Proportional multi-state multiple-cohort life table model

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1 Introduction

The proportional multi-state multiple-cohort life table model (PMSLT) is a population level model (macro) approach to simulate health (and economic) implications of changes in exposure to health risk factors (e.g. physical inactivity, air pollution and diet). The PMSLT has been widely used to simulate outcomes for population level interventions for the reduction of chronic diseases.

The model was developed by Jan Barendregt and colleagues (REF ACE prevention and core papers) and has been widely used in Australia and New Zealand (Ref ACE-report and BODE website of key publications).

The basic infrastructure of the model consist of three components: (1) Effect size for the intervention of interest (e.g. intervention to urban design that modifies population levels of physical activity); (2) Calculation of the potential impact fraction (PIF) to derive the change in occurence of disease (indidence rate/mortality rate) attributable to a change in the distrubution of the risk factor (e.g. physical activity); and (3) Use of the PMSLT to simulate health (and economic) outcomes attributable to a change in the distribution of health risk factor/s in the population of interest. Figure 1 summarises the basic infrastructure of the model. ITHIM is included in Figure 1 to show that both approaches share in common steps one and two and differ in the mechanisms of calculation of change in health burden.

1.1 Contribution to ITHIMR

The PMSLT similar to ITHIM is a comparative risk assessment approach (REF BRIGGS 2016) that consist of calculating the change in the health burden for a population of interest from a change in exposure to health risks factors (e.g. physical inactivity, air pollution and road trauma).As depicted in Figure 1, both methods need estimates of the potential impact fraction (PIF), which indicates the proportion of the disease burden attributable to a risk factor of interest (e.g. physical inactivity). A step further back, is the development of scenarios that bring about change in the distrubution of the risk factor of interest. For now, we only focus on calculations from the PIF onwards, and provide a hypothetical example of change in population levels of
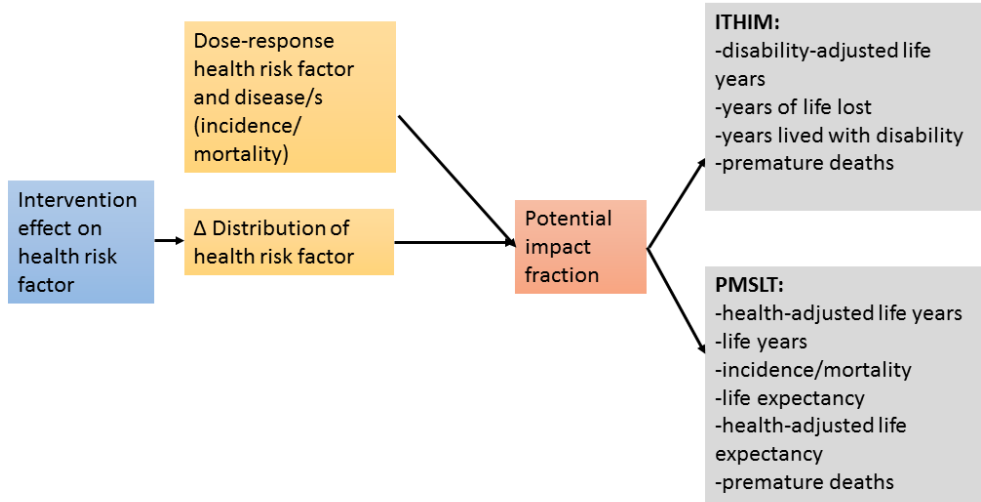
Figure 1: Figure 1. Basic model infrastructure.

physical activity. Incorporation of additional health risk factor (air pollution, road trauma, NO2 and noise) will be discussed in the relevant code sections.

1.1.1 Difference between ITHIM and PMSLT

- **Time component** The *PMSLT* follows a population of interest over time. For example, as set up here, we simulate sex and age (5 years starting at 18) cohorts over time until they die or reach 100 years of age. This implies that we can include trends for diseases, time lags between change in exposure to risk factors and change in health and demographic changes (e.g. population growth). In addition, we can estimate yearly changes in the burden of diseases over the life course or for a speficied number of years. The *ITHIM* approach is a snapshot of change in burden for one year.

- **Interaction between multiple diseases** The *PMSLT* accounts for the interaction between multiple diseases, with proportions of the population being able to be in more than one health state (REF BRIGGS 2016). This avoids overestimation of outcomes as a result of summing health outcomes attributable to each disease individually as done in *ITHIM*. It is important to note that the *PMSLT* assumes that diseases are independet of each other. That is to say, developing a disease is unrelated to a concurrent diagnoses of another disease).

- **Mortality rate** The *PMSLT* calculations for changes in life years (and health-adjusted life years) and mortality outcomes is based on observed mortality rates for the population of interest. In the *ITHIM* model, if burden of disease estimates from the Global Burden of Disease (GBD) study are used, then, the mortality component is based on the highest attained life expectancy observed in the world.
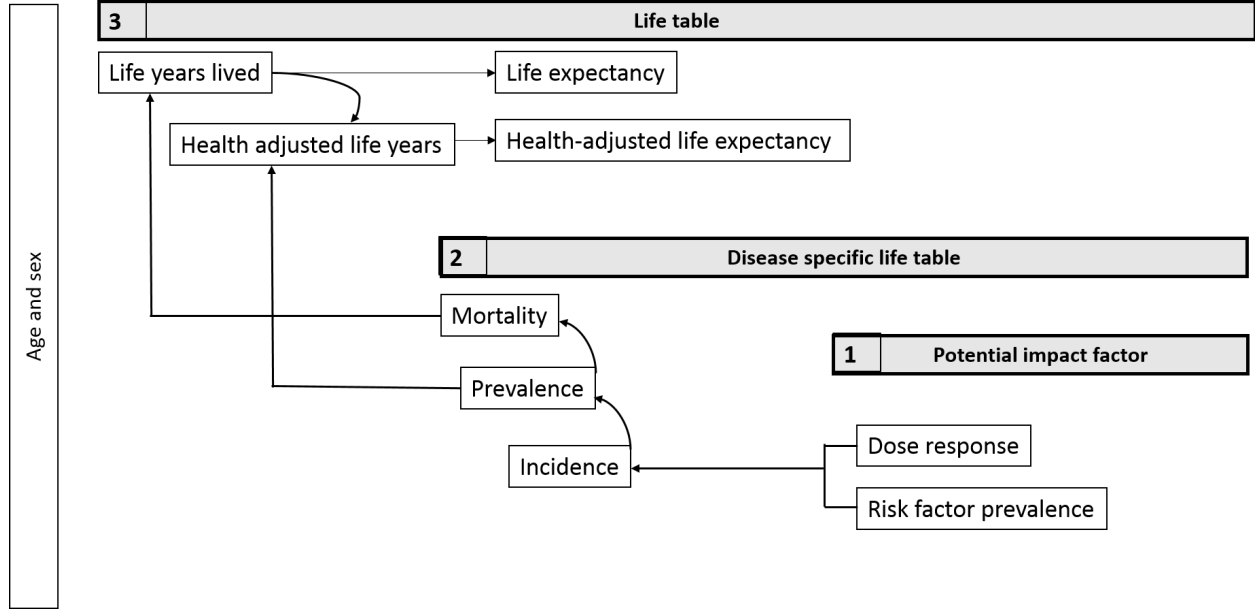
Figure 2: Figure 2. Proportional multi-state life-table .

- **Impact of disability in increased life expectancy** In GBD studies, YLLs are not adjusted for disability; hence, their use in estimating intervention effects results in over-estimation, which the *PMSLT* approach avoids. Another way of seeing this is that estimated changes in morbidity using the *ITHIM* do not allow for how implicit increases in life expectancy impact on morbidity. While the changes in deaths and prevalence using the *PMSLT* are in some ways more accurate than those from the *ITHIM* approach it should be noted that that the average age of death and incident disease will change and thus the disease burden will be on average be shifted later in life (which is a realistic approach).

2 R development

The model is set up as a long script to perform the required mathematical calculations. Where possible, we wrote functions and loops to avoid repetition. We set up the model with Australian data, for Melbourne. Figure 2 is depicts the PMSLT model framework, which was followed in the code development.

In what follows, first, we specify input parameters. Second, we present the code with explaining notes. Third, we present examples of outcomes and lastly we comment on topics related to implementation. Here we only included the physical activity health pathway. In the comments section, implementation of exposure to air pollution and road trauma is discussed. Note that in the presentation of input parameters, those needed to calculate PIFs are excluded, as these are common to the ITHIM, expect if trends are included (refer to comments section)

2.1 Inputs

When you click the **Knit** button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document. You can embed an R code chunk like this:

```
summary(cars)
```

```
##      speed           dist
##  Min.   : 4.0   Min.   :  2.00
##  1st Qu.:12.0   1st Qu.: 26.00
##  Median :15.0   Median : 36.00
##  Mean   :15.4   Mean   : 42.98
##  3rd Qu.:19.0   3rd Qu.: 56.00
##  Max.   :25.0   Max.   :120.00
```

2.2 Including Plots

You can also embed plots, for example:
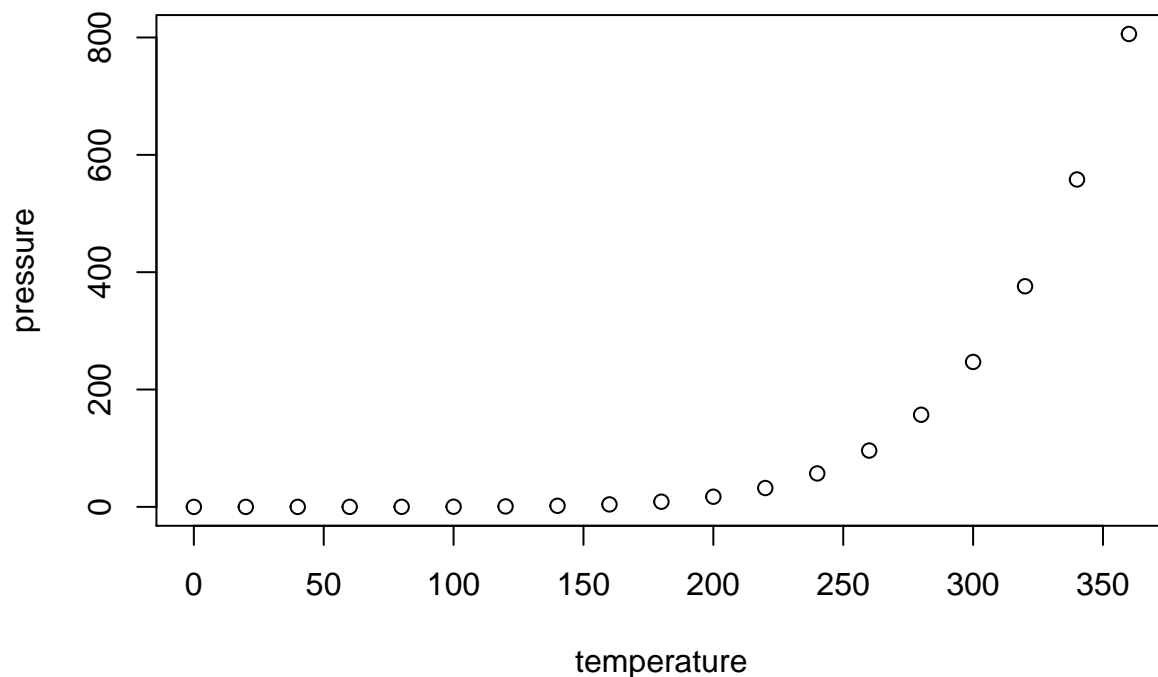
Note that the `echo = FALSE` parameter was added to the code chunk to prevent printing of the R code that generated the plot.