perform services for the business under a contract – they pay their own tax and ACC levies)
   - ○ Other:
   - ○ Don't know
   - ○ Prefer not to say

6. Which of the following best describes you:
   - ○ Business owner/partner
   - ○ Senior manager
   - ○ Supervisor
   - ○ Employee
   - ○ Don't know
   - ○ Prefer not to say
   - ○ Other:

7. Do you work in an office for most of your workday: ○ Yes ○ No (yes = terminate)
   Termination message: Unfortunately, we need to hear from those who don't usually work from an office. Thank you for your time.

8. Since you left school, about how many years, in total, have you been doing this type of work? This could be for yourself or for an employer.
   - ○ Less than a year
   - ○ 1–5 years
   - ○ 6–10 years
   - ○ 11–15 years
   - ○ 16–20 years
   - ○ More than 20 years
   - ○ Don't know
   - ○ Prefer not to say

9. In which of the following regions do you mostly work: (select all that apply)
   - ○ Northland
   - ○ Auckland
   - ○ Waikato
   - ○ Bay of Plenty
   - ○ Gisborne
   - ○ Hawke's Bay
   - ○ Taranaki
   - ○ Manawatū-Whanganui
   - ○ Wellington-Wairarapa
   - ○ Tasman
   - ○ Nelson
   - ○ Marlborough
   - ○ West Coast
   - ○ Canterbury
   - ○ Otago
   - ○ Southland
   - ○ Don't know

10. Do you belong to a union: ○ Yes ○ No ○ Don't know ○ Prefer not to say

11. The next couple of questions are about the business/organisation where you currently working. To the best of your knowledge, about how long has this business/organisation been operating:
    - ○ Less than a year
    - ○ 1–5 years
    - ○ 6–10 years
    - ○ 11–15 years
    - ○ 16–20 years
    - ○ More than 20 years
    - ○ Don't know
    - ○ Prefer not to say

12. Including yourself, how many staff work for the business/organisation, in total:
    - ○ 1 staff member (only myself)
    - ○ 2–5 years
    - ○ 6–9 years
    - ○ 10–19 years
    - ○ 20–49 staff
    - ○ 50–99 staff
    - ○ 100 or more staff
    - ○ Don't know
    - ○ Prefer not to say

2. OccIDEAS questions

The following questions are about the usual tasks you do each day while at your job. Module-specific questions from OccIDEAS will be asked here.

3. A few questions about you

To end this survey, we would like to ask you some questions about yourself. We will use the answers to these questions to group respondents into groups of workers so we can examine and compare their results. Your information and privacy will be protected, as all responses are completely confidential. WorkSafe will not be able to identify who replied or what was said.

13. How old are you:
    - ○ 18–24
    - ○ 25–34
    - ○ 35–44
    - ○ 45–54
    - ○ 55–64
    - ○ 65 and over
    - ○ Prefer not to say

14. Were you born in New Zealand:
    - ○ Yes
    - ○ No
    - ○ Prefer not to say

15. (if Q14=2, ask) Which country were you born in:
    - ○ United Kingdom
    - ○ China
    - ○ Australia
    - ○ Samoa
    - ○ India
    - ○ South Africa
    - ○ Fiji
    - ○ South Korea
    - ○ Don't know
    - ○ Prefer not to say
    - ○ Other:

16. (if Q14=2, ask) About how long ago did you arrive in New Zealand:
    - ○ Less than 5 years ago
    - ○ 5–10 years ago
    - ○ 11–20 years ago
    - ○ 21–30 years ago
    - ○ More than 30 years
    - ○ Don't know
    - ○ Prefer not to say

17. (if Q14=2, ask) Which of the following best describes your status in New Zealand:
    - ○ I'm a New Zealand citizen
    - ○ I'm a New Zealand resident (resident visa/permanent resident)
    - ○ I'm on a work visa
    - ○ I'm on a student visa
    - ○ Don't know
    - ○ Prefer not to say
    - ○ Other:

18. Which ethnic group (or groups) do you belong to: (select all that apply)
    - ☐ New Zealand European (or Pākehā)
    - ☐ Other European group:
    - ☐ New Zealand Māori
    - ☐ Samoan
    - ☐ Tongan
    - ☐ Niuean
    - ☐ Cook Island Māori
    - ☐ Other Pacific Island group:
    - ☐ Chinese
    - ☐ Indian
    - ☐ Other Asian group:
    - ☐ Other ethnic group:
    - ☐ Don't know
    - ☐ Prefer not to say

19. Is English your first language: (the language mainly spoken by you at home)
    - ○ Yes
    - ○ No
    - ○ Don't know
    - ○ Prefer not to say

20. Which best describes where you live:
    - ○ A main city (for example, Auckland, Hamilton, Wellington, Christchurch, Dunedin)
    - ○ A provincial town/centre (for example, Whanganui, Invercargill, Gisborne etc)
    - ○ A rural area/settlement/village
    - ○ Don't know
    - ○ Prefer not to say

21. How many people live at your home:
    - ○ 1 (live on my own)
    - ○ 2
    - ○ 3
    - ○ 4
    - ○ 5
    - ○ 6–10
    - ○ More than 10
    - ○ Don't know
    - ○ Prefer not to say

22. (if Q21=1, 98 or 99 skip, else) Do you have children in your household that are under 16 years of age, or older people that you care for:
    - ○ Yes
    - ○ No
    - ○ Prefer not to say

23. (if Q22=1, ask) For whom do you have parenting and/or caring responsibilities:

- ○ Children under the age of 5 years, including mokopuna/grandchildren
- ○ Children aged 5–13 years, including mokopuna/grandchildren
- ○ Children/young people aged 14 years or over
- ○ Elderly whanau/family or friends
- ○ Whanau/family or friends with a disability or long-term illness
- ○ Prefer not to say
- ○ Other:

24. Which of these best describes your **total personal income** before tax, for the last year: (include any child support, benefits or other income support you may receive)

- ○ $20,000 or less
- ○ $20,001–$40,000
- ○ $40,001–$60,000
- ○ $60,001–$80,000
- ○ $80,001–$100,000
- ○ More than $100,000
- ○ Don't know
- ○ Prefer not to say

25. What is the **highest qualification** you have:

- ○ No qualification
- ○ Secondary school qualification
- ○ Tertiary qualification (for example, trade, polytechnic degree or bachelor's degree)
- ○ Postgraduate degree/diploma/certificate or higher (for example, honours, masters, doctorate)
- ○ Don't know
- ○ Prefer not to say

26. (if Q25=3 or 4, ask) Is this qualification related to your current job:

- ○ Yes
- ○ No
- ○ Don't know
- ○ Prefer not to say

27. (if Q26=2, ask) What is the **highest qualification** you have for your **current job**:

- ○ No qualification
- ○ Secondary school qualification
- ○ Tertiary qualification (for example, trade, polytechnic degree or bachelor's degree)
- ○ Postgraduate degree/diploma/certificate or higher (for example, honours, masters, doctorate)
- ○ Don't know
- ○ Prefer not to say

28. What is your gender:

- ○ Male
- ○ Female
- ○ Another gender:
- ○ Don't know
- ○ Prefer not to say

You have now reached the end of the survey. Thank you for your time. Is there anything else you would like to tell us about your job, which you feel is important from a Health and Safety point of view?

Comments:

Completion message

Thank you for your participation. WorkSafe will use the information from this survey to help them better understand the workplace risks for workers in specific industries and occupations. As a result, WorkSafe will develop a health and safety work programme that is focused on helping to support workers in these industries and occupations.

If you feel that you need to speak with someone about the subject of this survey, you can contact the **National Telehealth Helpline** by calling or texting 1737 from your mobile phone. Alternatively, you can call the **Ministry of Health's Helpline** at 0800 611 116.

Notes

Disclaimer

WorkSafe New Zealand has made every effort to ensure the information contained in this publication is reliable, but makes no guarantee of its completeness.

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