# Health and air pollution in New Zealand 2016 (HAPINZ 3.0)

*He rangi hauora he iwi ora*

## Health effects model – Users' guide

Prepared for

Ministry for the Environment
Ministry of Health
Te Manatū Waka Ministry of Transport
Waka Kotahi NZ Transport Agency

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**Disclaimer**

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## Health effects model – Users' guide

Prepared by

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March 2022

# Introduction

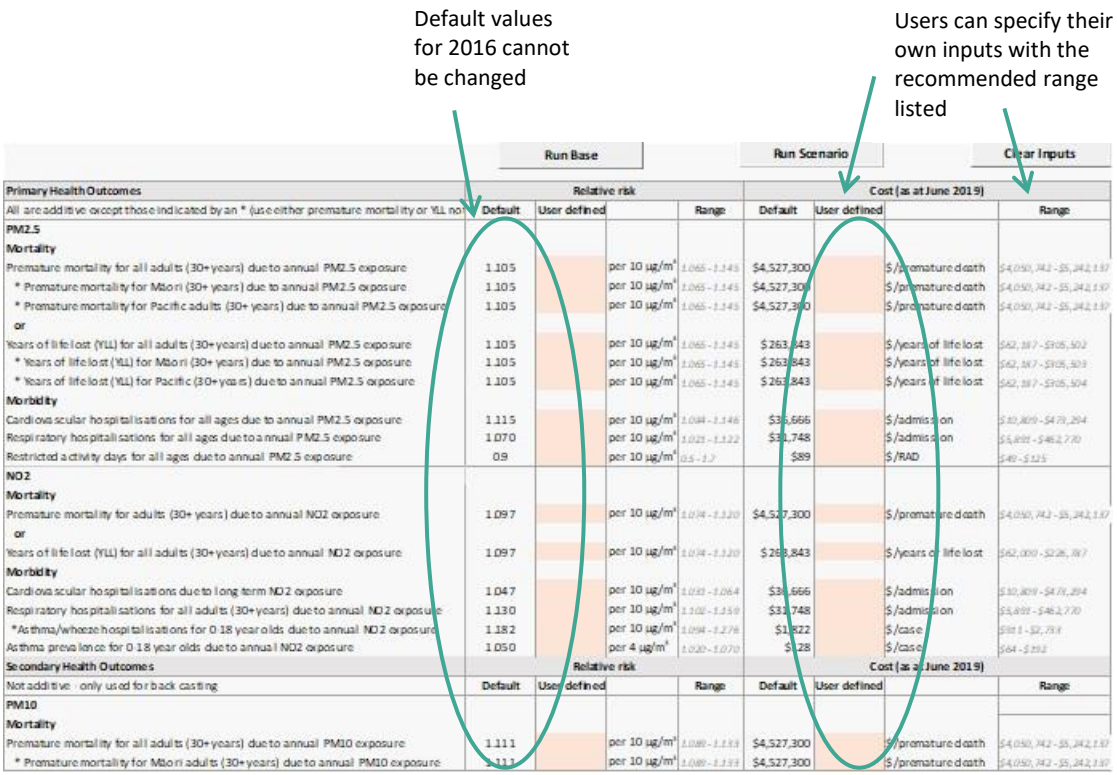
This guide is intended for anyone wishing to apply the HAPINZ 3.0 model and covers:

- The functions available in the model
- How to change inputs for sensitivity testing or scenario modelling
- How to update the model with air quality or population data.

# 1 Input sheet

The *Input* sheet provides a list of all primary health outcomes (due to $PM_{2.5}$ and $NO_2$) and secondary health outcomes (due to $PM_{10}$) assessed in the HAPINZ 3.0 Model. Default relative risk factors and costs for each health outcome are provided in columns labelled "*Default*" and cannot be changed. However, the *Input* sheet also enables users to define their own relative risk factors or costs, which can be done in the columns labelled "*User defined*".

**Note:** The column labelled "*Range*" indicates the 95% confidence intervals or low/high estimates for each parameter recommended for sensitivity testing but users can enter any value if they wish.

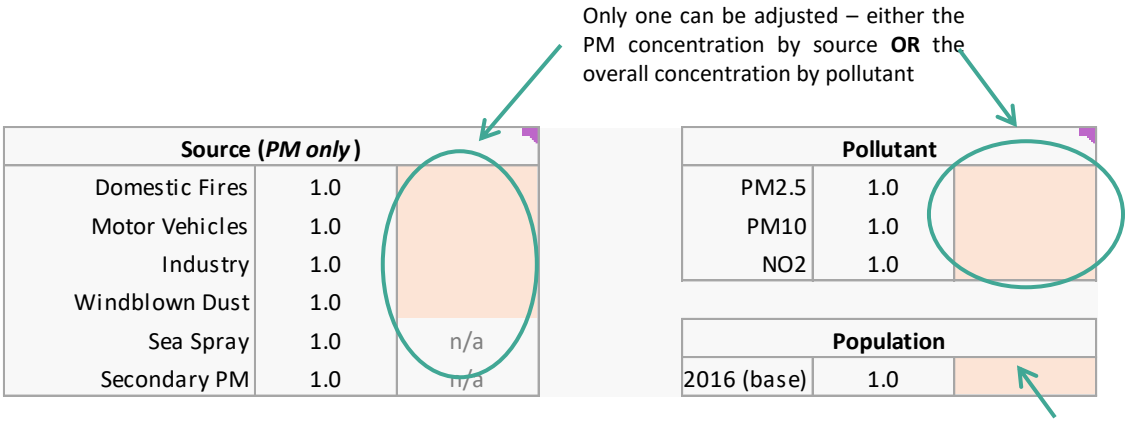



| Primary Health Outcomes | Relative risk | | | | Cost (as at June 2019) | | | |
|---|---|---|---|---|---|---|---|---|
| All are additive except those indicated by an * (use either premature mortality or YLL not | Default | User defined | | Range | Default | User defined | | Range |
| PM2.5 | | | | | | | | |
| Mortality | | | | | | | | |
| Premature mortality for all adults (30+ years) due to annual PM2.5 exposure | 1.105 | | per 10 µg/m³ | 1.065 - 1.145 | $4,527,300 | | $/premature death | $4,050,742 - $5,242,137 |
| * Premature mortality for Māori (30+ years) due to annual PM2.5 exposure | 1.105 | | per 10 µg/m³ | 1.065 - 1.145 | $4,527,300 | | $/premature death | $4,050,742 - $5,242,137 |
| * Premature mortality for Pacific adults (30+ years) due to annual PM2.5 exposure | 1.105 | | per 10 µg/m³ | 1.065 - 1.145 | $4,527,300 | | $/premature death | $4,050,742 - $5,242,137 |
| or | | | | | | | | |
| Years of life lost (YLL) for all adults (30+ years) due to annual PM2.5 exposure | 1.105 | | per 10 µg/m³ | 1.065 - 1.145 | $263,843 | | $/years of life lost | $62,187 - $105,502 |
| * Years of life lost (YLL) for Māori (30+ years) due to annual PM2.5 exposure | 1.105 | | per 10 µg/m³ | 1.065 - 1.145 | $263,843 | | $/years of life lost | $62,187 - $105,503 |
| * Years of life lost (YLL) for Pacific (30+ years) due to annual PM2.5 exposure | 1.105 | | per 10 µg/m³ | 1.065 - 1.145 | $263,843 | | $/years of life lost | $62,187 - $105,504 |
| Morbidity | | | | | | | | |
| Cardiovascular hospitalisations for all ages due to annual PM2.5 exposure | 1.115 | | per 10 µg/m³ | 1.044 - 1.146 | $36,666 | | $/admission | $30,809 - $47,294 |
| Respiratory hospitalisations for all ages due to annual PM2.5 exposure | 1.070 | | per 10 µg/m³ | 1.023 - 1.122 | $31,748 | | $/admission | $5,493 - $462,770 |
| Restricted activity days for all ages due to annual PM2.5 exposure | 0.9 | | per 10 µg/m³ | 0.5 - 1.7 | $89 | | $/RAD | $49 - $125 |
| NO2 | | | | | | | | |
| Mortality | | | | | | | | |
| Premature mortality for adults (30+ years) due to annual NO2 exposure | 1.097 | | per 10 µg/m³ | 1.034 - 1.320 | $4,527,300 | | $/premature death | $4,050,742 - $5,242,137 |
| or | | | | | | | | |
| Years of life lost (YLL) for all adults (30+ years) due to annual NO2 exposure | 1.097 | | per 10 µg/m³ | 1.034 - 1.320 | $263,843 | | $/years of life lost | $62,000 - $226,187 |
| Morbidity | | | | | | | | |
| Cardiovascular hospitalisations due to long term NO2 exposure | 1.047 | | per 10 µg/m³ | 1.033 - 1.064 | $36,666 | | $/admission | $30,809 - $47,294 |
| Respiratory hospitalisations for all adults (30+ years) due to annual NO2 exposure | 1.130 | | per 10 µg/m³ | 1.102 - 1.159 | $31,748 | | $/admission | $5,493 - $462,770 |
| *Asthma/wheeze hospitalisations for 0-18 year olds due to annual NO2 exposure | 1.182 | | per 10 µg/m³ | 1.094 - 1.278 | $1,822 | | $/case | $911 - $2,733 |
| Asthma prevalence for 0-18 year olds due to annual NO2 exposure | 1.050 | | per 4 µg/m³ | 1.020 - 1.070 | $128 | | $/case | $64 - $192 |
| **Secondary Health Outcomes** | **Relative risk** | | | | **Cost (as at June 2019)** | | | |
| Not additive - only used for back casting | Default | User defined | | Range | Default | User defined | | Range |
| PM10 | | | | | | | | |
| Mortality | | | | | | | | |
| Premature mortality for all adults (30+ years) due to annual PM10 exposure | 1.111 | | per 10 µg/m³ | 1.089 - 1.133 | $4,527,300 | | $/premature death | $4,050,742 - $5,242,137 |
| * Premature mortality for Māori adults (30+ years) due to annual PM10 exposure | 1.111 | | per 10 µg/m³ | 1.089 - 1.133 | $4,527,300 | | $/premature death | $4,050,742 - $5,242,137 |

Users can either select the *Run Base* option, which will run the macro-based model with all default values for 2016 or select *Run Scenario* if the user has defined their inputs.

**Note**: In the *Run Scenario* option, any health outcome that does not have a user defined input will use the default value instead.

Additional functionality is provided for the user to adjust pollutant concentrations either by source (for $PM_{2.5}$ and $PM_{10}$ only) **OR** the overall pollutant concentration for all three pollutants. **Users cannot adjust both source and overall concentrations for particulate matter at the same time.** User defined values are based on multipliers and have a default set to 1.0 for the 2016 base case. For example, if the user wants to halve the concentration for the domestic fires source component of PM, then the user would input a value of 0.5 against *Domestic Fires* in the *"User defined"* column.




For example, the following table compares the $PM_{2.5}$ splits for one CAU in Auckland (Maungawhau ref 518301) for the base case (100% of the 2016 concentration) and adjusting the $PM_{2.5}$ for all anthropogenic sources by a factor of 0.9 or the $PM_{2.5}$ overall by a factor of 0.9.

| $PM_{2.5}$ concentration ($\mu g/m^3$) | $PM_{2.5}$ base case for Maungawhau in 2016 | $PM_{2.5}$ source scalar of 0.9 all anthropogenic | $PM_{2.5}$ pollutant scalar of 0.9 overall concentration |
|---|---|---|---|
| **Total** | **5.789** | **5.442** | **5.210** |
| Domestic Fires | 2.026 | 1.824 | 1.688 |
| Motor Vehicles | 1.100 | 0.990 | 0.917 |
| Industry | 0.000 | 0.000 | 0.000 |
| Windblown Dust | 0.347 | 0.313 | 0.289 |
| Sea Spray | 1.274 | 1.274 | 1.274 |
| Secondary PM | 1.042 | 1.042 | 1.042 |
| **Versus base case** | **100%** | **94%** | **90%** |

**Note:** The **natural sources do not change** using either the PM source or PM pollutant scalar.

Similarly, users can also adjust the population (set to the base year of 2016) in the user defined column by adding a multiplier.

**Note**: How to develop scale factors for pollutant concentrations and population (and their likely accuracy) are discussed in section 7.3.4 of the *HAPINZ 3.0: Volume 2 – Detailed methodology* report.

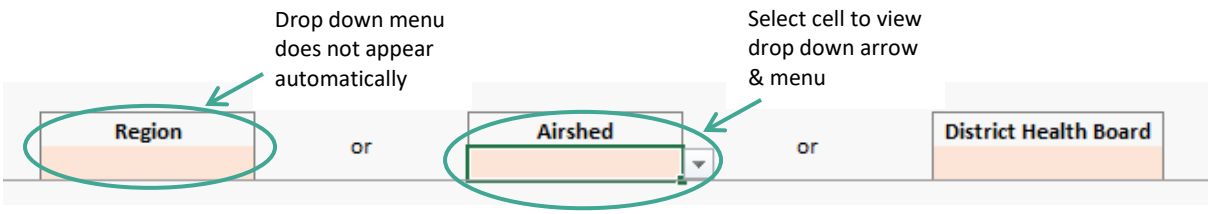
To clear any user defined inputs, select *"Clear Inputs"* at the top of the page.

# 2 Summary sheet

This sheet summarises the results for all health outcomes and associated costs assessed in this model, for both the 2016 results and for any scenario. The summaries show national results as the default for both 2016 and scenarios.

Results can be presented by region, territorial authority (**TA**), airshed or district health board (**DHB**). To select a specific area, click in the desired box and select from the drop-down menu.

**Note:** A dropdown menu does not appear automatically. The cell must be selected first.




Only one type of area can be selected at a time. For example, if the user has viewed results for the Auckland Urban airshed, and wants to view results for the Auckland region, the airshed field must be cleared first.

Options are available to view detailed 2016 results or the scenario results.

Some airsheds are combined due to the size of the underlying census area unit (**CAU**). Two exceptions to note are:

- The *Te Awamutu & Kihikihi* airshed in the model is a single airshed in reality. It covers both townships.
- The *Dunedin* airshed in the model is not a single airshed in reality. It amalgamates the individual airsheds of North Dunedin, Central Dunedin, South Dunedin, Green Island and Port Chalmers.

# 3 Results sheets

The two results sheets in the model include one for the base *"2016 Results"* and one for the *"Scenario Results"*. Both sheets are laid out the same way. Results are presented by CAU and can be filtered by airshed, TA, region, and DHB. A *filtered total* and *national total* summary is provided at the bottom of each sheet and are used to populate the "*Summary"* sheet.

Each sheet shows the total population, pollutant concentrations, and a breakdown by source for each health outcome (i.e. the number of cases attributed to the anthropogenic sources - domestic fires, motor vehicles, industry, crustal material and other - and to the natural sources - marine aerosol and secondary sulphate). For $NO_2$, the cases are all attributed to motor vehicles. The total cost associated with the total cases is calculated for each health outcome.

The macros in the model run through the calculation sheets and export the results to the *"2016 Results*" or "*Scenario Results"* sheets accordingly.

**Note:** The results are all presented as values and the calculations in the sheets are done in the macros.

# 4 Calculation sheets

There are seven calculation sheets: six calculating health outcomes from sources of particulates ($PM_{2.5}$ and $PM_{10}$) and one calculating health outcomes due to $NO_2$.

- **DF** – health outcomes related to domestic fire PM
- **MV** –health outcomes related to motor vehicle PM
- **Industry** - health outcomes related to industry PM
- **Crustal** - health outcomes related to windblown dust PM
- **Marine** –health outcomes related to sea spray PM
- **Secondary** - health outcomes related to secondary PM
- **NO2** - health outcomes related to motor vehicle $NO_2$.

Each sheet is calculated the same way. To reduce the size of the model, only the first row of each sheet contains the formulae used for the calculations. The macros in the model repeat the formulae for each CAU, then paste the results in as values for all except the first row. The results are then exported to the results sheets.

# 5 Data sheets

The model uses a series of data sheets to calculate exposure from ambient monitoring, source apportionment, population and health data. The data sheets are briefly described below:

- *PAF*: Calculates the overall population attributable fraction (**PAF**) for $PM_{10}$ and $PM_{2.5}$.

**Note:** The PAF % is not a linear equation so the overall PAF is calculated for each CAU in the *PAF* sheet based on the $PM_{2.5}$ and $PM_{10}$ concentration for each CAU. The PAF for each source is calculated (in each source calculation sheet) from the overall PAF based on the proportion of each source's contribution to the $PM_{2.5}$ and $PM_{10}$ concentration.

- *Population & Health Data*: Contains population and health incidence/prevalence data for all health outcomes.
- *Industry Sites*: Identifies CAUs dominated by industry and estimates PM concentrations for each industrial CAU.
- *$PM_{10}$ Data*: Collates $PM_{10}$ annual averages from 2004 to 2018 at monitoring sites across NZ and calculates a 2016 average for the model.
- *$PM_{2.5}$ Data*: Collates $PM_{2.5}$ annual averages from 2004 to 2018 at monitoring sites across NZ and calculates a 2016 average for the model.
- *PM Values*: Assigns concentrations based on monitoring data for airsheds or areas without any monitoring.
- *PM Ratios*: Calculates $PM_{2.5}$ / $PM_{10}$ ratios using monitoring data.
- *Conc'n by CAU*: Assigns $PM_{10}$ and $PM_{2.5}$ concentrations for each CAU and lists the $NO_2$ population-weighted concentrations for each CAU for use in this model.

- *Source Appt*: Assigns PM concentrations/proportions for each source (domestic fires, motor vehicles, industry, windblown dust, sea spray and secondary PM) based on source apportionment data for each airshed or area.
- *SA by CAU*: Calculates PM concentrations for each source by CAU from the *Source Appt* sheet.
- *SA Scenario*: Calculates PM concentrations for each source by CAU based on the user defined inputs. Values default to the original 2016 concentrations if no user inputs are entered.
- *AU Geographic Codes*: Details the geographic location of each CAU – by region, urban area, district health board and airshed.

# 6 Other sheets

There are two other sheets in the model, included for information:

- *Glossary:* Provides a list of terms and definitions used in the model.
- *Report Tables:* Generates the tables shown in the *HAPINZ 3.0: Volume 1 – Findings and implications* report.

# 7 Updating the model

## Ambient monitoring data

*$PM_{10}$ and $PM_{2.5}$*

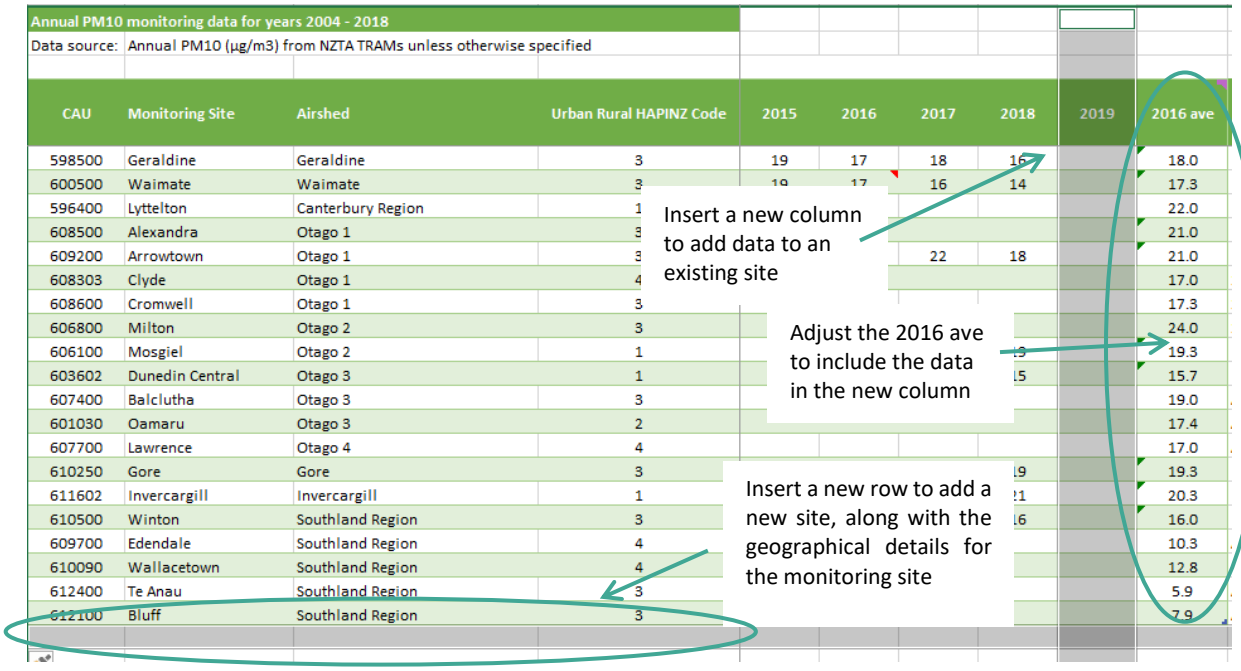
The *PM10 data* and *PM2.5 data* sheets are set up using the tables function in MS Excel. This makes it easier to update columns and rows.

To add more recent data to an existing monitoring site(s), insert a column in the desired location, enter the annual average for the site(s), then adjust the "*2016 ave*" column to use the newly entered data. This will automatically update the monitored value used in the *PM values* sheet.

To add a new site, insert a new row after the last monitoring site in the table. Geographical details for the new site will also need to be entered for the monitoring site, such as the CAU it is in, the airshed, and its respective urban/rural code. The urban/rural code can be found in the *AU Geographic Codes* sheet.

If ambient monitoring data are available for any CAU, the model will assign the CAU that concentration.

If monitoring results are not available for the period of interest, the $PM_{2.5}$ (and $PM_{10}$) data can be scaled using the approach based on population-weighted annual averages (described in section 7.3.4 of the *HAPINZ 3.0: Volume 2 – Detailed methodology* report).




*$NO_2$*

The $NO_2$ exposure dataset in the model uses exposure estimates from the Waka Kotahi NVED tool for 2016 rather than ambient data itself. The best option for updating this dataset is to request a comparable dataset for the relevant year from Waka Kotahi.

If this information is not available for the period of interest, the 2016 $NO_2$ dataset can be scaled using the approach based on trends in the Waka Kotahi $NO_2$ passive sampling data (described in section 7.3.4 of the *HAPINZ 3.0: Volume 2 – Detailed methodology* report).

## Data for areas without monitoring

To update the concentration assigned to an airshed or an area, the user can change the value in the *PM values* sheet. In the *PM values* sheet, concentrations for areas are shown in black font if the value comes from the ambient monitoring data, while concentrations for areas in orange font are either calculated or assumed to be similar to another area.

Updating concentrations in the *PM values* sheet will then update concentrations in the *SA values* sheet.

## Source apportionment data

Each airshed or area is assigned a different source apportionment breakdown. The source contributions are calculated based off the overall concentration for an area (from the *PM values* sheet), and percentage splits by source.

To update the source contributions, the user can update the percentage splits for the respective area for each source, **making sure that the sum of all the percentage splits between the sources adds up to 100%.** The source contributions will then automatically update the source contributions of the CAUs that fall within that area in the *SA by CAU* sheet.

## Population and health data

Both population and health incidence/prevalence data can be updated in the *Population and Health Data* sheet based on each CAU.

If possible, use the most recent actual mortality and morbidity data for a three-year period (to minimise inter-annual variability in numbers due to temperature). Recent hospitalisation data are likely to be available; however, mortality data often has delays of 2-3 years due to waiting on the coroners' reports.

If this information is not available for the period of interest, the most recent mortality and morbidity data can be estimated using the scalar approach described in section 7.3.4 of the *HAPINZ 3.0: Volume 2 – Detailed methodology* report, based on estimated resident population (preferably at the CAU level). However, this method assumes that mortality and hospitalisation rates are stable and does not account for any underlying changes (e.g. due to COVID-19), which may lead to increased error. Any predicted data (rather than actual data) should be treated with caution.

Asthma prevalence due to air pollution can be updated using the indirect method (outlined in section 5.3.5 of the *HAPINZ 3.0: Volume 2 – Detailed methodology* report). This method uses estimated resident population data (for 0-18 years) at the CAU level, and national-level estimates of the number of children with medicated asthma (from the New Zealand Health Survey), to calculate a national PAF for asthma prevalence, and from this, the asthma prevalence due to air pollution.

## Different area units

**Note:** This model has been designed so it can be updated in the future to accommodate statistical area units (SA1 and SA2). However, at this stage, the health incidence data, which form the basis of this model, are not yet available in this format. Consequently, these user notes do not outline the steps to change the census area units to statistical area units.