Simulating the impacts of lifestyle-related risk factors on the health of Australians: Understanding the complexities of modelling disease prevention

The Australian Prevention Partnership Centre
Systems and solutions for better health

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Aim

The overarching aim of the Compelling Case for Prevention Project (CCP) is to pull together the 'big picture' of prevention using system dynamics modelling, by developing a tool that allows decision-makers to explore the health and economic impacts of reducing the prevalence of different common risk factors. The goal is to establish a compelling argument for investment in prevention and to determine how best to target strategies for maximum impact over time across the common risk factors for many chronic conditions.

Phase 1: Proof-of-concept model

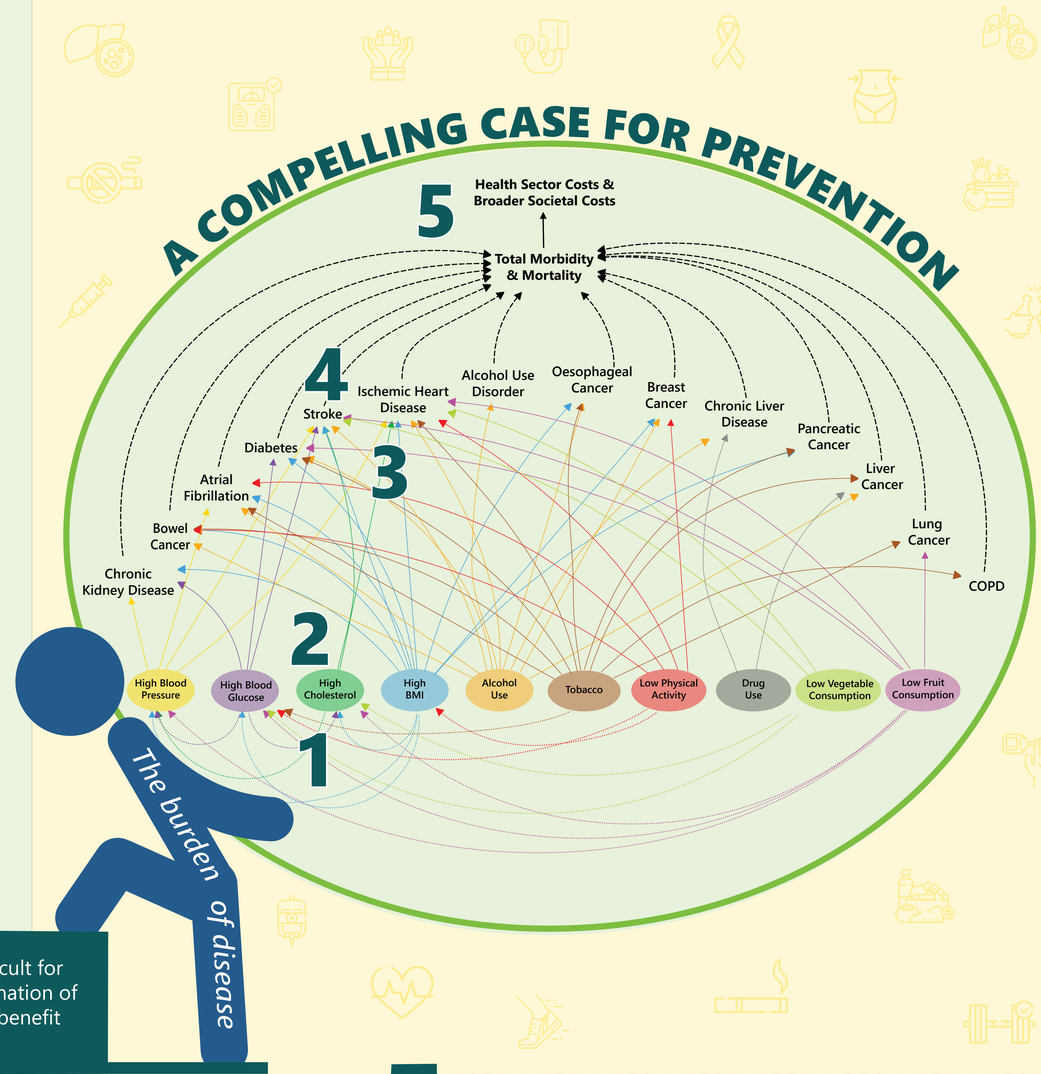
Phase 1 of this project (2016-2018) tested the feasibility of applying system dynamics modelling to the challenge of reducing the preventable component of Australia's growing chronic disease burden. We used a participatory approach, with several workshops to engage population health researchers, national and state policy makers and advocacy organisations to develop a conceptual model and agree on selected national interventions to test. The first phase system dynamics model incorporated current demographic trends, national burden of disease data, all-age prevalence data for 6 risk factors and overall Disability Adjusted Life Years (DALYs) over a 40-year time horizon.

Challenges in preventing chronic disease

Despite many major chronic diseases being largely preventable through changes to health behaviours (including, poor diet, physical inactivity, tobacco use, harmful alcohol consumption and obesity) only 1.3% of all health spending is currently directed towards prevention programs. The complex nature of the causal relationships between risk factor exposures and the development of non-communicable diseases, coupled with the long time delays between exposure and effect, makes it difficult for policy makers to identify and target the optimal combination of prevention strategies that maximise population health benefit and cost effectiveness.

Phase 2: Full national model

Building on the proof-of-concept model produced in Phase 1, the Decision Analytics team at the Sax Institute was funded in 2019 to undertake Phase 2. This phase involves expanding the model to include additional risk factors and multiple related chronic diseases. This ongoing phase is building a full simulation of the ten most common modifiable risk factors, their interactions and combinations in producing chronic disease burden and related economic outcomes, that will be made available as an online interactive decision tool. Datasets from our key data sources - the *Australian Burden of Disease Study* (AIHW, 2019) and *Global Burden of Disease Study* (IHME/UW,2019) - used to inform this model, are being analysed, transferred, and calibrated to inform the more nuanced model structure of this model. The complexities in variable combination, epidemiology of disease attribution, consistency of data availability and model versus software capacity are current issues for model construction.



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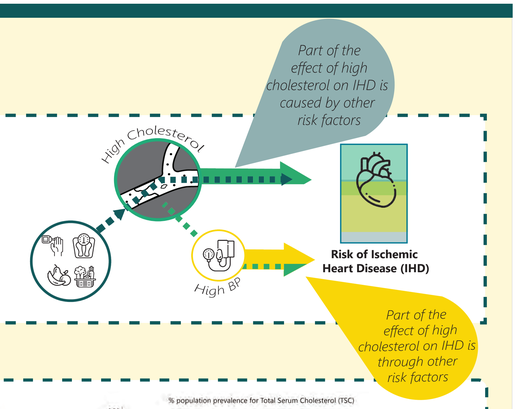
The model accounts for the interrelationships between risk factors through different mediation pathways. Using high cholesterol and IHD as an example, you can see that the role high cholesterol plays in the risk of IHD both partially accounts for, and is accounted for by, other risk factors.



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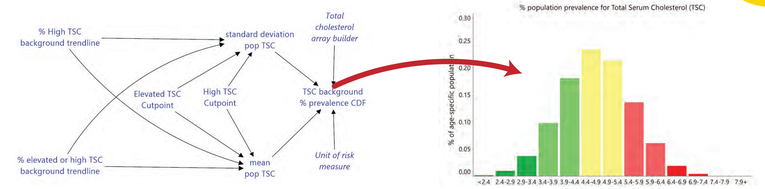

Population risk factor prevalence is treated as continous variables expressed using cumulative distribution functions (CDF). In this example, the CDF of total serum cholesterol (TSC) is shown. Interventions in the model act by changing either the mean level of risk factor exposure in the population, or adjusting the percent of the population exposed to a risk factor at one or more specific cutpoint levels.

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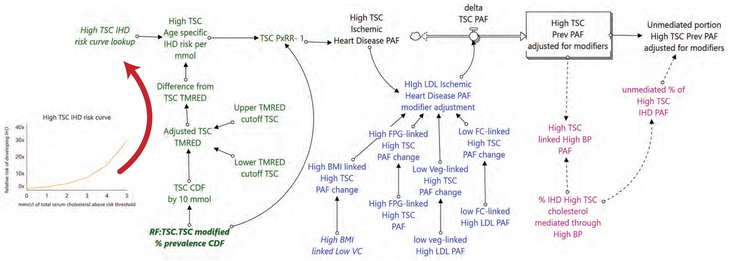

The risk factor CDFs are then combined with disease-specific risk curves to estimate the proportion of the morbidity of a specific disease that can be attributed to a specific risk factor (Population Attributable Fraction (PAF) shown in green). The PAF is then adjusted by the percent change in other risk factors that mediate that particular risk factor (shown in blue), and fractioned off to account for the proportion of other risk factors that it mediates (shown in purple). This is repeated for every risk-factor disease combination in the model.

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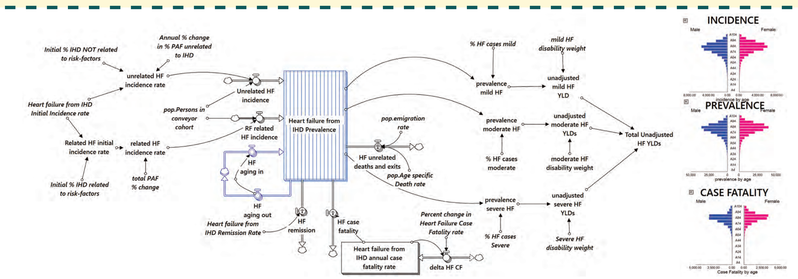

The PAFs for each of the risk factors associated with a particular disease group are combined together to calculate the total burden for that disease that can be attributed to the included risk factors (between 0 and 100%) . Using current disease incidence and population data, the model calculates the annual percent change in PAF, and adjusts the annual disease incidence rate accordingly. Known or estimated death, remission and case fatality rates allow the model to output age and gender-specific measure of morbidity (Years Living with disability - YLD, Years of Life Lost - YLL), weighted by severity. Within each disease group (e.g Ischemic Heart Disease) there are several sub-conditions (e.g. heart failure, acute myocardial infarction, angina pectoris), which are all modeled seperately and then combined to calculate the total risk by disease group.

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Funding partners:
Australian Government Department of Health
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