Work-related health estimates

WORK-RELATED HEALTH DEATHS AND HOSPITALISATIONS ESTIMATES, AND UPDATE OF THE ACC WORK-RELATED HEALTH CLAIMS FIGURE

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1.0
Brief summary
This report estimates the number of deaths and hospitalisations caused by chronic exposure to work-related hazards in New Zealand each year.

It excludes deaths and hospitalisations caused by acute injury. It also reports the latest three year average of Accident Compensation Corporation (ACC) claims flagged by ACC case managers as gradual process.

The revised estimate for work-related health deaths is 750–900 per year (rounded to the nearest 50).

The revised estimate for work-related health hospitalisations is 5000–6000 per year (rounded to the nearest 1000).

The latest three year (2015–2017) average figure for ACC gradual process claims is 5281 per year.

The major similarity between the methodology used in this revision and that of the previous Ministry of Business, Innovation and Employment (MBIE) (2013) estimate of work-related health deaths and hospitalisations is that both apply international work-related attributable fractions to New Zealand mortality and hospital event data. The major differences between the methodologies are:

- this revision replaces most of the attributable fractions used by MBIE with recently published attributable fractions, and
- this revision reports the hospitalisation estimate and ACC gradual process claim components of non-fatal ill-health quite separately.

In line with previous estimates, the ranges of the work-related health estimates are scenario-based (low and high), due to the uncertainty of the work-relatedness of some diseases. They are not confidence intervals (ie they do not account for additional uncertainty from sampling error, being random error/chance imprecision inevitable with smaller numbers of events), and they do not represent the inherently large uncertainties in individual attributable fractions.

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1 In this context, ‘work-related health’ means the effect on health from chronic exposure to work-related hazards.
2 Data extracted 6 June, 2019. This number is subject to change slightly as the source data is updated by ACC.
5 For excellent coverage of this see Hutchings, S., & Rushton, L. (2017). Estimating the burden of occupational cancer: assessing bias and uncertainty. Occupational and Environmental Medicine, oemed-2016. Also see the caveats in the discussion section.
2.0 Abstract

IN THIS SECTION:

2.1 Background
2.2 Aim
2.3 Methods
2.4 Results
2.5 Conclusion
2.0 Abstract

2.1 Background
It is timely to revise the previous estimate of work-related health deaths and non-fatal disease cases published in 2013 by MBIE for three reasons:

1. Since publication, ACC has revised and greatly reduced their own work-related health claims figure for the 2010 year, which is the claims year included in the previous estimate.
2. The number of work-related health claims recorded in subsequent years are substantially fewer than the revised figure for 2010.
3. Relating to deaths and hospitalisations estimates, new research quantifying the fraction of diseases attributable to work has been published since 2001, the increasingly outdated year of publication of the primary source of work-related attributable fractions used by MBIE (2013).

2.2 Aim
To revise the work-related health deaths and hospitalisations estimates using the best available international work-related attributable fractions applied to the most recently available New Zealand deaths and hospital event data, and to also report an updated figure for the number of ACC gradual process claims.

2.3 Method
For the revision of work-related health deaths and hospitalisations, work-related attributable fractions were applied to count data from the 2015 New Zealand Mortality Collection, and 2015/16 National Minimum Dataset (hospital events). Literature searches were conducted to identify recent, high quality work-related attributable fractions research. The list of diseases that attributable fractions were applied to was based upon the list used in the previous MBIE (2013) estimate and its primary source publication, and the list kept the two categories of diseases: those with a better established occupational link ‘A’ and those with a less well established occupational link ‘B’. ‘A’ diseases were used to derive the lower estimates and ‘A’ + ‘B’ diseases were used to calculate the higher estimates of the ranges.

The number of ACC gradual process claims were collated from the average number of claims from the last three years from the WorkSafe Gradual Process data set, which contains work-related ACC claims assigned a gradual process flag by ACC case managers.

2.4 Results
Sixteen cancer diseases and 14 non-cancer diseases were included in the final list of work-related diseases. Nine articles were selected as sources for attributable fractions for these 30 diseases. Estimated work-related health deaths (ie excluding injury) were 750–900 per year (rounded to the nearest 50). Estimated work-related health hospitalisations were 5000–6000 per year (rounded to the nearest 1000). The latest three year (2015–2017) average figure for ACC gradual process claims was 5281 per year.\(^6\)

2.5 Conclusion
This revision updates the estimates for New Zealand work-related health deaths and hospitalisations, using the most up-to-date international attributable faction research and New Zealand mortality and hospital event data. It also reports an up-to-date three-year average of ACC gradual process claims.

\(^6\) This number is count data, not an estimate. It is subject to change slightly as the source data is updated by ACC.
3.0
Background
A review of the currently used WorkSafe work-related health estimates\(^7\) revealed two problems with the reported non-fatal disease estimate of 30,000 cases.

Firstly, the initially published 2010 figure for ACC gradual process claims contributed 24,000 of the 30,000 cases, but has subsequently been revised down by ACC to under 11,000 (for the 2010 year). In addition to this, the counts for the 2017 ACC gradual process claims are now between 5,300 and 7,300, depending on the dataset used.\(^8\)

Secondly, the MBIE (2013) estimate for non-fatal disease cases appears to have added together two different categories of data: hospitalisations and ACC gradual process claims. There is only one ACC claim per case of disease, however there is often more than one hospitalisation per case of disease per year. It is therefore incorrect to classify hospitalisations as individual cases of disease, since this will over-estimate individual cases. ACC claims and estimated hospitalisations should therefore be reported separately. For the above reasons, the estimate for work-related health non-fatal cases needed to be revised.

Another reason for updating the work-related health estimates is that since MBIE (2013), a large international research programme by the Occupational Cancer Research Centre (sited at and co-funded by Cancer Care Ontario) has published a series of work-related attributable fractions for cancer\(^9\) that are based on higher quality evidence than the attributable fractions used in the two previous New Zealand work-related health estimates, being:


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\(^8\) ACC gradual process claims, flagged as such by an ACC case manager, or ACC data held by Statistics NZ; different methodologies are used for each dataset. The lower estimate is from the former, which is likely to be the most valid (Zeeman van der Merwe, ACC; Personal communication).

Availability of updated work-related attributable fractions is the limiting factor for calculating estimates of work-related deaths and hospitalisations. If the same work-related attributable fractions are used from one revision to the next, then any changes in estimates will be mostly due to changes in non-work-related exposures, and improvements in medical treatment. This is because the only new data used in the revision are the most recent total mortality and total hospitalisation counts, which are mostly influenced by non-work-related factors. Therefore there is no strong rationale for regularly revising work-related health estimates if there are no new and better quality attributable fractions available.\textsuperscript{10}

\textsuperscript{10} Another reason why more regular updates would be of little value is that the uncertainty in attributable fractions would far outweigh the changes in the number of total deaths and hospitalisations from one year to the next.
4.0 Methods

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4.1 Scope
4.2 Outside of scope
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4.0 Methods

4.1 Scope

The scope of this revision is modest. It is a revision of the MBIE (2013) estimates, and intends to replicate, where reasonable, the same approach. This includes using:

- the same core method used in the MBIE (2013) estimates; that is, applying attributable fractions to New Zealand Ministry of Health mortality, and hospital events data.
- as a reference point, the list of diseases used in previous New Zealand estimates\(^{11,12}\) and their key reference publications\(^{13,14}\) with the exception that the list of cancers be replaced by either the list included in the research from Cancer Care Ontario’s Occupational Cancer Research Centre (2017)\(^{15}\) or by more recent, higher quality attributable fractions than these.

Within scope is to identify recent, high quality, and applicable work-related attributable fractions from published literature, to replace the somewhat out of date attributable fractions used in previous estimates.

4.2 Outside of scope

As with previous estimates, this revision does not calculate new attributable fractions; it uses attributable fractions published in the peer-reviewed epidemiological scientific literature. For almost all exposure-disease pairings, the necessary data has not been derived and/or calculated for New Zealand.

As with the previous MBIE (2013) estimates, this revision is not intended to re-assess the strength of the occupational link of diseases included in previous estimates nor of diseases not included in previous estimates.

As with the previous estimates, this revision is not intended to quantify the full burden of work-related health harm. Work-related cases of ill-health that do not require hospitalisation and are not captured by ACC claims, are not quantified by this report. This includes for example many primary health care visits for illness not covered or claimed for under ACC.

Nor does this revision measure health losses from years of life lost through premature death or long-term non-fatal disability and suffering (which are both age-related), nor losses in quality of life, nor economic losses from productivity losses and monetised losses in health.

The revision only captures:

1. estimated deaths
2. estimated hospitalisations of conditions generally not captured by ACC claims, and
3. ACC gradual process claims, flagged as such by ACC case managers.

\(^{10}\) Another reason why more regular updates would be of little value is that the uncertainty in attributable fractions would far outweigh the changes in the number of total deaths and hospitalisations from one year to the next.


As with the previous estimates, this revision does not attempt to quantify the uncertainty inherent in the attributable fraction methodology, including the large range between reasonable lower and upper bounds for each individual attributable fraction as applied to their own jurisdiction, nor the uncertainties from applying attributable fractions derived in one jurisdiction to another, nor the uncertainty from applying an attributable fraction derived for one health outcome (for example cancer registrations) to another (for example cancer deaths).

It is not within scope to comprehensively describe all work-related attributable fraction studies found by the literature search. Studies from which attributable fractions are selected will be briefly described, as will the small number of reasonable alternative studies from which attributable fractions were considered, but not selected.

### 4.3 Data sources

**New Zealand data sources**

- Ministry of Health Mortality collection 2015 (the latest finalised release available).
- Ministry of Health Public and Private Hospitalisations data 2015/16 (the latest available).

**International data sources**

International work-related attributable fractions.

### 4.4 Selection of attributable fractions

A structured literature search using systematic and non-systematic search techniques for all work-related attributable fractions published since those used in the previous estimates was conducted. Systematic search techniques were applied to Embase and Medline databases. The search strategies were tailored to each database’s MeSH terms, and also used key words. The generic key word of ‘work’ was not included due to the hundreds of thousands of false positive search hits. In addition to these academic databases, Google Scholar was searched for work-related attributable fraction research, and key researchers in the field were asked for sources of attributable fraction research in peer-reviewed and grey literature.

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17 This is commonplace in the literature, and more common than deriving local attributable fractions, due to the common situation of the lack of detailed local exposure data.

18 It is reasonable to assume that the work-related attributable fraction of disease cases is similar to that of disease deaths; see Steenland. (date unknown). Attributable fraction: example, cancers due to occupation in the US. Rollins School Public Health, Emory University, Atlanta, Ga. www.occupationalcancer.ca/wp-content/uploads/2011/03/Steenland.pdf

19 All accepted work-related ACC claims assigned a gradual process flag by an ACC case manager.

20 See results for selected attributable fractions and their publication source.
From the publications identified in the searches, attributable fractions were selected based upon relevance to the list of diseases within scope (see above), currency (ie how recent), subjective quality, applicability of the research to the New Zealand context, and applicability to deaths and hospitalisation data. Where there was little difference in these factors, more conservative attributable fractions were favoured, given the large uncertainty inherent in all attributable fraction research.22

Assessing quality of the research required judgement from the author but based on standard clinical epidemiology techniques and measures for assessing levels and grades of evidence. This favoured attributable fractions derived from higher levels of the evidence hierarchy; that is, systematic reviews, over cohort studies, over case-control studies. It also favoured research from acknowledged leading experts in the field of occupational attributable fractions research. Assessing applicability to New Zealand entailed only including attributable fraction research from countries with developed economies.

4.5 Applying attributable fractions to New Zealand mortality and hospital events data

For each disease, the selected work-related attributable fraction was multiplied by the specified age range of the corresponding disease outcome count data from the most recent New Zealand mortality (2015) and hospitalisation (2015/16) data to estimate the annual number of work-related health deaths and hospitalisations.

The specified age range for each disease is based upon the disease latency, and where published, was taken from the same research as the attributable fraction. Where no age range was published, for consistency, the age ranges were taken from those used by the National Health and Safety Advisory Committee (NOHSAC) work-related health estimate by Driscoll et al. (2004), or from their primary source, Nurminen and Karjalainen (2001), or from consideration of the latency and mechanism of the exposure. Given that almost all work-related diseases are more common in older age, the choice of specified upper age limit has a substantial impact on estimates, while the choice of lower age limit usually has no or minimal impact. The age ranges used are reported in the results tables, and the source is provided in the notes to the tables.

4.6 Determining the final list of diseases and corrections to previous estimates’ methodology

Cancers

As explained in the scope, the starting point for the list of cancer diseases included in this revision are those from Cancer Care Ontario’s Occupational Cancer Research Centre (2017):21 The rationale behind this decision is that this Cancer Care Ontario research is widely considered amongst the most substantial and advanced work-related attributable fractions research in the world to date. It included 44 different known and suspected occupational carcinogens and 27 associated cancer sites, based on evaluations conducted by the International Agency for Research on Cancer (IARC) Monographs. The prevalence of exposure to each occupational carcinogen was mostly based upon exposure estimates developed by CAREX24 Canada, which is a multi-institution research project.


23 Carcinogen Exposure database.
that combines academic expertise and government resources to generate an evidence-based Canadian carcinogen exposure surveillance programme.25

Work-related attributable fractions for cancer found by the literature search were assessed for inclusion against these Cancer Care Ontario attributable fractions.

Non-cancers

The starting point for the list of non-cancer diseases was those used in the two previous New Zealand work-related health estimates26,27 and their primary reference publication and source of almost all previously used attributable fractions, Nurminen and Karjalainen (2001).28

In the previous estimates an error arose from cross-walking between ICD-10 to ICD-9, which meant that vascular and unspecified dementia (ICD-10 codes F01 and F03) was incorrectly listed as senile and pre-senile organic psychotic conditions.29 This revision corrected that error.

For pneumonia, Driscoll et al. (2004) included ICD-9 codes:

- 480 Viral pneumonia
- 481 Pneumococcal pneumonia (Streptococcus pneumoniae pneumonia)
- 482 Other bacterial pneumonia
- 483 Pneumonia due to other specified organism
- 484 Pneumonia in infectious diseases classified elsewhere
- 485 Bronchopneumonia, organism unspecified
- 486 Pneumonia, organism unspecified

This was based on the ICD-10 codes included by Nurminen and Karjalainen (2001):

- J12 Viral pneumonia, not elsewhere classified
- J13 Pneumonia due to Streptococcus pneumoniae
- J15 Bacterial pneumonia, not elsewhere specified
- J17 Pneumonia in diseases classified elsewhere

The source of Nurminen and Karjalainen’s attributable fraction is a study by Coggon et al. (1994), which reported an increased risk of lobar pneumonia in welders. There was no increased risk for those older than 65, which the Coggon et al. surmised was due to the reversibility of the susceptibility of the lung to pneumonic infection. Hence the appropriate age range of New Zealand death and hospitalisation data to apply to the attributable fractions used by previous estimates is the working age range used by Coggon et al.; 15-64 years. Previous estimates used 30+ years, which would cause an overestimate of the effect of welding fumes on pneumonia cases, given that the vast majority are in those over 65 years of age.

An added complication since the publication of Nurminen and Karjalainen (2001) is that the ICD-10 code J18 Pneumonia, organism unspecified, has been added to the ICD-10 classification system, and that most New Zealand deaths and hospitalisations are classified under this code. This revision has not included J18 cases, which may lead to an underestimation if there is misclassification of lobar pneumonia to this code. Most cases of lobar pneumonia are due to Streptococcus pneumoniae, so should be coded under J13, which is included in the analysis.

29 Which was later summarised as ‘mental health’ conditions in widely used presentation slides.
For kidney disease, due to cross-walking between ICD-10 and ICD-9, in an attempt to represent the approximate count of the kidney diseases considered to have an occupational cause, previous estimates included one third of the cases under ICD-9 codes 580-589. This revision reverts back to the original ICD-10 codes used by Nurminen and Karjalainen (2001).

Both previous New Zealand estimates omitted four non-cancer diseases/outcomes that were included by their primary source publication. These diseases are depressive episode, spinal muscular atrophy (or motor neuron disease or amyotrophic lateral sclerosis), cryptogenic fibrosing alveolitis (or idiopathic pulmonary fibrosis), and suicide. These four diseases were deemed in scope for the attributable fractions literature search and any subsequent analysis.

Musculoskeletal conditions such as low back pain and carpal tunnel syndrome were not included in the hospitalisation estimate for reasons of consistency with MBIE (2013), and because musculoskeletal conditions are captured to some degree by the ACC gradual process claims.

4.7 Applying the categorisation of ‘well established’ v ‘less well established’ to the list of diseases; the origin of the ranges in the estimates

The categorisation used by the NOHSAC estimate (Driscoll et al. 2004) between ‘A’ diseases ‘with the most well established links to occupation’ and ‘B’ diseases ‘for which the occupational link was less well established’ was retained for this revision, as it was outside of the scope to re-evaluate based on current scientific evidence, how well established the occupational link of each disease is. The NOHSAC ‘A’ category is the list of diseases included by Steenland et al. (2003) and the ‘B’ category is the list of diseases included by Nurminen and Karjalainen (2001), but not included by Steenland et al.

For cancers, NOHSAC’s ‘A’ category referred to cancers caused by carcinogens classified as definite or probable by the International Agency for Research on Cancer (IARC). The Cancer Care Ontario, Occupational Cancer Research Centre research (2017) almost exclusively only included cancers caused by carcinogens classified as definite or probable by IARC, hence (with one exception) all cancers from this research were classed as ‘A’. The exception is bladder cancer; the portion of the work-related attributable fraction of bladder cancer that was due to polycyclic aromatic hydrocarbons was classified as ‘B’. Over 99% of the estimated work-related cancer deaths derived from the Cancer Care Ontario, Occupational Cancer Research Centre research (2017) attributable fractions fall under category ‘A’.

For non-cancers, this revision retained the same NOHSAC categorisations where one had been assigned, however there were at least four diseases/outcomes not assigned a categorisation, due to their exclusion from the NOHSAC estimate: depressive episode, spinal muscular atrophy (or motor neuron disease), cryptogenic fibrosing alveolitis (or idiopathic pulmonary fibrosis), and suicide. For the purposes of this analysis, a category was applied to these diseases based on the source of the attributable fraction and internal review within WorkSafe New Zealand.

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31 Estimating work-related musculoskeletal hospitalisations may be explored in future work.
32 While this is not explicitly stated by NOHSAC, it is implicit, since all cancers included by Steenland were given an A category, and all were chosen by Steenland based on the IARC classification of 1 (definite), and 2A (probable). Nurminen and Karjalainen (2001) included some cancers caused by carcinogens classified by IARC as 2B (possible).
33 This is based upon Cancer Care Ontario, Occupational Cancer Research Centre. (2017) ‘there was weaker evidence for the association between PAHs and bladder cancer’ (p. 39).
4.0 Methods

4.8 Sensitivity analysis of the work-related health deaths and hospitalisations

Two sensitivity analyses were undertaken, which compared the primary results from this study to analysis using different sets of attributable fractions. The first applied the most recent Ministry of Health mortality and hospitalisation data to the work-related attributable fractions used by MBIE (2013). The second applied the same Ministry of Health data to the cancer attributable fractions in a comprehensive French study by Micallef et al. 2019.

4.8 Methodology of the update of the ACC gradual process claims figure

The number of ACC gradual process claims for 2015-2017 were collated from gradual process claims, flagged as such by an ACC case manager, to give a three year average. This data set contains all approved work-related claims that have been assigned an ACC gradual process flag by an ACC case manager. This gradual process flag is how WorkSafe determines whether an ACC claim is a work-related health claim, rather than an acute injury claim. The gradual process flag is thought to be the most valid method of determining gradual process claims. These claims were cross-tabulated by disease.

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24. 2018 data was not used since there is a lag in this data set due to how claims are assigned a year by ACC; the 2018 claims count extracted at the end of 2019 compared with the start of 2019 will be several hundreds of claims higher.

25. Zeeman van der Merwe, ACC. (Personal communication)
5.0 Results

IN THIS SECTION:

5.1 Work-related attributable fractions search
5.2 Cancers
5.3 Non-cancers
5.4 The revised work-related health estimates
5.5 Results of the ACC gradual process claims analysis
5.1 Work-related attributable fractions search

Systematic literature search of Embase and Medline

The Embase search returned 520 publications and the Medline search returned 304 publications. After duplications between databases were removed, the search returned 543 distinct publications (see Appendix 6).

Attributable fractions were selected from these 543 publications, and from other means as outlined in the methods. In the few cases where the source publication was not found through the systematic literature search, this is noted below.

5.2 Cancers

IARC based multi-carcinogen studies


This publication was identified through the website of the Institute for Work and Health, Toronto, Canada. The research included 44 different known and suspected occupational carcinogens and 27 associated cancer sites, based on evaluations conducted by the International Agency for Research on Cancer (IARC) Monographs. The prevalence of exposure to each occupational carcinogen was mostly based upon exposure estimates developed by CAREX Canada which is a multi-institution research project that combines academic expertise and government resources to generate an evidence-based Canadian carcinogen exposure surveillance programme.

This Cancer Care Ontario research considered several other carcinogens for inclusion in the study, but ultimately did not report attributable fractions for their effects, due to insufficient data. Carcinogens not included were antineoplastic agents, nanomaterials, pesticides, and sedentary work.


Labrèche and Kim et al.’s publication is essentially the peer reviewed version of the 2017 Cancer Care Ontario, Occupational Cancer Research Centre’s publication. However there are some notable differences, including: fewer carcinogens (31) and slightly fewer cancer sites (24), resulting in 64 exposure-cancer site pairs; and the use of a method to avoid over-estimation of lung and bladder cancers from overlapping carcinogens in industries and occupations.

A comprehensive French study has recently been published that has a similar approach to the Cancer Care Ontario study.


The systematic literature search found a citation for a peer reviewed article of this research, however it seems that it is currently in press, as Labrèche F. (2019). The current burden of cancer attributable to occupational exposures in Canada. Preventive Medicine. (no pagination).
5.0 Results

At least two of the attributed researchers in the Cancer Care Ontario, Occupational Cancer Research Centre (2017) work are co-authors of the French study: Hutchings and Rushton.

Micallef et al.’s primary analysis only includes carcinogens classed as definite by IARC, whereas the Cancer Care Ontario research and Labrèche and Kim et al. include IARC definite and probably carcinogens, although the latter only include two IARC probable carcinogens (creosotes and night shift work). Micallef et al. included 25 agents in the primary analysis, which were causally related to 23 cancer sites, and 44 carcinogen–cancer pairings. Micallef et al. undertook a secondary analysis of carcinogens classified as definite or probable by IARC. This analysis included 34 carcinogens, causally related to 23 cancer sites, and 73 carcinogen–cancer pairings.

Micallef et al. adjust for the changing level of exposures over time by categorising exposures into three groups: ‘(i) agents which have been used with no change since 1965, (ii) agents very little used after 2000 (eg asbestos, benzene), and (iii) agents where there has been a moderate decrease in use since 1965’ (p 23). The Cancer Care Ontario research also adjusts for changes in exposures over time using historical trend analysis from the Canadian job exposure matrix and unique analysis for asbestos and environmental tobacco smoke exposure.

Micallef et al. do not include the impact of para-occupational exposure to asbestos in their mesothelioma attributable fraction, while the Cancer Care Ontario, and Labrèche and Kim et al. research do. This lowers the Micallef et al. mesothelioma attributable fraction by approximately 3%, and lowers the New Zealand estimate based on this attributable fraction by approximately three deaths.

Any of the three above studies could be used for the cancer attributable fractions for this revision of estimates. Labrèche and Kim et al. was selected over Micallef on the basis that its primary analysis included the effects of IARC definite and probable carcinogens (as did previous New Zealand estimates) and its attributable fractions had published confidence intervals, which have the potential to be included in further analysis. Labrèche and Kim et al. was selected over the Cancer Care Ontario research since it was essentially the more recent peer reviewed version, but improved upon the methodology by accounting for overlapping carcinogens.

Melanoma of the skin


Rushton and Hutchings (2017), report an attributable fraction of melanoma of the skin caused by work-related solar radiation (sun exposure) of 2%. They also report that there is uncertainty in the literature as to whether melanoma of the skin is work-related.

Melanoma of the skin from solar radiation was not included by Labrèche and Kim et al. or the Cancer Care Ontario study on the grounds that the occupational link is not established; the rationale was that childhood exposures are the substantive cause. However, given the significance of this disease to New Zealand, and given that there is a recently published, high quality work-related attributable fraction, this cancer has been included, but as a NOHSAC category ‘B’ disease, so will not affect the lower work-related health estimates.

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Data from both studies will likely be used in the future, particularly the exposure data.
Alternative sources are the Micallef et al. attributable fraction of 0.1% for men and 0% for women based on exposure to polychlorobiphenyls, or the Labrèche and Kim et al. attributable fraction of 0.1% for men and women from exposure to mineral oils.

### List of included and excluded cancers in this revision

As a result of using the Labrèche and Kim et al. attributable fractions, and the exception made for melanoma of the skin, the following cancers have been **included** in this revision:

- bladder cancer
- breast cancer
- laryngeal cancer
- leukaemia
- liver cancer
- lung cancer
- melanoma of the skin
- mesothelioma
- multiple myeloma
- nasopharyngeal cancer
- non-melanoma skin cancer
- ocular eye melanoma in welders
- ovarian cancer
- pharyngeal cancer
- sinonasal cancer
- stomach cancer.

As a result of using the Labrèche and Kim attributable fractions, the following cancers and cancer sites that were included in previous estimates have been **excluded** from this revision:

- bone and articular cartilage
- brain
- cervix uteri
- colon
- gallbladder
- Hodgkin’s disease
- kidney
- non-Hodgkin’s lymphoma
- oesophagus
- oral cavity
- pancreas
- prostate
- rectum, rectosigmoid junction and anus
- uterus.

Evidence for the occupational link for these excluded cancers is not strong. All except kidney cancer were categorised as ‘B’ by NOHSAC; which means they were not included by Steenland (2003) on the grounds that they were not associated with an IARC probable or definite carcinogen.
The kidney cancer attributable fraction calculated by Nurminen and Karjalainen is based upon four studies which include data from several countries, covering exposures such as petroleum, gasoline (and the additive tetraethyl lead), solvents, cadmium and lead. An attributable fraction for kidney cancer caused by trichloroethylene is included in the supplementary material of Labrèche and Kim et al. however it is 0.0 (0.0-0.1) for the exclusion of kidney cancer. Kidney cancer caused by exposure to cadmium, and trichloroethylene is included in the French study by Micallef et al. (2019). If the attributable fractions from this study are applied to New Zealand health outcome data, then kidney cancer accounts for 4 deaths and 16 hospitalisations (see Appendix 3).

5.3 Non-cancers

Chronic obstructive pulmonary disease


While this is an abstract, the yet to be released Health and Safety Executive UK chapter from which it is based has been received: Section 3 Estimation of the Burden of Chronic Obstructive Pulmonary Disease due to Occupation in Great Britain. The research reviewed the literature to select the best risk estimate for work-related COPD for the UK population, and used a UK developed airborne chemical exposure job exposure matrix (ACEJEM) to estimate the proportion of the population exposed to COPD hazards. The attributable fractions were 18.3% for men, and 6.1% for women, with combined attributable fraction of 12.3%.

Another recent publication considered was Lytras et al. (2018). This multi-centre, prospective cohort study with 20 years follow-up reported a work-related attributable fraction of 21.0% for men and women.

The Hutchings et al. (2017) attributable fractions were selected over this for the following reasons: i) Hutchings et al. reported results for men and women separately28 ii) the cohort in Lytras et al. (2018) is relatively young (median age of 55 years) and ranges from 39 to 68 years, so there is some uncertainty regarding generalisability to older age groups, and iii), the Hutchings et al. attributable fraction is substantially lower, hence is a more conservative choice.

Asthma


This prospective cohort study reported attributable fractions for new-onset work-related asthma of 14.3% for men and 6.6% for women.

Another publication considered was Torén et al. (2011). This prospective cohort study reported attributable fractions for occupational exposure to gas, dust and fumes of 17.3% for men, 5.1% for women; 9.4% in total.

28 Although Lytras et al. (2018) did report finding no significant difference between men and women.
The Lillienberg et al. (2011) attributable fractions were selected primarily on the basis that the Toren et al. (2011) study assessed exposures by a single survey question: ‘Have you ever in your work been exposed to gas, dust or fume?’, whereas the Lillienberg et al. (2011) study used a job exposure matrix that included 17 risk groups of known asthmagens.

**Idiopathic pulmonary fibrosis**


This is the only study found with an attributable fraction for idiopathic pulmonary fibrosis due to dust (13%); in order of greatest effect, agricultural dust, metal dust, and wood dust. While this publication is only an abstract, one of the authors was contacted, and the full study publication in a peer-review scientific journal is currently in press.

There is no specific ICD-10-AM 8th edition code for idiopathic pulmonary fibrosis. To apply this attributable fraction to New Zealand health outcomes, data is required for the 4-digit ICD-10 codes under J84, including J840 Alveolar and parietoalveolar conditions; J841 Other interstitial pulmonary diseases with fibrosis; J848 Other specified interstitial pulmonary diseases; and J849 Interstitial pulmonary disease, unspecified. Ministry of Health Clinical Coding Helpdesk advised that ‘By following the conventions within the ICD-10-AM classification ‘idiopathic pulmonary fibrosis’ is classified to J84.1 Other interstitial pulmonary diseases with fibrosis. The ICD-10-AM code J84.1 is the default code for ‘fibrosis lung’, so the code is not specific to ‘idiopathic’.’ It is therefore not possible to determine the exact number idiopathic pulmonary fibrosis deaths or hospitalisations from available Ministry of Health data sets, so this disease was not included in the revision. This judgement call may change to include idiopathic pulmonary fibrosis if expert respiratory physician opinion can indicate the likely proportion of code J84.1 that is idiopathic pulmonary fibrosis.

The upper limit for work-related idiopathic pulmonary fibrosis deaths can be determined by assuming all 105 deaths for 2015 attributed to J841 Other interstitial pulmonary diseases with fibrosis are idiopathic pulmonary fibrosis. The upper limit would be 14 deaths attributable to work-related dust exposure.

**Ischaemic heart disease**


This study was selected on the grounds that it conducted a systematic review and meta-analysis, and included several risk factors for ischaemic heart disease. Some other studies only include the effects of psychosocial factors or shift work. Ha et al. include attributable fractions for noise (0.53%), work-related
environmental tobacco smoke (ETS) (3.48% for men and 2.43% for women), shift work (1.02% for men and 0.64% for women), and low job control (4.54% for men and 2.53% for women), for combined attributable fractions of 9.29% for men and 5.78% for women. It applied these to ICD-10 codes I21-I25, which includes acute and chronic ischaemic heart disease.

Ha et al. (2011) likely over-estimates the effect of ETS since it is based on exposure prevalence of 19% for men and 11.3% for women, defined as exposed to ETS for more than a quarter of working time.

Järvholm, Reuterwall and Bystedt (2013) assessed multiple risk factors, but this study did not conduct a systematic review or meta-analysis to identify risk estimates. It reported attributable fractions for acute myocardial infarction attributable to job strain, shift work, exhaust gases, combustion products, or environmental tobacco smoke (ETS). The attributable fractions reported are high; 23% for women and 21% for men, but are only applied to ICD 10 I21 (acute myocardial infarction), because the authors state that there are better established work-related factors for this diagnosis. If these attributable fractions are applied to New Zealand data for acute myocardial infarction, then the estimated number of deaths is 99, compared with 81 estimated deaths if Ha et al.’s lower attributable fractions are applied to the wider grouping of diagnoses (ICD 10 I21-I25).

Three further single risk factor studies illustrate the variability in attributable fractions research.

Vyas et al. (2012) reported, reported an attributable fraction of 7.0% for myocardial infarction caused by shift work. This compares to the 1.02% for men and 0.64% for women reported by Ha et al. This large difference is primarily due to very different population exposure prevalence figures used in the studies (32.8% for Vyas et al. and 8.6% for men and 5.4% for women in Ha et al.). There is also a small difference between the risk estimates (1.23 for Vyas et al. compared with 1.17 for Ha et al.)

Sultan-Taïeb et al. (2013) reported an attributable fraction for ischaemic heart disease caused by job strain of 9.4% for men; their meta-analysis reported a non-significant relationship for women. This compares to Ha et al.’s findings of 4.54% for men and 2.53% for women (also a non-significant finding, but included in the final attributable fraction). Sultan-Taïeb et al.’s relative risks used were 1.53 for men and 1.09 for women, obtained from the SUMER survey, a national periodical cross-sectional survey.

Lee and Kim (2018) reported an attributable fraction for ischaemic heart disease caused by job strain of 6.7%. The relative risk of 1.34 was from Kivimaki et al. (2012), and their proportion exposed to high job strain was 21.2%, from the 2006 Korean Working Conditions Survey.

**Stroke**


Lee and Kim report an attributable fraction for stroke caused by job strain. They used relative risks of 1.24 for ischaemic stroke and 1.01 for haemorrhagic stroke from Fransson et al. (2015). This revision is only using the attributable fraction for ischaemic stroke, since the relative risk for haemorrhagic stroke is

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42 Lee and Kim seem to make an error when determining the population attributable fraction (PAF) for all stroke, by summing the PAFs for ischaemic, and haemorrhagic stroke, rather than determining a weighted average of the two PAFs. This error does not affect the ischaemic stroke PAF used by this revision.
extremely close to 1.00, and is not statistically significant (RR 1.01 (95% CI 0.75–1.36)), indicating that job strain does not cause haemorrhagic stroke. Lee and Kim reported an attributable fraction for ischaemic stroke (ICD-10 I63) of 4.84%. This revision used an attributable fraction of 3.68% derived from the job strain prevalence data in Lee and Kim, but using the Fransson et al. adjusted (for socioeconomic status) relative risk of 1.18 rather than the unadjusted relative risk of 1.24.

Given the high quality of the Fransson et al. (2015) meta-analysis, and the consistency with the same causal mechanism for ischaemic heart disease, ischaemic stroke from job strain was assigned a NOHSAC category A.

A potential limitation of using Lee and Kim’s attributable fraction for ischaemic stroke is that it only takes into account the effects of one exposure; job strain. Previous estimates use Nurminen and Karjalainen’s (2001) attributable fraction of 10.5%, which incorporates the exposures of shift work (4.8% for men and women), and work-related environmental tobacco smoke (ETS) (7.6% for men and 3.2% for women). The work-related ETS portion of this attributable fraction is almost certainly an over-estimate, given that the reference source was a 1999 New Zealand study which did not differentiate between work and non-work ETS.

Nurminen and Karjalainen’s (2001) shift work attributable fraction of 4.8% is considerably higher than a more recent study by Vyas et al. (2012), which reported an attributable fraction of 1.6% for stroke events, but no significant finding identified for stroke deaths.

A study by Jaakkola and Jaakkola (2006) calculated an ETS attributable fraction for stroke for Sweden of between 1-5% for an ETS exposure prevalence (exposed to tobacco smoke for greater than or equal to 75% of their working time) of 3-10%. The proportion of New Zealand’s exposure to this level of ETS at work is not known, but it seems likely to be far less than 10%, given New Zealand’s smoke free legislation.

Based on the above, it is very likely that the Nurminen and Karjalainen (2001) attributable fraction is an over-estimate. However it is likely that the Vyas et al. (2012) attributable fraction is an under-estimate, given that it only includes the effects of one risk factor (shift work), and reported a higher non-significant relative risk for cerebrovascular death (1.12 v 1.05). Despite Vyas et al.’s systematic review, these attributable fractions were based on only 4 and 2 studies respectively, illustrating the lack of research in this area at that point in time.

Motor neuron disease


This is the only study found with an attributable fraction for motor neuron disease (amyotrophic lateral sclerosis). The study reported an attributable fraction of motor neuron disease caused by lead of 4.9%. To apply this attributable fraction to New Zealand health outcomes, data for the 4-digit ICD-10 codes under G12, including G122 motor neuron disease were requested and received from the Ministry of Health.43

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43 ICD-10 4-digit code breakdowns are not available on the Ministry of Health website.
Depressive episode (and anxiety)


This cohort study used data from a national child development study to assess the prospective association between job strain and future depression and anxiety. The study reported a work-related attributable fraction of 14%. While attributable fractions were not calculated separately for men and women, the study population was 48% female and the modelling adjusted for sex. Another potential limitation of the study is that it assessed midlife depression and anxiety, that is, depression and anxiety that developed in a cohort between the ages of 45 to 50 years. It is possible that the pathogenesis of work-related midlife depression and anxiety differs to that of other age groups, which if the case, would limit the generalisability of this study.

Attributable fractions from several other studies were considered, however Harvey et al.’s was used on the basis that it was a recent, large prospective study. Another advantage over some other studies is that it enables the inclusion of anxiety in the revised estimates. While anxiety was not included in previous estimates, there is good evidence from longitudinal New Zealand research that work stress precipitates both depression and anxiety.\(^44\) The Malaise Inventory was used to detect case-level common mental disorders, however this inventory was not designed to align with specific ICD anxiety disorders. For this revision, Harvey et al.’s attributable fraction was applied to ICD 10 F41, which includes:

- F41.0 Panic disorder (episodic paroxysmal anxiety)
- F41.1 Generalised anxiety disorder
- F41.2 Mixed anxiety and depressive disorder
- F41.3 Other mixed anxiety disorders
- F41.8 Other specified anxiety disorders
- F41.9 Anxiety disorder, unspecified.

Other potential attributable fractions for depressive episodes (and anxiety)

Cocco and Agius (2018) is a recent study, and has the advantage of including the effects of two psychosocial hazards; effort-reward imbalance, and job control. It reported a work-related attributable fraction for major depressive disorder of 11.2%. The study used risk estimates and proportions exposed from a 2012 study that uses data from large international surveys.\(^45\) Most of the data used was cross-sectional.

McTernan, Dollard & LaMontagne. (2013) reported an attributable fraction for depression due to job strain and bullying of 8.7%. It used a telephone survey with a response rate of 31% to ascertain the population exposure, so is more prone to bias. It also had a smaller sample than Harvey et al. (2018).

Sultan-Taïeb et al. (2013) used meta-analysis to calculate risk estimates for job strain’s contribution to mental disorders (depression and anxiety), and used a 2003 large national government run survey with a high response rate to assess the population exposure to this risk. Attributable fractions based on multi-


adjusted relative risks were 15.2% for men and 14.3% for women. While this high quality study has the added strength that it reports separate attributable fractions for men and women, Harvey et al. (2018) was chosen on the basis that it is more recent, prospective, and whilst noting there is very little difference between the two studies’ attributable fractions.

LaMontagne et al. (2008) was based on cross-sectional survey data and calculated the attributable fraction of depression caused by job strain. It has the advantage of reporting separate attributable fractions for men (13.2%) and women (17.2%). The risk estimate for job strain was obtained from a 2006 meta-analysis that included two studies for job strain.46 Job strain prevalence was obtained from a 2003 population-based telephone survey. However, Harvey et al. (2018) was preferred to this research on the grounds of currency and the prospective cohort study design, which is less prone to bias than cross-sectional survey data.

Other mental and behavioural disorders

Mental and behavioural disorders due to alcohol and drugs (ICD-10 F10-19) were considered for inclusion because of a published work-related attributable fraction from the World Health Organization of 15.8%.46 However, this attributable fraction was based upon expert opinion, a lower level of evidence than the other attributable fractions used in this revision, which were calculated from a risk estimate and the proportion of the population exposed. For this reason, the World Health Organization attributable fraction was not included in the analysis.

No other population attributable fractions for mental and behavioural disorders due to alcohol and drugs were found from the systematic literature search.

Suicide

No work-related attributable fractions were found for suicide from the literature searches, nor from asking key researchers in the field of work-related suicide.46

Suicides were excluded by NOHSAC/MBIE, probably on the basis that they were excluded from their main outcome data source, the Work-related fatal injuries study (WRFIS). NOHSAC refers to the attributable fractions calculated by Nurminen and Karjalainen (2001), which were 0.4% for men and 0.3% for women, but does not use them. They were based on Finnish research using data from 1971-80 (Rimpela et al. 1987), which compared rates of suicide in physicians with other professionals, and with the economically active population.

Routley and Ozanne-Smith (2012) studied the nature of work-related suicides by analysing records from the Victorian Work Related Fatality Database for the period July 2000 – December 2007. A very broad definition of ‘work-related’ was used by this study, over-estimating the figure reported for work-related suicides. A re-analysis of the data by this work-related health estimates revision calculated that 5.9% of suicides had a work-related stressor. This figure is not an attributable fraction; it is not derived from a risk estimate and the proportion of a population exposed. It is the proportion of suicides that the coroner reported having a work-related stressor; many of these suicides also had non-work-related stressors. Therefore, the 5.9% figure should be used with caution, even though it is the best known published estimate for the proportion of suicides that may be caused by work. The 5.9% figure was not used in the primary analysis for the work-related estimates, but analysis has been included in the appendices.

48 Key researchers contacted were Prof. Tony LaMontagne and Assoc. Prof. Allison Milner.
Lee and Kim (2018) note the Korean National Police Agency reported that approximately 4% of suicides were related to work or workplace-related issues. This proportion is not too dissimilar to the result of the re-analysis of the Routley and Ozanne-Smith (2012) data. The Korean police agency report is not accessible in English, so the definition of ‘work or workplace-related issues’ is not available.

There is sufficient data reported to calculate a work-related attributable fraction for suicide from completed research in Australia (risk estimates for job strain causing suicide, and worker exposure survey data giving a population exposed to job strain), however this step has not been done by those researchers, and is outside of the scope of this revision.

An alternative approach given consideration was to construct a work-related attributable fraction for suicide from two sources:

i. a work-related attributable fraction for mental health conditions such as depression, and combine this with

ii. depression-related attributable fractions for suicide. The literature on the latter is contested, with some research showing no association between depression and suicide once other risk factors (such as impulsivity) are taken into account (Nock, 2009).

Therefore, conservatively, this approach was not pursued. Note that Sultan-Taïeb (2013) does pursue this approach, but the literature this was based upon is prior to Nock (2009).

For all other non-cancer diseases

For all other non-cancer diseases not covered above, the Nurminen and Karjalainen attributable fractions used by Driscoll et al. (2004) and MBIE (2013) were retained. These diseases are:

- vascular and unspecified dementia
- Parkinson’s disease
- Alzheimer’s disease all classified
- pneumonia
- pneumoconiosis
- gastric and duodenal ulcer
- chronic renal failure and nephritic syndrome.

With the exception of Pneumoconiosis and Chronic renal failure and nephritic syndrome, these diseases fall under NOHSAC’s ‘B’ category, so do not influence the lower work-related health estimates of this revision. ‘B’ diseases are diseases for which the work-related link is less well established or harder to quantify.

Pneumoconiosis (almost all of which is asbestosis, but also includes silicosis) has an indisputable work-related link, and most studies use a work-related attributable fraction of 100%, which is what Nurminen and Karjalainen use.

Chronic renal failure and nephritic syndrome is the only remaining NOHSAC ‘A’ category disease (excluding the special case of pneumoconiosis). The absence of attributable fraction research in this area may be an indication that the work-related link is not well accepted or established, however further specific literature searching on this topic would be required to test this hypothesis.

Note the inclusion of (acute) nephritic syndrome by Nurminen and Karjalainen onwards. This is distinct from, and quite different to, (chronic) nephrotic syndrome.
5.4 The revised work-related health estimates

Table 1 shows the estimates calculated from the above selection of attributable fractions and subsequent application to New Zealand mortality and hospitalisation data. The precise work-related health death estimates calculated for NOHSAC category ‘A’ and ‘A’ + ‘B’ are 753 and 902 deaths. The precise work-related health hospitalisation estimates calculated for NOHSAC category ‘A’, and ‘A’ + ‘B’ are 5,202 and 5,725 hospitalisations.

Table 2 shows that of the estimated 753 NOHSAC ‘A’ category deaths, an estimated 53% are cancers. Two cancers account for nearly half of total deaths: lung cancer (35%) and mesothelioma (12%). For non-cancers, chronic obstructive pulmonary disorder accounts for 28% of total deaths, with ischaemic heart disease accounting for 11%.

For the estimated 5202 NOHSAC ‘A’ category hospitalisations, Table 2 shows that 30% are estimated to be due to chronic obstructive pulmonary disease, 21% due to non-melanoma skin cancer, 13% due to ischaemic heart disease, and 6% due to asthma.

The lower estimate (753) for the number of work-related health deaths per year is over 15 times the number of work-related injury deaths (49) for the 2017/18 year.

A sensitivity analysis was done for NOHSAC ‘A’ diseases, which applied the most recent New Zealand deaths and hospitalisations data to the same attributable fractions as were used in previous estimates (see Appendix 2). The total results were similar (704 deaths and 5745 hospitalisations), but the distribution by disease has some notable differences, due to the different set of attributable fractions used. For deaths, the major differences are that for the sensitivity analysis, lung cancer only contributes 20% of deaths compared with 35% for this revision, and ischaemic heart disease contributes 23% of deaths compared with 11% for this revision.

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[50] In this section, the use of the precise numbers and percentages from the tables should not be interpreted as having accurate numbers and percentages. In this context, accuracy means the degree to which the estimated numbers and percentages conform to the actual (unknowable) numbers and percentages. The uncertainty in the reported estimated numbers and percentages (except for perhaps mesothelioma) are large, making them indicative only. See the caveats in the discussion section.
<table>
<thead>
<tr>
<th>DISEASE</th>
<th>ICD-10 CODE</th>
<th>AGE RANGE</th>
<th>NO HSE A OR B</th>
<th>ATTRIBUTABLE FRACTION</th>
<th>SOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver cancer</td>
<td>C22</td>
<td>25+</td>
<td>A</td>
<td>0.1</td>
<td>Labrèche, Kim et al. (2019)</td>
</tr>
<tr>
<td>Larynx cancer</td>
<td>C32</td>
<td>25+</td>
<td>A</td>
<td>2.1</td>
<td>Labrèche, Kim et al. (2019)</td>
</tr>
<tr>
<td>Lung cancer</td>
<td>C33-C34</td>
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<td>A</td>
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</tr>
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<td>Melanoma of the skin</td>
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<td>25+</td>
<td>A</td>
<td>10.8</td>
<td>13</td>
</tr>
<tr>
<td>Non-melanoma skin cancer</td>
<td>C44</td>
<td>25+</td>
<td>A</td>
<td>10.8</td>
<td>13</td>
</tr>
<tr>
<td>Multiple myeloma</td>
<td>C90</td>
<td>5-84</td>
<td>A</td>
<td>0.2</td>
<td>Labrèche, Kim et al. (2019)</td>
</tr>
<tr>
<td>Multiple sclerosis</td>
<td>C58</td>
<td>25+</td>
<td>A</td>
<td>20.7</td>
<td>20.7</td>
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<tr>
<td>Multiple sclerosis</td>
<td>C58</td>
<td>25+</td>
<td>A</td>
<td>20.7</td>
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<tr>
<td>Multiple sclerosis</td>
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<td>25+</td>
<td>A</td>
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<tr>
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<td>A</td>
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<tr>
<td>Multiple sclerosis</td>
<td>C58</td>
<td>25+</td>
<td>A</td>
<td>20.7</td>
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</tr>
<tr>
<td>Motor neuron disease</td>
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<td>30+</td>
<td>B</td>
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</tr>
<tr>
<td>Parkinson’s disease</td>
<td>G20-G22</td>
<td>30+</td>
<td>B</td>
<td>0.9</td>
<td>10.9</td>
</tr>
<tr>
<td>Parkinson’s disease</td>
<td>G20-G22</td>
<td>30+</td>
<td>B</td>
<td>0.9</td>
<td>10.9</td>
</tr>
<tr>
<td>Parkinson’s disease</td>
<td>G20-G22</td>
<td>30+</td>
<td>B</td>
<td>0.9</td>
<td>10.9</td>
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<tr>
<td>Parkinson’s disease</td>
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<td>30+</td>
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<tr>
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<tr>
<td>Parkinson’s disease</td>
<td>G20-G22</td>
<td>30+</td>
<td>B</td>
<td>0.9</td>
<td>10.9</td>
</tr>
</tbody>
</table>

**TABLE 1:** Estimated work-related health deaths and hospitalisations (A and B diseases)\(^1\)

\(^1\) These subset of attributable fractions were calculated by this revision using Supplementary Table S1 data and the complement of the product of complement method described by Labrèche and Kim et al. (2019).

\(^2\) The attributable fraction for breast cancer is the average of the high and low attributable fractions from Labrèche and Kim et al. (2019).

\(^3\) Age ranges for the cancer attributable fractions are based upon a latency time of 10-50 years for solid tumours, and 0-20 years for haematopoietic cancers used by Labrèche and Kim et al. (2019). Age ranges for vascular and unspecified dementia, cerebral vascular disease, chronic obstructive pulmonary disease (COPD), asthma, pneumoconiosis, chronic renal failure and nephritic syndrome, and gastric and duodenal ulcer are from NHSA work-related health estimates (Disscote et al. 2004). Note that for COPD, Hutchings, Rushton et al. (2017) use 18+ years (HSE, UK, unpublished).
### Table 2: Estimated work-related health deaths and hospitalisations (A diseases)

54 The diseases shaded grey are classified as NOHSCA 'B' diseases, which are diseases with a less well established occupational link (Driscoll et al. 2004).

55 For ischaemic stroke, an adjustment factor of 0.231 was applied to I64: Stroke, not specified as haemorrhage or infarction, and I69: Sequela of cerebrovascular disease, to adjust for these classifications including both haemorrhagic and ischaemic stroke. The adjustment factor of 0.231 is the ratio of deaths from (I60: Subarachnoid haemorrhage + I61: Intracerebral haemorrhage)/I63: Cerebral infarction, for the specified age range of 15-69.

56 Refer to footnotes to Table 1.
Sensitivity analyses using Micallef et al. (2019) cancer attributable fractions (Appendix 3)

When New Zealand mortality data is applied to the Micallef et al. (2019) primary (IARC 1 definite) and secondary (IARC 1 definite and 2 probable) attributable fractions, estimated cancer deaths would be 309 and 404 respectively,\textsuperscript{58} and cancer hospitalisations would be 595 and 927 respectively.

The estimated number of deaths derived from Micallef et al.’s IARC 1+2 attributable fractions (404) is almost identical to the 402 estimated deaths derived from using Labrèche and Kim et al. (2019). This small difference is remarkable, and is consistent with the fact that very similar methods were used in both studies. However, the small difference in combined cancers masks some notable differences at the level of individual cancers, such as Labrèche and Kim et al. giving higher estimates for lung and breast cancer, and including non-melanoma skin cancer, and Micallef et al. including a far higher estimate for liver cancer, and including colorectal and stomach cancer.

The estimated number of hospitalisations from Micallef et al.’s IARC 1+2 attributable fractions is far less than the estimate derived from the Labrèche and Kim et al. attributable fractions (927 compared with 1945). Most of this difference is due to the fact that Micallef et al. excluded the effects of solar radiation due to a lack of exposure data for the French population; non-melanoma skin cancer accounts for an estimated 1109 hospitalisations in Table 2. When non-melanoma skin cancer is excluded from the estimates derived from Labrèche and Kim et al. attributable fractions, the total falls to 836. Micallef et al.’s estimate is 11% greater than this. Labrèche and Kim et al. attributable fractions result in higher estimates for breast cancer and lung cancer, while Micallef et al. attributable fractions give higher estimates for pharyngeal and liver cancer, and include stomach, and colorectal cancer, and non-Hodgkin’s Lymphoma.

5.5 Results of the ACC gradual process claims analysis

Table 3 shows the results of the extraction of ACC gradual process claims, flagged as such by an ACC case manager.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>NUMBER OF ACC GRADUAL PROCESS CLAIMS</th>
</tr>
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<tbody>
<tr>
<td>2015</td>
<td>4750</td>
</tr>
<tr>
<td>2016</td>
<td>5528</td>
</tr>
<tr>
<td>2017</td>
<td>5566</td>
</tr>
<tr>
<td>2015-2017 average</td>
<td>5281.3</td>
</tr>
</tbody>
</table>

TABLE 3: ACC gradual process claims

On initial analysis of these claims, 75% had a primary diagnosis group of deafness\textsuperscript{59} and 18% had a musculoskeletal related primary diagnosis\textsuperscript{60}.

\textsuperscript{58} If Micallef et al.’s ‘Total’ attributable fractions are used rather than their ‘Men’ and ‘Women’ attributable fractions, the estimated cancer deaths for IARC 1 carcinogens would be 361 and IARC 1+2 carcinogens would be 466. The difference between the ‘Total’ attributable fractions and ‘Men’ and ‘Women’ attributable fractions reflects the difference in cancer distribution between men and women in France compared with New Zealand.

\textsuperscript{59} Mostly recorded as noise induced hearing loss.

\textsuperscript{60} The five musculoskeletal diagnoses were: Fracture/dislocation; Gradual Process – Compress Syndrome; Gradual Process – Local Inflammation; Infective/non-infective laceration, puncture, sting; Soft Tissue Injury.
6.0 Discussion

IN THIS SECTION:

6.1 Strengths
6.2 Caveats
This work has revised MBIE’s previous work-related health estimates from 2013, using similar methodology and scope.

Within the scope of the list of diseases used in previous estimates, the attributable fraction methodology enables an estimation of the total number of work-related deaths and hospitalisations, which is not possible if using data from individual cases of illness categorised as work-related at the time of diagnosis.

The major difference between this and previous estimates is the attributable fractions used. Therefore, the difference between this estimate and previous estimates is mainly due to advances in the scientific understanding of the association between work and illness, rather than the change in the New Zealand working environment. The use of international attributable fractions means that no New Zealand work-related exposure data or worker distribution by occupation and industry was used.

Another significant difference between this revision and the MBIE (2013) estimate is that this revision reports work-related health hospitalisation estimates and ACC gradual process claims separately, since they are different categories of data. It is not the purpose of this revision to critically analyse the ACC gradual process claims data in terms of quality, completeness and validity. This will potentially be considered in a separate piece of work. Briefly, the factors that have the strongest influence on this ACC data are more likely to be ACC policy changes, Accident Compensation Act amendments, and societal changes influencing claimant behaviour, rather than changes in work-related health exposures and disease. Therefore, raw ACC gradual process claims data counts are not good work-related health indicators. For example, in the past decade the change that arguably has had the most influence on accepted ACC gradual process claims is the July 2010 amendments to the Accident Compensation Act 2010, which tightened the criteria regarding hearing loss claims. Accepted gradual process claims for noise induced hearing loss decreased from 6439 in 2009 to 1854 in 2011 largely due to these amendments.

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61 The amendments included clause 26 (1A), which set a threshold for hearing loss claims ‘Personal injury includes any degree of hearing loss that is 6% or more of binaural hearing loss caused by a personal injury...’.

62 ACC gradual process claims, flagged as such by an ACC case manager.
6.0 Discussion

6.1 Strengths

This revision has several strengths:

1. Most attributable fractions used are based on high quality research such as meta-analyses, and are very recently published. This contrasts with MBIE (2013) WRH estimates, which used attributable fractions from 2001, and had a more limited scientific knowledge base at that point in time.

2. Systematic search techniques were used, including documented searches of the two major medical science databases (Embase and Medline), to identify relevant attributable fractions.

3. Often, several attributable fractions for the same disease were considered, critically assessed, and compared before one was selected.

4. Two sensitivity analyses have provided some ability to compare this revision’s results with previous and alternative sets of attributable fractions.

5. The latest mortality and hospital event data, which are very high quality data sets, have been applied to the attributable fractions.

6. Some errors and inaccuracies mostly caused by mapping ICD-10 to ICD-9 codes in previous work-related health estimates have been corrected for vascular and unspecified dementia, chronic renal failure and nephritic syndrome, and pneumonia. These corrections should be taken into account when directly comparing estimates for these diseases between this and previous estimates.

7. This revision made three exceptional additions to the list of diseases used in previous estimates. Two of these were diseases included in the source reference of the previous estimates (Nurminen and Karjalainen, 2001): depression, and motor neuron disease; and the other was to include anxiety, on the basis of published evidence and its diagnostic proximity to/merging with depression as one syndrome. The challenge with the inclusion of anxiety was to choose the appropriate ICD-10 codes to apply the attributable fraction to. A conservative approach was taken, with only F41 Other anxiety disorders chosen. It may be appropriate to also include F43 Reaction to severe stress, and adjustment disorders, but this decision would best be made based on further review of published literature.

8. Reported ACC gradual process claims do not use the initial 2010 figure reported by ACC, which was an over-estimate that has been subsequently revised downwards by ACC.

9. Work-related health hospitalisation estimates and ACC gradual process claims are reported separately.

6.2 Caveats

There are several important caveats to this revision.

Inherent to attributable fractions research

1. Attributable fractions have large uncertainty, mainly due to i) selection of the risk estimate, and ii) estimation of the population exposed. See Hutchings and Rushton (2017) for further discussion. Where published in the source literature, the range of uncertainty between reasonable lower and upper estimates for each attributable fraction is large (see Appendix 5 for 95% confidence intervals for A diseases). For example, the 95% confidence interval for the Labrèche and Kim et al. attributable fraction for lung cancer gives an estimated range of 171 to 541 work-related lung cancer deaths when applied to New Zealand mortality data.
The above confidence interval only takes into account the uncertainty from the relative risk, and the proportion of the population exposed. As explained by Hutchings and Rushton (2017), while these are the greatest source of uncertainty, they are not the only uncertainties in attributable fractions. Other sources of uncertainty include the selected latency range for diseases, and bias resulting from using Levin’s equation in the presence of confounding (Hutchings and Rushton, 2017).

To use the example from Hutchings and Rushton (2017), when taking into account the full range of known sources of error, the reasonable lower and upper range for the fraction of lung cancer caused by respirable crystalline silica in men in the UK was reported to be between 2.0% and 16.2%, with a point estimate of 3.9%. If this range is applied to New Zealand data, this is equivalent to estimated deaths of between 19 and 154, with a point estimate of 37 deaths.

Labrèche and Kim et al. give an attributable fraction of lung cancer caused by respirable crystalline silica in men of 4.38% (95% CI 2.85 – 11.96), giving an estimated range of deaths of between 27 and 114, with a point estimate of 48 deaths. The range of estimated deaths is still large, though narrower than that calculated by Hutchings and Rushton (2017). The reasons for this are firstly, Labrèche and Kim et al. had more detailed exposure data, but secondly because Hutchings and Rushton include more sources of error in their analysis.

The examples above illustrate that the use of precise figures for work-related estimates of disease outcome can obscure the large reasonable range of possible estimates; attributable fractions are an imprecise method, and results derived from their use have very large uncertainties.63

2. The attributable fraction methodology largely tells us about current health outcomes from past exposures. It is limited in what it can tell us about the current workplace environment (where prevention or mitigation can occur). This is due to the long latency of many of the diseases, including those that cause most harm: cancers and chronic obstructive pulmonary disease.

Specific to this revision and previous estimates

3. As illustrated by the sensitivity analyses, the selection of one attributable fraction or a set of attributable fractions over others for common diseases such as lung cancer, breast cancer, colorectal cancer, chronic obstructive pulmonary disease, and ischaemic heart disease can make a substantial difference to the estimates. There is often very little reason to choose between two published attributable fractions. What may assist in this selection process in the future is more comprehensive and detailed New Zealand exposure prevalence data. However, this is likely to be limited to a few exposures such as shift work, job strain, and work-related environmental tobacco smoke.

4. This revision and previous estimates do not attempt to incorporate the uncertainty within each attributable fraction into the results. Many of the attributable fractions published have included lower and upper bounds, so there is scope to do further analysis using this data in the future, by combining standard errors using regular methods for indirect comparison.64,65

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63 Confidence intervals or upper and lower estimates incorporating uncertainties in the risk estimates and uncertainties in the proportion of the population exposed, can be found in the source publications for most but not all of the attributable fractions used in this revision. Different methods are used to calculate these confidence intervals, so they are not always directly comparable. Most, including for cancers and COPD, use Monte Carlo simulations.

64 Wells GA, Sultan SA, Chen L, Khan M, Coyle D. Indirect evidence: indirect treatment comparisons in meta-analysis. Ottawa: Canadian Agency for Drugs and Technologies in Health, 2009. www.cadth.ca/media/pdf/H0462_itc_tr_e.pdf

5. There is added uncertainty from applying an attributable fraction derived for one country's population to the New Zealand population, because of differences in the prevalence and distribution of work-related and non-work-related exposures, differences in country income, income distribution, and labour market participation etc, and differences in population distribution by gender, sex and ethnicity. In the published literature, it is very common practice to undertake such translation of attributable fractions from some countries to another, and indeed it was done in both previous New Zealand estimates of the burden of work-related ill-health.

6. The list of diseases used in this revision is based on the list used in previous estimates, which in turn is essentially the same list as is used by Nurminen and Karjalainen (2001). This list may need revising, but this was deemed out of the scope of this revision, since it would require an assessment of the published literature on the occupational link of many diseases; a substantial piece of work. Related to this would be the re-assessment of the NOHSAC categorisation of diseases as ‘A’ or ‘B’, based on how well established the occupational link is. In this and previous estimates, the diseases in the ‘B’ category which have the greatest influence on the estimates are vascular dementia, Alzheimer’s and Parkinson’s.

7. As covered in the results, no attributable fraction research was found since Nurminen and Karjalainen for some of the diseases in the list. This could possibly be because the occupational link is uncertain, or that it is too difficult to quantify.

8. It was not possible to include idiopathic pulmonary disease due to the New Zealand data sets grouping this disease with other diseases, based on the ICD-10 version currently in use by the Ministry of Health.

9. No attributable fractions were found for suicide. The results discuss research from Australia and Korea, which gives an indication of the number of work-related suicides, but suicide was not included in the estimates based on the fact that all other diseases included have published work-related attributable fractions. Better evidence quantifying the work-related proportion of suicide is needed before inclusion, due to the sensitive nature of suicide data and the importance of this health outcome to New Zealand.

10. Number of hospitalisations is a reasonably blunt measure, since it does not account for severity of illness or length of stay. For example, an overnight admission for non-melanoma skin cancer would be counted the same as a ten day admission for end-stage lung cancer.

11. Numbers of deaths is not susceptible to the above limitation for hospitalisations. However, on its own, it does not take account of the mean age of death between deaths from work-related ill-health, and work-related injury. HSE UK research reported that the average age of diagnosis of a fatal cancer is 71 years of age (Zand, 2016). Analysis using lost life potential can account for the difference between causes of deaths that occur at different mean ages.

12. This revision and the previous MBIE (2013) estimate do not capture hospitalisations for musculoskeletal disease. An example would be operations for work-related carpal tunnel syndrome. The reasons for this are partly due to consistency between estimates, and partly because some of these cases will be captured by the ACC gradual process claims. However, a work-related attributable fraction approach may capture more of the work-related musculoskeletal harm than ACC gradual process claims, and the literature search did find several published work-related musculoskeletal attributable fractions.
13. This revision and previous estimates do not capture the primary health care burden of work-related ill-health. This is because there is no equivalent primary health care data set to the mortality and hospital events data set. Therefore there is no data set to apply the attributable fractions to. This applies particularly to conditions that cause high disease burden but little hospitalisation stays and no direct mortality (eg low back pain).

Regarding this revision

14. The literature search may not have identified all work-related attributable fractions published since 2001. Given the broad search terms that were used relating to occupation and attributable fractions/risk, it is likely that few articles have been missed. However, not all work-related attributable fraction research uses the term ‘attributable fraction’ and not all are stored under occupational MeSH terms. The literature search is very likely to have missed some relevant grey literature, although key researchers in the field were consulted. Regardless of these limitations, the primary aim of the literature search was to replace the increasingly outdated Nurminen and Karjalainen attributable fractions with more recent, higher quality attributable fractions. Ideally, the replacements would be the best available attributable fractions, but this cannot be guaranteed and should not detract from the fact that the use of better (rather than the best) attributable fractions is still an improvement on the status quo.

15. The cancer attributable fractions used in this revision largely exclude pesticides. The documented exception in the Supplementary Table S-3 of Labrèche and Kim et al. (2019) is that certain pesticides contain Chromium VI. According to Cancer Care Ontario, Occupational Cancer Research Centre. (2017), the reasons that pesticides were largely excluded is that not many of the hundreds of pesticides have been classified by IARC, there is limited human epidemiological evidence relating to pesticides, and there is limited knowledge of their exposure prevalence in Canada, which is also the case in New Zealand.  

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66 Dr Laura Beane Freeman, the US National Cancer Institute (NCI) Principal Investigator on the Agricultural Health Study, the Early Life Exposures in Agriculture Study and the NCI Formaldehyde Industries Cohort, and key note speaker at the International Symposium on Epidemiology in Occupational Health (EPICOH) 2019 confirmed that based on current scientific knowledge, it is unlikely that it is possible to quantify the number of deaths and hospitalisations caused by chronic exposure to pesticides (Personal communication, May 2019).
7.0 Conclusion
This revision used more recent and better quality attributable fraction research where available, to update the estimates of New Zealand work-related health deaths and hospitalisations.

This revision does not avoid the inherent uncertainty in estimates derived from attributable fractions, however its advantage is that it takes account of advances in scientific knowledge since 2001, being the year when the attributable fractions used in previous estimates were published. This revision also does not avoid the inherent fact that work-related health estimates describe current health outcomes from past exposures, many of which happened decades ago and are not amenable to present preventive or mitigating measures.

The results of this revision reinforce the main message from all work-related health estimates research: that deaths from work-related ill-health are at least an order of magnitude greater than deaths from work-related acute injury. This revision identified that when limiting the scope to those diseases with more well-established occupational links, the same four work-related diseases that predominated in previous estimates (lung cancer, mesothelioma, ischaemic heart disease, and chronic obstructive pulmonary disease) predominate in this estimate, but to an even greater degree.
Appendices

**IN THIS SECTION:**

**Appendix 1:** Database search strategies

**Appendix 2:** Sensitivity analysis using previous estimates’ attributable fractions

**Appendix 3:** Sensitivity analysis using Micallef et al. (2019) attributable fractions

**Appendix 4:** Suicide analysis

**Appendix 5:** Attributable fractions and 95% confidence intervals (A diseases)

**Appendix 6:** Literature search citations

**Appendix 7:** References
### Appendix 1: Database search strategies

**Embase – all years**  
(1947 – present with daily update)

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Appendix 2: Sensitivity analysis using previous estimates’ attributable fractions

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TABLE 4: Estimated work-related health deaths and hospitalisations (NOHSAC A diseases) using the attributable fractions from previous New Zealand work-related health estimates.\((^67)^{,^68}\)

67 For consistency, the age ranges are the same as those used in Table 1.
68 The columns “Total NZ deaths (2015)” and “Total NZ public and private hospitalisations (2015/16)” are restricted to the deaths and hospitalisations for the specified age ranges only.
Appendix 3: Sensitivity analysis using Micallef et al. (2019) attributable fractions

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<th>TOTAL NZ DEATHS FOR AGE RANGE (2015 IARC 1+2)</th>
<th>TOTAL NZ PUBLIC AND PRIVATE HOSPITALISATIONS FOR AGE RANGE (2015/16) IARC 1+2</th>
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<td>Colorectal</td>
<td>C18-19</td>
<td>25+</td>
<td>3.4</td>
<td>0.4</td>
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<td>Liver</td>
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<td>25+</td>
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<td>Larynx</td>
<td>C32</td>
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<td>8.5</td>
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<td>Lung</td>
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<td>8.3</td>
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<td>Ovary</td>
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<td>168</td>
<td>66</td>
<td>234</td>
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<td>156</td>
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<td>0.7</td>
<td>169</td>
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<td>270</td>
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**TABLE 5:** Estimated work-related health deaths and hospitalisations (IARC 1+2) using attributable fractions from Micallef et al. (2019)^{69,70,71,72}_{69,70,71,72}

^69 The age ranges are the same as those used in Table 1.

^70 The columns ‘Total NZ deaths age range (2015) IARC1+2’ and ‘Total NZ public and private hospitalisations age range (2015/16) IARC1+2’ are restricted to the deaths and hospitalisations for the specified age ranges only.

^71 Only female breast cancer is included in the analysis because IARC (2010) only considers the effects of shift work on female breast cancer.

^72 The diseases shaded grey are caused by IARC 2 carcinogens.
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<td>32.9</td>
<td>19</td>
<td>25</td>
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<td>7.6</td>
<td>21</td>
<td>5</td>
<td>26</td>
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<td>25+</td>
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<td>9.53</td>
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<td>1.3</td>
<td>1.3</td>
<td>0</td>
<td>207</td>
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<td>1.7</td>
<td>135</td>
<td>73</td>
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<td>0.0</td>
<td>0.2</td>
<td>101</td>
<td>55</td>
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<tr>
<td>Leukaemia</td>
<td>C91-C96</td>
<td>15-84</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
<td>169</td>
<td>101</td>
</tr>
<tr>
<td>Total</td>
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<td>275</td>
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<td>361</td>
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**TABLE 6:** Sensitivity analysis: estimated work-related health deaths and hospitalisations (IARC 1) using attributable fractions from McAllen et al. 2019\(^{3,74}\)

\(^{73}\) The age ranges are the same as those used in Table 1.

\(^{74}\) The columns ‘Total NZ deaths for age range (2015) IARC 1’ and ‘Total NZ public and private hospitalisations for age range (2015/16) IARC 1’ are restricted to the deaths and hospitalisations for the specified age ranges only.
Appendices

Appendix 4: Suicide analysis

Routley and Ozanne-Smith (2012) report that 17% of suicides in Victoria for the period July 2000 – December 2007 were work-related. This relies on a very broad definition of work-related, which includes for example, people who suicide by stepping in front of trains, on the basis that the train is a workplace of the train driver. Reanalysis of the data in the study excluded stressors that were not due to the nature of work, excluded ‘unable to find employment’, and excluded those who were recorded as ‘unemployed, retired, pensioners or students’. This brought the reported figure of 17% down to 5.9%.

In 2015 there were 451 suicides in the 15-64 year age-group in New Zealand. Based on the 5.9% figure above, 27 of these 451 suicides may have involved a work-related stressor. This is not equivalent to an attributable fraction for suicide, since the 5.9% does not take into account the non-work-related stressors which will likely be present in a large proportion of these 27 suicides. Routley and Ozanne reported that ‘the majority (54.8%) of work-related stressor suicides also had additional stressor causes not recorded as work related by police or coroners’ (p. 132).

Appendix 5: Attributable fractions and 95% confidence intervals (A diseases)\textsuperscript{6,77}

<table>
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<tr>
<th>DISEASE</th>
<th>ICD-10 CODE</th>
<th>AGE RANGE</th>
<th>NOHSAC A OR B</th>
<th>ATTRIBUTABLE FRACTIONS: LOWER AND UPPER 95% CONFIDENCE INTERVALS</th>
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<tr>
<td><strong>CANCER</strong></td>
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<td><strong>Men</strong> 95% LCI 95% UCI <strong>Women</strong> 95% LCI 95% UCI <strong>Total</strong> 95% LCI 95% UCI</td>
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<tr>
<td>Nasopharyngeal cancer</td>
<td>C13</td>
<td>25+</td>
<td>A</td>
<td>5.5 4.3 6.1</td>
<td>Labrèche, Kim et al. (2019)</td>
</tr>
<tr>
<td>Pharyngeal cancer</td>
<td>C14</td>
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<td>A</td>
<td>2.4 1.8 5.0</td>
<td>Labrèche, Kim et al. (2019)</td>
</tr>
<tr>
<td>Stomach cancer</td>
<td>C16</td>
<td>25+</td>
<td>A</td>
<td>0.5 0.3 1.6</td>
<td>Labrèche, Kim et al. (2019)</td>
</tr>
<tr>
<td>Liver cancer</td>
<td>C22</td>
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<td>A</td>
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</tr>
<tr>
<td>Sinonasal cancer</td>
<td>C30-C31</td>
<td>25+</td>
<td>A</td>
<td>6.7 3.3 23.1</td>
<td>Labrèche, Kim et al. (2019)</td>
</tr>
<tr>
<td>Lung cancer</td>
<td>C33-C34</td>
<td>25+</td>
<td>A</td>
<td>2.1 1.2 4.4</td>
<td>Labrèche, Kim et al. (2019)</td>
</tr>
<tr>
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<td>C44</td>
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<td>A</td>
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<td>Labrèche, Kim et al. (2019)</td>
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<td>Mesothelioma</td>
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<td>A</td>
<td>60.0 60.0 NP</td>
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<td>25+</td>
<td>A</td>
<td>5.6 1.4 13.6</td>
<td>Labrèche, Kim et al. (2019)</td>
</tr>
<tr>
<td>Ovarian cancer</td>
<td>C56</td>
<td>25+</td>
<td>A</td>
<td>0.5 0.2 1.2</td>
<td>Labrèche, Kim et al. (2019)</td>
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<td>Bladder cancer</td>
<td>C67</td>
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<td>A</td>
<td>5.4 3.6 15.2</td>
<td>Labrèche, Kim et al. (2019)</td>
</tr>
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<td>Ocular eye melanoma in welders</td>
<td>C69</td>
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<td><strong>NON-CANCER</strong></td>
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<td>Mental disorder</td>
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<tr>
<td>Depression</td>
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<td>20-64</td>
<td>A</td>
<td>14.0 14.0 14.0</td>
<td>Harvey et al. (2018)</td>
</tr>
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<td>Anxiety disorder</td>
<td>F41</td>
<td>20-64</td>
<td>A</td>
<td>14.0 14.0 14.0</td>
<td>Harvey et al. (2018)</td>
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<tr>
<td><strong>Diseases of circulatory system</strong></td>
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<tr>
<td>Ischaemic heart disease</td>
<td>I21-I25</td>
<td>15-69</td>
<td>A</td>
<td>9.3 0.3 18.5</td>
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<td>I63, I63.4 (I64, I69)</td>
<td>15-69</td>
<td>A</td>
<td>3.7 3.7 3.7</td>
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<td><strong>Diseases of respiratory system</strong></td>
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<td>Chronic obstructive pulmonary disease</td>
<td>J44-J45, J47</td>
<td>20+</td>
<td>A</td>
<td>18.3 2.6 42.9</td>
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<td>Chronic renal failure and nephritic syndrome</td>
<td>K08, K11, K18, K19, K28</td>
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<td>17.6 2.3</td>
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\textsuperscript{1} These subset of attributable fractions were calculated by this revision using Supplementary Table S-1 data and the complement of the product of complement method described by Labrèche and Kim et al. (2019).

\textsuperscript{2} The attributable fraction for breast cancer is the average of the high and low attributable fractions from Labrèche and Kim et al. (2019).

\textsuperscript{3} 95% confidence intervals were reported in the source literature for lung cancer, non-melanoma skin cancer, bladder cancer, ocular eye melanoma, multiple myeloma, ovarian cancer, pharyngeal cancer, depressive episode, other anxiety disorder, ischaemic heart disease, and chronic obstructive pulmonary disease. For nasopharyngeal, pharyngeal, sinonasal, and liver cancers and leukaemia, 95% confidence intervals were calculated using the ‘complement of the product of complements’ formula applied to the confidence intervals for the two or more exposures contributing to the cancer’s attributable fraction, reported in the source literature.

\textsuperscript{4} NP = not published; NA = not applicable.

**TABLE 7:** Attributable fractions and 95% confidence intervals (A diseases)
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<td>How to improve the assessment of the impact of air pollution using time series analyses.</td>
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<td>Productivity loss associated with the consumption of sugar- sweetened beverages in Mexico.</td>
<td>Preventive Medicine. 115 (pp 140-144), 2018. Date of Publication: October 2018.</td>
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<td>Chen Y., Zang L., Chen J., Xu D., Yao D., Zhao M.</td>
<td>Characteristics of ambient ozone (O&lt;inf&gt;3&lt;/inf&gt;) pollution and health risks in Zhejiang Province.</td>
<td>Environmental science and pollution research international. 24 (35) (pp 27436-27444), 2017. Date of Publication: 01 Dec 2017.</td>
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<td>Cao X., MacNaughton P., Laurent J. C., Allen J. G.</td>
<td>Radon-induced lung cancer deaths may be underestimated due to failure to account for confounding by exposure to diesel engine exhaust in BEIR VI miner studies.</td>
<td>Radiation Protection Dosimetry. 177 (1-2) (pp 69-77), 2017. Date of Publication: 01 Nov 2017.</td>
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### Appendices

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<td>Labreche F., Duguay P., Boucher A., Arcand R.</td>
<td>But other than mesothelioma? An estimate of the proportion of work-related cancers in Quebec.</td>
<td>Current Oncology. 23 (2) (pp e144-e149), 2016. Date of Publication: April 2016.</td>
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<td>The proportion of cancer attributable to occupational exposures</td>
<td>Epidemiology and Infection. 143 (10) (pp 2135-2147), 2015. Article Number: e02340. Date of Publication: 10 Jul 2015. <a href="http://dx.doi.org/10.1017/S0950268814002477">http://dx.doi.org/10.1017/S0950268814002477</a></td>
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