SYNTHESIS REPORT

The Australian Prevention Partnership Centre

A Centre of Sax Institute

The value of dynamic simulation modelling in the prevention landscape

Synthesis of knowledge from the Prevention Centre

December 2024

Read the full report, preventioncentre.org.au

Lead authors

Dr Danielle Currie

Jacqueline Davison

Contributing authors

Christine Whittall

Dr Simon Chiu

Associate Professor Louise Freebairn

Nadia Mastersson

Dr Mishel Shahid

Ainsley Burgess

Disclaimer: The views contained in this report are those of the authors and do not in all cases reflect the views of each of the policy agencies participating in this knowledge synthesis.

The evidence and knowledge included in this synthesis has been selectively drawn from The Australian Prevention Partnership Centre's research programs (2013–2023). This evidence review does not claim to be, nor is it meant to be, a review of all available evidence.

Suggested citation: Currie DJ, Davison J, Whittall C, Chiu S, Freebairn L, Mastersson N, Shahid M, Burgess A. The value of dynamic simulation modelling in the prevention landscape. Synthesis of knowledge from The Australian Prevention Partnership Centre. Sydney, Australia: The Sax Institute, December 2024.

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Our funding partners

Australian Government Department of Health and Aged Care

ACT Government ACT Health

Cancer Council Australia

NSW Government

Government of South Australia Preventive Health SA

Tasmanian Government

VicHealth

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Introduction

Dynamic simulation modelling (DSM) has emerged as a powerful tool in the field of public health, particularly for disease prevention policy makers. DSM builds on systems thinking, an approach that helps us understand complex problems by examining how different parts of a system interact and influence each other. DSM allows stakeholders to simulate the complex interactions within health systems to explore various scenarios and understand the potential impacts of different interventions.

This modelling approach provides a dynamic and comprehensive view of the factors influencing disease progression and prevention, enabling policy makers to make more informed decisions. In the context of chronic disease prevention, DSM offers valuable insights that go beyond traditional statistical methods, helping to identify effective strategies, optimise resource allocation, and ultimately improve health outcomes.

Since its inception in 2013, The Australian Prevention Partnership Centre (the Prevention Centre) has promoted the application of systems thinking among chronic disease prevention policy, practice and research partners. This focus has inspired the development of some of the first-use cases of DSM in Australian health agencies for preventive health.

The knowledge synthesis process

The Prevention Centre has developed a knowledge synthesis approach that emphasises co-production with policy makers to support decision makers working in chronic disease prevention. It combines the findings of a program of research with policy knowledge, combining the expertise of research, policy and science communication experts. This report follows the knowledge synthesis approach[1] summarised in Figure 1.

Figure 1: The knowledge synthesis approach: Combining public health evidence, policy experience and communication expertise to inform preventive health

1. Commissioning of knowledge synthesis
2. Establishment of working group
3. Development of content for policy dialogue #1
4. Policy dialogue #1
5. Development of research questions
6. Evidence gathering and synthesis
7. Policy dialogue #2
8. Finalisation of synthesis and dissemination

The focus of this report is a synthesis of knowledge that has been generated by the Prevention Centre in relation to the use of DSM in chronic disease prevention research. The specific research questions outlined below were developed in conjunction with existing Prevention Centre policy partners with previous experience in DSM, ensuring this synthesis is relevant and applicable to the current policy environment.

1. In what ways can/does dynamic simulation modelling add value to chronic disease prevention decision-making processes?
2. What factors might constrain the ability of a dynamic simulation model to add value to chronic disease prevention decision-making processes?

This synthesis differs from traditional systematic or scoping reviews in that evidence is primarily drawn from Prevention Centre projects. It does not provide an exhaustive review on all evidence in relation to the research questions, but rather provides case summaries of highly relevant work conducted through the Prevention Centre.

The synthesis elicits a specific insights framework designed to guide and be used by future policy partners interested in engaging with newer modelling approaches to their research or policy questions.

Background

What are dynamic simulation models?

At their core, all simulation models are simplified representations of reality designed to help us understand, analyse and explore different facets of the world around us. They can be viewed as miniature versions of complex systems, like a toy train set that mimics the workings of a real railway system, but on a larger scale. The beauty of modelling lies in its ability to take complex, often overwhelming amounts of information and, using only what is important, distil it into something manageable and understandable. The level of abstraction in a model – how detailed or simplified – is designed intentionally around the model's intended use. The process of building a model involves carefully selecting which elements of the system to include and how to represent them, ensuring that the model is fit for its purpose.

The term ‘dynamic simulation models’ is used for a group of specific types of models that go beyond static representations by incorporating time-dependent changes (i.e. dynamics) and interactions within a system. These models are particularly valuable in complex scenarios where various factors interact and evolve over time, such as the spread of diseases, the impact of health interventions, or the progression of chronic conditions.

DSMs differ from other non-dynamic methods commonly used in public health research, such as decision trees, Markov modelling, and cost-effectiveness analysis. While other methods support decision making and are similar to DSM, they cannot easily incorporate system complexity and dynamics. DSMs simulate the dynamic behaviour of systems by capturing how variables influence each other over time, including the presence and effects of feedback loops that drive system behaviour. This enables the exploration of counterfactual ‘what-if’ scenarios, where modifications to the system can be tested and compared to a base case to understand potential impacts.

Unlike static models, which typically provide a snapshot in time, DSMs can account for feedback loops, delays, and non-linear relationships, offering a more comprehensive understanding of how complex systems behave under various conditions. With a more nuanced and interactive approach to modelling, DSMs offer a powerful tool for policy makers and researchers to test strategies and make informed public health decisions.

DSM is an umbrella term that encompasses a variety of modelling techniques used to simulate the behaviour of complex systems over time. In this report, we focus on the application of three key types of DSMs: system dynamics modelling (SDM), agent-based modelling (ABM), and discrete-event simulation modelling (DES), as well as hybrid models that combine these approaches.

System dynamics modelling
SDM is used to simulate and analyse the behaviour of systems characterised by interdependent components, feedback loops, delays and accumulations. It is particularly well suited for modelling systems where the relationships between components are continuous and aggregate, such as population-level health trends or the spread of diseases. Stock-and-flow diagrams and causal loop diagrams are commonly used to represent and explore the system structure. SDM is especially useful for understanding long-term trends and testing strategic policy interventions in systems where feedback mechanisms drive outcomes.

Agent-based modelling
ABM simulates the behaviour and interactions of individual entities, known as agents, within a system. These agents can represent people, organisations, or other components, each with unique characteristics, decision rules and adaptive behaviours. ABM is ideal for exploring systems where individual-level behaviour or heterogeneity has a significant impact on system outcomes, such as vaccine uptake, disease transmission, or community responses to public health policies. It excels in capturing emergent phenomena, such as the collective outcomes of individual decisions, and in exploring how local interactions influence broader system dynamics.

Discrete-event simulation modelling
DES focuses on modelling systems as sequences of discrete events that occur over time. Each event represents a specific change in the system state, such as the arrival of a patient, the completion of a procedure, or the utilisation of a resource. DES is particularly effective for analysing processes with clear, sequential workflows, such as patient flow in emergency departments, appointment scheduling, or resource allocation in health services. It is a powerful tool for identifying bottlenecks, evaluating efficiency, and optimising resource use under various scenarios, often with a focus on operational improvements and capacity planning.

Hybrid models
Hybrid models combine elements of SDM, ABM and DES to capture the strengths of each approach. For example, a hybrid model might use SDM to model high-level system dynamics, ABM to simulate individual behaviours, and DES to represent detailed processes. This approach allows for a more comprehensive analysis of complex systems, offering insights that might not be achievable with a single modelling technique.

These different modelling techniques provide a flexible and powerful toolkit for exploring complex public health challenges, each offering unique insights that contribute to more effective decision making.

The role of models in disease prevention policy and decision support

When it comes to shaping disease prevention policies and making critical decisions, models can be incredibly helpful tools, but they also have their limitations. Models come in various forms and serve different purposes. Some models might use numbers and data to show trends over time, such as how the rate of a certain disease has increased or decreased in response to public health initiatives. Others might simulate the behaviour of individuals or populations to see how changes in policy could affect health outcomes.

In the realm of chronic disease policy, models can be used to represent a multitude of societal, clinical, environmental and population factors, allowing policy makers to explore how different factors – such as healthcare interventions, lifestyle changes or environmental influences – interact and impact public health outcomes. This enables decision makers to test what-if scenarios, project future challenges, and make informed decisions without the need to wait for real-world outcomes, which could be costly or impractical to obtain.

However, it is important to remember that models are simplifications. They cannot capture every detail of the real world, and their outputs are based on the information and assumptions they are built upon. As such, while models are very valuable for guiding decision making, they are best used as one of many tools in a policy maker's toolkit, complemented by real-world data, expert knowledge and critical judgement.

Models are powerful allies in the fight against chronic diseases, offering insights into patterns, forecasting future trends, and evaluating potential interventions. However, they are not infallible. Their outputs inherently carry uncertainties, they may not foresee sudden changes, and they require quality data and human expertise to be truly effective. By understanding these strengths and limitations, users can better leverage models to support informed, evidence-based decision making in disease prevention policy.

What models can do

Illuminate patterns and trends: Models are like high-powered magnifying glasses that help us see patterns in data we might miss with the naked eye. They can highlight how diseases are spreading, who is most at risk, and what factors contribute to disease prevalence. This insight is invaluable for targeting interventions more effectively.

Project future scenarios: Models, especially predictive ones, are able to examine the past and then take that information to see what the future might be. The do this by estimating how systems might change under different scenarios. This can be useful in planning for future healthcare needs, allocating resources, and anticipating the impact of new policies.

Assess intervention outcomes: Before investing in a large-scale public health campaign, it is useful to have a sense of its potential impact. Models can simulate the effects of interventions, providing an early look at what might happen if a new vaccine is introduced, a screening program is expanded, or lifestyle changes are promoted within a community.

Support evidence-based decision-making: At their core, models are about making informed choices. They synthesise vast amounts of data into actionable insights, helping policy makers choose between different options based on their likely outcomes.

What models cannot do

Predict with absolute certainty: Models are not fortune tellers or crystal balls; their projections are based on assumptions and available data, which means there is always some level of uncertainty. They offer probabilities, not certainties, and their accuracy can be affected by how well the model reflects real-world complexities.

Automatically account for unexpected events: Models work best when past patterns are a good indicator of future events. They might not fully account for sudden, unforeseen changes, like a new disease variant emerging or a rapid shift in public behaviour.

Replace human judgement: Perhaps most importantly, models are tools to aid decision making, not replace it. They provide valuable insights, but interpreting these insights and considering their broader implications requires human judgement and expertise.

Operate independently of quality data: The old saying ‘garbage in, garbage out’ applies here. Models rely on data and expert information, and the quality of their outputs is directly tied to the quality of the data they are fed. Poor or incomplete data can lead to misleading conclusions.

Establishing the appropriateness of dynamic simulation modelling for a policy question

Within the broad spectrum of modelling tools, DSM is just one of many tools available to policy makers in public health. Each tool has its strengths and is suitable for different types of questions and problems. When considering what value DSM can bring to chronic disease prevention decision making, it is crucial to first ensure that DSM is the appropriate approach to support the specific policy question at hand. When exploring the suitability of DSM for a particular policy problem, decision or question, there are important factors to consider, both in terms of the nature of the question/problem itself, and any logistical considerations that may constrain the ability of a DSM project to be successful.

Factors related to the policy question or problem

Nature of the question

DSM is particularly well suited for questions that involve complex systems with multiple interacting factors. For example, when addressing chronic disease prevention, there are numerous interrelated variables that interact dynamically, such as lifestyle behaviours, socioeconomic factors and healthcare access. If the policy question requires understanding these intricate relationships, DSM is likely appropriate. Conversely, if the question is simple and linear, where relationships between factors are straightforward and well understood, DSM may not be the best choice.

Intended use of outputs

The purpose of DSM outputs significantly influences design and implementation. DSM excels in improving understanding, not just predicting outcomes. It is most suitable when the goal is to deepen comprehension of how different factors interact within a system and to explore the potential impacts of various interventions. For instance, using scenario analyses to understand the dynamic relationships and mechanisms affecting the complexity of public health can provide valuable insights. However, if the desired outputs are just predictions or quick, one-time decisions that do not require extensive understanding of dynamic interactions, statistical analyses may suffice.

Understanding of variables and outcomes

A clear understanding of the key variables and their interactions ensures accurate and meaningful modelling. If there is a robust understanding of the factors affecting the policy issue, DSM can effectively model these dynamics. For example, if previous research has established clear relationships between the factors influencing chronic disease, DSM can provide valuable insights. On the other hand, if the variables and outcomes are poorly understood or highly uncertain, the model may struggle to offer reliable insights.

Dynamic changes over time

Dynamic simulation models centre on capturing and simulating changes over time, making them suitable only for questions involving temporal dynamics, such as how a disease spreads over time or the long-term impact of interventions on health outcomes. If the policy question involves these temporal changes, DSM techniques may be suitable. However, alternative methodologies may be more suitable if the question is static and does not centre on understanding how and why a system has, and will, change over time.

Uncertainty and scenario analysis

DSM can simulate various scenarios and assess the impact of different interventions, making it valuable when there is a need to explore what-if scenarios to inform policy decisions. For instance, evaluating the impact of various public health policies on disease incidence can benefit greatly from DSM. Conversely, if uncertainty is minimal and the decision does not require exploration of multiple scenarios, DSM might not be necessary.

Practical and logistical considerations

Availability and quality of data and evidence

For some emerging areas of prevention research, the availability of good data, particularly historical prevalence data, is not yet available. Calibrating a DSM to local conditions requires data, or at a bare minimum, a comprehensive understanding of how several points in the system have changed over time. Additionally, if the evidence or understanding surrounding a particular topic is still uncertain or of poor quality, particularly around risk and disease causality or consequences of behaviour change, this can make populating and building DSMs difficult, and the insights generated by DSM may be less reliable or actionable. DSMs for purely exploratory or learning purposes can certainly be built and can be powerful learning tools; however, tools other than DSMs may be more appropriate for policy makers.

Resources and capacity

Implementing DSM requires adequate resources, including financial, technical and human capital. It is important to evaluate whether the necessary resources are available to develop, run and maintain the model. This includes access to software, computational power, and skilled personnel with expertise in modelling, data analysis, and subject matter knowledge. Without these resources, the development and sustainability of the model could be compromised. The level of resources required to build a DSM can often be considerable.

Turnaround time

Developing a robust DSM can be time consuming. It is essential to consider whether there is enough time to develop, refine and validate the model, particularly as DSMs are typically built using extensive participatory processes. If the timeline is too tight, it may compromise the model's quality and the insights it can provide. Adequate time ensures that the model can be comprehensively built and thoroughly tested and validated, resulting in more reliable outputs.

Level of stakeholder engagement and support

Successful DSM projects often require the involvement of multiple stakeholders, including policy makers, researchers, healthcare providers and the community. Engaging stakeholders early in the process ensures that their perspectives, knowledge and concerns are incorporated into the model. This collaborative approach not only enhances the relevance and accuracy of the model, but also fosters buy-in and support for the insights and recommendations generated. Effective communication and ongoing dialogue with stakeholders are critical for aligning the model's outputs with their needs and expectations. DSM is unlikely to be a suitable methodology for a policy question in settings where extensive stakeholder engagement is not possible or desired as part of the decision-support process.

What is an 'insight'?

The term 'insight' is widely used when describing models and can mean different things in different contexts.

In the context of this report, an insight is a point of decision support value derived from the modelling process or its outputs.

Insights can be tangible outputs such as model projections, policy recommendations, or identified research gaps and priorities, or intangible outcomes such as a deeper understanding of system behaviour, stakeholder consensus, or a more holistic contextualisation of the likely effect of policy actions at the population or system level.

Clarity of objectives

For DSM to be effective, there must be a clear understanding of the objectives and specific questions that the model is intended to address. These objectives should be well defined and aligned with the policy goals. Clear questions help in the design of the model, ensuring that it is tailored to provide relevant and actionable insights. The very nature of the complex problems and systems DSM is used to model means that, without clearly defined objectives, DSM projects are vulnerable to significant scope creep and over complication. This can undermine the usefulness of the model and the feasibility of the project as a whole.

Access to technical expertise

The effectiveness of a DSM heavily relies on the availability of skilled personnel who can design, develop, maintain and interpret the model. It is crucial to assess whether there is sufficient technical expertise within the project team to ensure that the model is correctly constructed, calibrated and validated, enabling it to generate reliable and meaningful insights. Without adequate expertise, the model may be prone to errors, misinterpretations or oversimplifications, which can limit its utility in supporting decision making. Additionally, having experts on the team is essential for communicating complex model outputs to non-technical stakeholders, ensuring that the insights are understood and effectively applied in the policymaking process.

By thoroughly evaluating these factors related to the policy question and problem, and practical and logistical considerations, you can determine whether DSM is the right tool to address your specific needs. This structured approach ensures that DSM is used effectively, maximising its potential to support informed decision-making and policy development in chronic disease prevention.

Capturing the broader value of DSM

British statistician George Box famously said, *"All models are wrong, but some are useful"*. This quote captures a fundamental truth about modelling: no model can perfectly represent the complexity of the real world. Every model, by necessity, simplifies reality, leaving out certain details and making assumptions that may not hold in every context. However, the value of a model does not lie in its perfection, but in its usefulness. A model's utility is determined by how well it serves its intended purpose – whether that is to explore potential outcomes, test hypotheses, or inform decisions.

In the context of DSM, this quote invites us to rethink what we consider useful. Traditionally, the value of a model has often been linked to its ability to predict future states or outcomes with accuracy. This predictive capacity is typically seen as the primary measure of a model's utility, especially in models designed for forecasting or scenario planning. However, focusing solely on prediction can obscure the broader array of insights that DSMs can provide.

DSM projects hold immense potential in chronic disease prevention research and policymaking. However, when assessing how, when, and why to use DSM, it is important to understand that the primary goal of these models is to support decisions, not to make them. The main ways the models support decisions are by producing insights that can inform advocacy for specific policy positions, guide the further gathering of data or evidence, and help stakeholders understand the complexities of the systems they are dealing with.

While predictive insights are undoubtedly valuable, the real strength of DSMs lies in their ability to enhance our understanding of the systems being modelled. The models excel in exploring and explaining the relationships, mechanisms and dynamics within those systems, offering a deeper, more nuanced comprehension of how different elements interact and influence one another.

This shift in focus – from prediction to exploration and explanation – requires a broader rethinking of how we assess and report the value derived from a DSM. It emphasises that the true power of some models resides in their ability to illuminate and communicate complex systems and processes, enabling more informed decision making rather than just projecting anticipated future events. Recognising and valuing this aspect of modelling can lead to more effective use of models in both research and policy contexts, fostering a more holistic approach to understanding and addressing complex challenges.

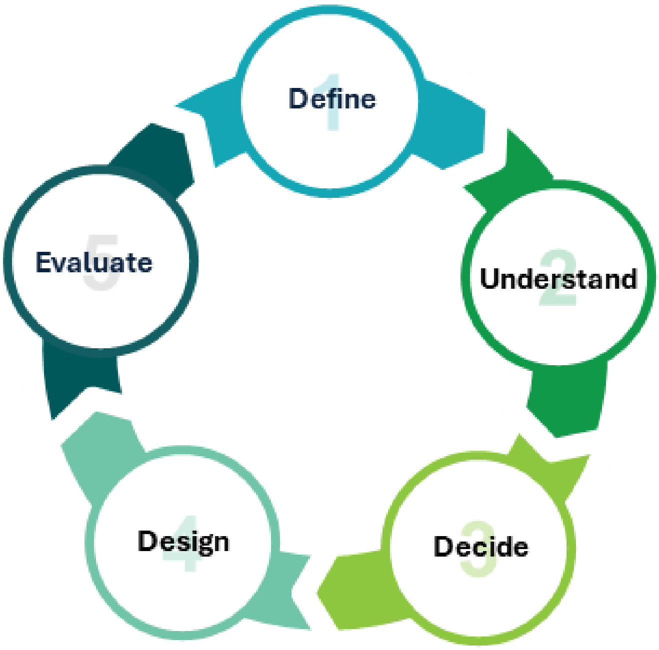
Insights derived from models can manifest in various forms, depending on the type of model used and the context in which it is applied. In ideal conditions, a DSM can provide meaningful insights across the entire spectrum of insights. However, in real-world conditions, logistical constraints and barriers can reduce a model's ability to provide certain types of insights. These constraints can include data availability, data quality, computational resources, time constraints, stakeholder engagement, and financial resources. Understanding these limitations is crucial for making the most of DSM projects.

Insights across the policy and decision-making cycle

While all types of insights are beneficial across the policy and decision-making cycle, the need for specific types of insights, along with the value modelling can deliver in providing those types of insights, can vary greatly depending on the stage of the process (see Figure 2).

At the initial stages, when defining and understanding the problem, there is often a need for insights that help establish a clear picture of the current situation, identify root causes, and uncover underlying issues that need addressing.

Figure 2: Stages of the policy decision-making cycle



As the decision-making process progresses to evaluating and selecting intervention options, there is greater need for insights that provide a deeper understanding of how different factors interact within the system, and that offer evidence-based recommendations on the most effective strategies to pursue.

During the design and implementation phase, there is often a need for clear and engaging presentations of data and strategies to ensure that all stakeholders, including policy makers, healthcare providers, and the community, understand and support the planned interventions. There is also a strong need at this stage for insights and tools that align different perspectives and foster collaboration among stakeholders, ensuring coordinated and unified efforts.

In the later stages, when evaluating and monitoring the impact of implemented solutions, insights that highlight areas where interventions may be falling short or where additional resources are needed are particularly beneficial, in addition to insights that help stakeholders adapt and improve their approaches based on the outcomes observed.

Considering the insight needs a decision maker might have at the specific stage of the decision-making cycle they are at, alongside the insight potential a DSM model can provide given the logistical constraints, will provide a clearer understanding of the holistic value proposition that DSM adds to decision making related to chronic disease prevention research and practice.

Methods and approach

This knowledge synthesis reviewed all research projects funded by the Prevention Centre between 2013 and 2023 that reported using DSM methods. The aim of the review was to answer the question: ‘What types of value do DSM methods provide?’ and synthesise the implications for policy makers.

This review included all projects identified on the Prevention Centre website and aggregated projects lists that used ‘system dynamics’, ‘agent-based modelling’ or ‘discrete-event modelling’ methods.

The Technical Working Group members collaborated to identify and categorise potential insight types relevant to DSM, drawing on their own modelling experiences.

All DSM research project output types (Publication, Findings Brief, Video, Webinar, Policy Brief, Report, Factsheet) were included in the review. Full text review of all outputs was undertaken, and the following data were extracted and recorded in a Microsoft Excel file:

- Project description
- Modelling approach
- Duration
- Modelling team
- Insight types
- Constraints to insights
- Program cycle stage
- Economic analysis inclusion
- Publications and references.

Insights for each project and where they were published or disseminated were coded according to the 10 insight types listed in the following section. Projects typically presented more than one insight type, and in several instances, three or four.

For this report, we reviewed 14 DSM projects funded by the Prevention Centre, of which seven were system dynamics models, five were agent-based models, one was a hybrid model (system dynamics, agent-based and discrete-event methods), and one was a qualitative model only based on system dynamics methodology.

Following the Prevention Centre’s established process for generating knowledge synthesis reviews, a policy dialogue consisting of representatives from Prevention Centre policy partners was held in May 2024. Policy partners who had been involved in some capacity in previous DSM projects were invited to this dialogue.

The dialogue informed the focus of this review, particularly its guiding questions. It highlighted policy partner interest in understanding where the value lies in developing DSMs and what to expect from a model once it is produced. This framing around understanding how models might be used in a policy or decision-making context informed the document review and synthesis of project information.

The review itself was centred on two guiding questions that emerged from the policy dialogue:

1. In what ways can/does dynamic simulation modelling (DSM) add value to chronic disease prevention decision-making processes?
2. What factors might constrain the ability of a dynamic simulation model to add value to chronic disease prevention decision-making processes?

Following the review of the project outputs and synthesis, a second policy dialogue with the same policy partners was held to present the synthesis findings. The dialogue provided comments to refine the messaging and clarity of this tool, which aims to capture the potential value of DSM for policy makers who might be interested in engaging with modelling for testing policy questions.

Findings

Summary of key insight types derived from dynamic simulation models

Through this review, we identified a taxonomy of **10 different types of insights** DSM models can produce (refer to Table 1 for a list of the 14 projects reviewed). Below is a short description of each of these insight types, followed by a more detailed explanation of each key insight type's value proposition, potential constraints and examples of Prevention Centre projects where these insights emerged.

1. **Descriptive**: Summarise and visualise data characteristics, providing a clear overview of the current state of the system. These are foundational for understanding the scope and scale of health problems.
2. **Explanatory**: Explain relationships and mechanisms within the system, crucial for understanding how different factors interact and influence health outcomes. These help in designing targeted interventions by identifying causal relationships.
3. **Diagnostic**: Identify problems and root causes. These are essential for pinpointing specific issues in the system that need addressing. In the context of chronic disease prevention, these insights can help identify underlying causes of disease outbreaks or inefficiencies in healthcare delivery.
4. **Projection**: Project future trends and outcomes, which help in anticipating potential scenarios and preparing for future events. In chronic disease prevention, projection insights can forecast disease incidence and prevalence, helping to allocate resources effectively.
5. **Prescriptive**: Recommend optimal actions and strategies that provide actionable guidance on how to achieve desired outcomes. Prescriptive insights are valuable for developing and implementing effective interventions and policies.
6. **Communicative**: Present information clearly and engagingly. These insights ensure that complex information is conveyed in an understandable and accessible manner. Effective communication is key to gaining stakeholder buy-in and support for interventions.
7. **Learning and capacity building**: Enhance understanding and skills through the use of models as educational tools to help stakeholders build their capacity to analyse and address health issues. This fosters a culture of continuous learning and improvement.
8. **Consensus-building**: Create a shared understanding among stakeholders. These insights align different perspectives and foster collaboration. Consensus-building is crucial for unified action and coordinated efforts in health interventions.
9. **Gap identification**: Identify deficiencies and unmet needs that highlight where evidence or resources are lacking and improvements are needed. Surfacing assumptions and making them explicit allows for critical examination and testing, leading to more transparent and accountable decision making.
10. **Contextualising:** Understand the extent or reach of impact or effect in a wider systems context. These insights allow the full extent of an intervention's effect size to be demonstrated in a real-world population and allow relative comparability of interventions to be better understood. Applying known intervention effects across a broader population and system facilitates improved decision making.

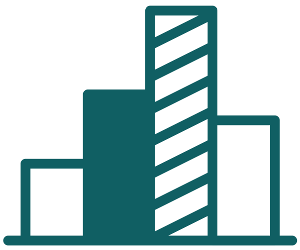
Overview of key insight types derived from dynamic simulation models

The projects reviewed for this report (refer to Table 1) generated a diverse range of insight types, with each project contributing multiple insights across various categories.

In this section, we explore each type of insight in more detail and describe the multifaceted value DSM offers for chronic disease prevention. Each type of insight – projection, explanatory, diagnostic, prescriptive, communicative, learning and capacity building, descriptive, consensus-building, contextual and gap identification – offers unique contributions to the decision-making process.

This shows how DSMs contribute beyond stated project outcomes; they enhance understanding, reveal underlying causes, recommend actions, and facilitate effective communication and collaboration among stakeholders.

Importantly, the examples provided are not intended to be an exhaustive list of all the insights generated by these reviewed projects. Instead, they are selected to serve as representative examples, highlighting the unique contributions of each insight type within the broader context of DSM.

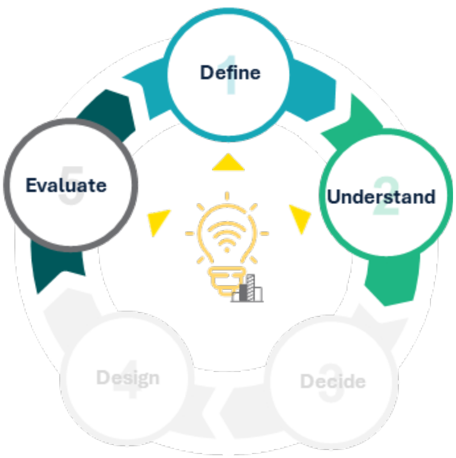


1. Descriptive insights

Descriptive insights involve summarising, visualising and presenting the characteristics of a dataset or system. These insights provide a clear and concise overview of the current state, allowing stakeholders to understand the basic attributes and distributions within the data. Descriptive insights help highlight key patterns, trends and anomalies that may warrant further investigation.

Value proposition

In the context of chronic disease prevention, descriptive insights are invaluable for establishing a foundational understanding of the prevalence, distribution and demographics of diseases. They enable health policy makers and practitioners to identify at-risk populations, track the incidence and progression of diseases, and recognise patterns in health behaviours and outcomes. This foundational knowledge is essential for informed decision making and the development of targeted interventions.



Descriptive insights are particularly valuable during several critical steps of the decision-making cycle. When **defining** the problem and supporting the response with evidence, descriptive insights provide the initial data needed to outline the scope and scale of chronic disease issues, justifying the need for intervention. In **understanding** the problem and its causes, summarising and visualising data facilitates the identification of potential causes and contributing factors. During the **evaluation** and monitoring of impact, descriptive insights establish baseline measures against which the effects of interventions can be compared, enabling ongoing assessment and adjustment of strategies.

Potential constraints

Several logistical constraints can affect the ability to generate and use descriptive insights effectively. The availability of comprehensive and relevant data is crucial; gaps in data can lead to incomplete or biased descriptions. Data quality also plays a significant role; inaccuracies, inconsistencies or outdated information can compromise the reliability of insights. By ‘data’, we mean the type of information that captures the key characteristics, behaviours and interactions of the system being modelled, at a level of granularity equal to or more than the level of granularity of the decisions the model is intended to support. This includes data that reflects temporal patterns, spatial variation and system heterogeneity. For descriptive insights, the data must not only be accurate, but also comprehensive enough to characterise the baseline dynamics of the system and its components. Moreover, stakeholder engagement is essential to ensure that stakeholders understand and trust the descriptive insights. Effective communication and visualisation of data can be challenging without proper engagement and feedback mechanisms in place.

Descriptive insights: Examples from Prevention Centre DSM projects

Phase 1 of the **Pilot of preventive burden**, or proof-of-concept study, aimed to test projections around the contribution of modelling risk factors to preventable chronic disease. This produced simplified descriptive insights focused on the combined contribution of key risks on overall disability adjusted life years (DALYs) and indicated relative increases in the forecasted burden of disease due to each known risk factor. Before this model, only individual risk factors and several outcomes of interest had been successfully modelled using system dynamic techniques in the health policy sphere in Australia, and the Australian Institute of Health and Welfare (AIHW) had not yet produced historical time series of the contribution of risk-related health burden.

Projecting to the year 2051, this highly aggregated model projected a consistent increase in risk factors for chronic disease such as alcohol consumption, high blood pressure, high body mass index (BMI) and physical inactivity. However, the tobacco-related burden remained stable, eventually commencing a decrease, relative to these other increases, once legislated future price rises, declining tobacco use prevalence, and a constant net migration rate combined to produce an impact.

The **COPD model** used individual data on smoking quit attempts in over 45-year-olds to estimate a 50-year future burden of Australia’s third highest cause of disease burden. Using the fine-grained behavioural data from the 45 and Up Study enabled this model to project expected burden for the first time, showing that longer and more frequent quit attempts will lead to less chronic obstructive pulmonary disease (COPD) among smokers in future.

2. Explanatory insights

Explanatory insights involve elucidating the relationships, mechanisms and dynamics within a system. These insights help stakeholders understand how different factors interact and influence each other, providing a deeper and more nuanced comprehension of the system's functioning. Explanatory insights go beyond mere description, offering explanations for observed patterns and behaviours.

Value proposition

Explanatory insights provide a deeper understanding of complex systems, allowing for more informed decision making and the development of targeted interventions that address root causes. In the context of chronic disease prevention, these insights are crucial for comprehending the multifaceted interactions between socioeconomic factors, lifestyle behaviours, healthcare access, and genetic predispositions. By revealing these underlying relationships, explanatory insights enable the design of interventions and policies that can more effectively prevent and manage chronic diseases, ultimately leading to better health outcomes and more efficient use of resources.

Explanatory insights are particularly valuable during the stages of **understanding** the problem and its causes, as well as **deciding** on options for addressing the problem. By providing a detailed analysis of how different factors contribute to chronic diseases, explanatory insights facilitate a comprehensive understanding of the problem. This deeper understanding is essential when exploring and evaluating various intervention options, ensuring that decisions are based on a thorough grasp of the system's dynamics. Additionally, explanatory insights support the **evaluation** and monitoring of impact by explaining why certain interventions succeed or fail, helping to refine and improve prevention strategies.

Potential constraints

Explanatory insights rely heavily on high-quality and available data that accurately capture the system's relationships. Without this, the model may oversimplify or misrepresent key dynamics. The complexity of the system is another constraint; if the system is too intricate, the model might struggle to effectively capture and explain its interactions. Clear objectives are essential to ensure the model focuses on the most relevant relationships. In the case of problems with wide scope or where detailed analysis is required, computational resources can limit a model's ability to produce explanatory insights, as sophisticated analytical methods and models may be required to derive explanatory insights. Time constraints can limit the depth of analysis, preventing thorough exploration of these dynamics. Lastly, stakeholder engagement is critical; without sufficient input, the model may overlook important factors, weakening the quality of the explanatory insights it can provide.

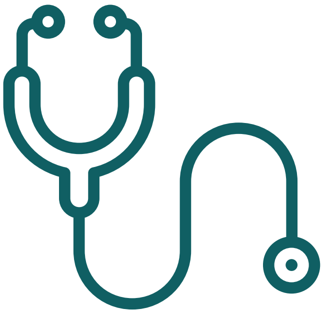
Explanatory insights: Examples from Prevention Centre DSM projects

The **COPD model,** an agent-based modelling project, produced additional explanatory insights that facilitated potential new ideas for health promotion programming and messaging. The scenarios and sensitivity testing in this model showed that cutting down or quitting, even for a relatively short time but frequently, has a significant effect on COPD risk over time. "Any intervention that increases frequency and duration of quit attempts has the potential to lead to significant reductions in the prevalence of COPD".[4] The quality of the available data and agent behaviour modelled in this project facilitated the structural development of this model and these insights.

The **Sydney lockouts agent-based model** of the regulatory impact on alcohol harm reduction provided an explanation of some of the unintended consequences of potential regulation change. For example, when testing the impact of raising drink prices in licensed venues, the model unexpectedly showed an increase in consumption and alcohol-related violent incidents. This was due to individual agents in the model shifting their behaviour to drinking more at home parties or 'preloading' due to the higher prices in pubs and clubs. These insights that explained underlying consumption behaviours at home versus in licensed venues improved understanding of how small changes to venue regulations could impact consumption and further impact the likelihood of acute events occurring.

The **National DiSCAO** youth obesity modelling project tested a range of age-limited settings-based scenarios which showed health benefits reduce as children age and leave childcare, school or organised sport. Childhood interventions in childcare and school settings are effective, however benefits over time do wane such that the effect of a whole-of-population measure is required to 'boost' these effects over the life span. Showing the comparisons of these scenarios in this model helped explain how the amount of time children spend in these settings can influence the population-level effect of interventions. This insight was also a contextual insight that supported awareness of intervention effectiveness across the whole-of-population.

Another example of a useful explanatory modelling insight arose from a modelling update of the NSW Premier's Priority Childhood Overweight and Obesity Model (**PP NSW CO&O)**. Insights were produced during the first iterations of this model suggesting that impact of mother's body mass status during pregnancy might be important to understanding birthweights of future generations, as historical data suggested a higher infant weight status than the model was originally producing. In later model extensions, this led to incorporation of pregnant mothers' categorical weight status with a link to large gestational age births into model structure. A longer model time horizon was introduced to enable the ripple effect of these population flows to be visualised.



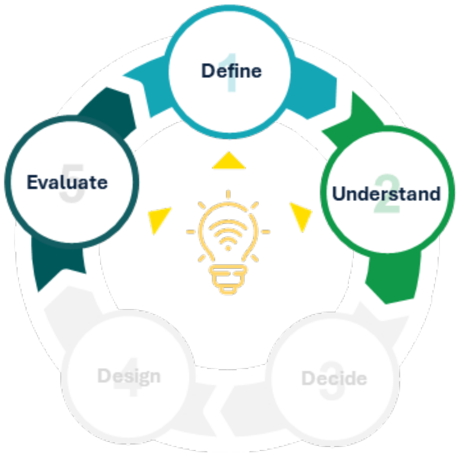
3. Diagnostic insights

Diagnostic insights focus on identifying problem areas, bottlenecks, inefficiencies, and root causes within a system. These insights delve into why certain issues arise and uncover the underlying factors contributing to problems. By dissecting these elements, diagnostic insights provide a clear understanding of where and why disruptions or inefficiencies occur within a system.

Value proposition

Diagnostic insights are essential for pinpointing the root causes of problems, which is crucial for developing effective interventions. In the realm of chronic disease prevention, these insights enable health professionals and policy makers to understand the specific factors that lead to higher disease prevalence and progression. This knowledge allows for the creation of precise, targeted strategies to address these factors, ultimately improving health outcomes and optimising the allocation of resources.

Diagnostic insights play a pivotal role in **defining** the problem and providing evidence to support the response. By identifying the root causes and underlying issues, these insights help clarify the scope of the problem, making it easier to justify and prioritise interventions. They are also critical in **understanding** the problem and its causes, offering a detailed analysis of why the problem exists. This in-depth understanding is essential for designing, planning and implementing effective solutions. Moreover, during the **evaluation** and monitoring phase, diagnostic insights help assess the effectiveness of interventions by identifying areas that need improvement and explaining why certain strategies may not be working as expected.



Potential constraints

The generation and application of diagnostic insights can be hindered by certain logistical constraints. In particular, the availability of high-quality data and detailed understanding of the problem and the systems in which the problem exists are key to a model producing strong diagnostic insights. Accurate and comprehensive data and system understanding are necessary to identify root causes and understand system inefficiencies. Time constraints can also limit a model's ability to produce diagnostic insights, as conducting thorough diagnostic analyses often requires significant time and effort. Lastly, stakeholder engagement is vital; ensuring that all relevant parties are involved and provide feedback can enhance the accuracy and applicability of diagnostic insights. Without sufficient stakeholder involvement, the insights may lack the contextual relevance needed for effective decision-making.

Diagnostic insights: Examples from Prevention Centre DSM projects

The **GoHealth model** of preventable chronic disease burden captured the interconnection and relationships between risk factors and disease. It provided diagnostic insights as to why programs that measure changes in disease burden in the context of individual risk factors tend to overestimate the true impact of efforts to reduce disease burden through individual risk factor reduction. This model was able to derive several insights demonstrating the collective impacts of risks on chronic disease burden. In particular, the kaleidoscopic effect of the multiple risk factors in impacting disease was a key insight. Both the additive and mediating effects of different risk factors, especially diet, BMI, cholesterol and blood pressure, on the overall attributable risk for disease(s) were estimated and visualised. This combinatorial effect allowed for the use of the model as an explanatory device to understand the multiple and sometimes non-linear drivers of prevention.

Another example from the **PP NSW CO&O** model, the simplification of the problem definition to one category ‘overweight and obesity’, in line with the description of government policy targets, meant the model was less able to demonstrate other more nuanced policy objectives, for example, strategies to move a percentage of children from obese to overweight. This insight promoted the importance of aligning problem definition to policy objectives.

In Tasmania, the **Tasmania Alcohol Strategy** model demonstrated the implementation of cross-sectoral strategic policies. It was clear that controlling the availability and price of alcohol in Tasmania is one of the most effective ways of reducing alcohol-related harms. Early results showed that measures taken outside the health system to limit supply and equalise the price of cheap alcohol were more than three times more effective than health-sector interventions, such as scaling up treatment programs for dependent drinkers or introducing brief interventions by GPs.[5] This insight demonstrated the visible scale of difference in prevention strategies that targeted consumption at lower levels of risk, versus those that manage consumption at extreme levels of risk (i.e. binge drinkers and chronic alcoholism), which assisted management of expectations of likely policy outcomes.

The **COPD model** found that in the next 50 years, quit attempts will significantly reduce the incidence and prevalence of COPD in NSW; “every quit attempt counts” in reducing COPD incidence. This diagnostic insight goes a long way to assist policy makers in identifying and helping smokers who are likely to attempt to quit and place greater encouragement on those attempts, which themselves the potential to substantially reduce the burden of COPD in NSW.

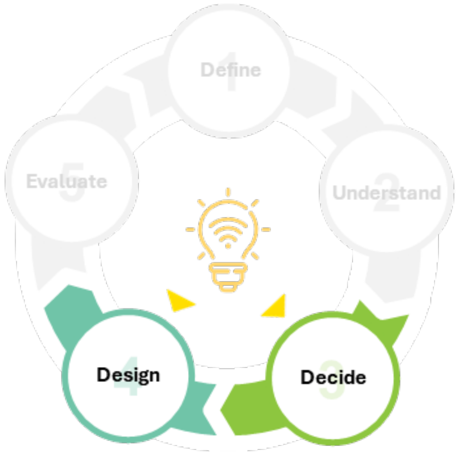
4. Projection insights

Projection insights involve projecting future states or outcomes based on current and historical data trends, combined with clearly defined transparent assumptions about system dynamics. These insights help stakeholders anticipate potential future scenarios by extending existing data patterns into the future.

Value proposition

Projection insights are invaluable for planning and decision making, especially in the context of chronic disease prevention. They enable health policy makers and practitioners to anticipate the future burden of diseases, identify emerging trends, and allocate resources more effectively. By understanding potential future scenarios, stakeholders can develop proactive strategies to mitigate adverse outcomes and enhance the effectiveness of prevention programs.

Projection insights are particularly beneficial during two key stages of the decision-making cycle. In **deciding** on options for addressing the problem, projection insights allow stakeholders to evaluate the long-term impacts of different strategies and choose the most effective ones. During the **design**, planning, and implementation of solutions, these insights provide trajectories of anticipated effect which can facilitate and support broader system planning.



Potential constraints

Several logistical constraints can impact the ability to generate and leverage projection insights effectively. Data availability is crucial; comprehensive and up-to-date data are necessary to produce accurate projections. The quality of data is equally important, as errors or inconsistencies can lead to flawed projections. Computational resources are another key factor; generating projection insights often requires sophisticated modelling techniques and substantial processing power. Time constraints can also be challenging, as developing robust projection models and conducting thorough analyses can be time intensive.

Projection insights: Examples from Prevention Centre DSM projects

Several projects demonstrated and reported projection insights relevant to policy makers. There was variation in the certainty or confidence of the reporting of some projections, however the gradient and directions of projection trends themselves tend to be the focus for policy; considerations of confidence are usually secondary.

Phase 1 of the **Pilot of preventive burden** model showed that around 10 years of implementation of any of the four modelled prevention interventions was required before any reduction at all in the growth of DALYs could be seen. It indicated that any modelling of chronic disease prevention needs to analyse long-term data and effect estimates and take a long-term view of population health improvement.

The **National DiSCAO** tested four setting-based interventions focusing on their comparative effects for childhood and adolescent obesity, and the extent to which effects could still be seen in the adult population. The uncertainty surrounding obesity causality in younger people and ability to sufficiently calibrate the model to historical data resulted in projection that focused on relative annual change in obesity, not projections in prevalence. Nevertheless, this analysis showed that a 20% sugar-sweetened beverage tax was projected to deliver the largest reduction in the prevalence of childhood and adolescent obesity, one of the only reductions that persisted into young adulthood.[6] This model showed that projection insights could be useful even if long-term forward year prevalence projections were not feasible.

The **Tasmania Alcohol Strategy** model was used to guide the development of long-term strategic investments in public health. While projections of increasing alcohol-related hospitalisations and mortality were produced, of most interest were the impact of sustained versus intermittent investments. With sustained investment, the effect of interventions can grow stronger over time, though the full impacts might not be seen within a five-year policy cycle. This type of long-term projection was highly suited to support strategic planning.

Good quality smoking use data and evidence linking COPD and its progressive burden in the NSW **COPD model** generated two simultaneous insights: the growing COPD burden in line with population ageing, combined with the projected COPD offsets over a longer time horizon as the smoking rate continues to decline, quit attempts become more frequent and COPD diagnoses eventually stabilise.[4]

Prediction vs Projection?

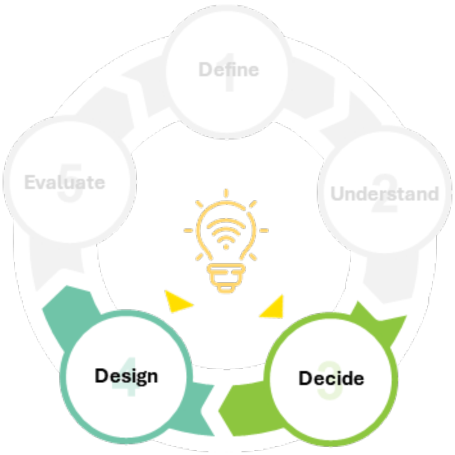
In the context of understanding model outputs, it is important to distinguish between **projections** and **predictions.** Projections explore what could happen under specific assumptions, while predictions attempt to state what is most likely to happen. Predictions rely heavily on the assumption that future conditions will closely follow observed trends and behaviours, making them highly dependent on the stability and reliability of historical patterns. In contrast, projections are designed to explore a range of possible futures based on defined scenarios, such as changes in policies, behaviours, or external conditions. They do not assume that the future will mirror the past, but instead examine how systems evolved to be the way they are and might evolve in the future under varying circumstances. This distinction is critical because DSM models are largely designed to produce projections to help stakeholders understand potential outcomes and uncertainties rather than deliver definitive answers about what will occur.

5. Prescriptive insights

Prescriptive insights provide recommendations for optimal decision making by evaluating different strategies and their potential outcomes. These insights go beyond merely identifying problems or projecting future states; they offer specific, actionable guidance on how to achieve desired goals. By simulating various scenarios and assessing their impacts, prescriptive insights help stakeholders choose the best course of action.

Value proposition

In the context of chronic disease prevention, prescriptive insights are crucial for developing and implementing effective interventions. They enable health policymakers and practitioners to determine the most efficient and impactful strategies to reduce disease prevalence and improve population health. By recommending targeted actions based on robust analysis, prescriptive insights help optimise resource allocation, ensuring that efforts are directed towards the most beneficial activities.



Prescriptive insights are particularly valuable during the stages of **deciding** on options for addressing the problem and designing, planning and implementing solutions. When stakeholders need to choose between different intervention strategies, prescriptive insights provide evidence-based recommendations on which options are likely to be most effective. During the **design** and planning phase, these insights guide the development of detailed action plans, specifying the best approaches to achieve the desired outcomes. Furthermore, prescriptive insights continue to be useful during the implementation stage, offering ongoing guidance to adapt and optimise interventions as new data and feedback become available.

Potential constraints

Several logistical constraints can affect the ability of a DSM to generate and utilise prescriptive insights effectively. Data quality is paramount; accurate and detailed data are essential for producing reliable recommendations. The availability of comprehensive data on all relevant factors can also be a limitation, as missing information may reduce the accuracy of prescriptive insights. Computational resources are another critical factor, as advanced models and simulations require substantial processing power and sophisticated software. Time constraints can pose a challenge, as developing and validating prescriptive models often requires considerable effort and expertise. Additionally, stakeholder engagement is crucial to ensure that the recommendations are practical, acceptable, and aligned with the needs and priorities of those involved. Without sufficient involvement and buy-in from stakeholders, the implementation of prescriptive insights may face resistance or challenges.

Prescriptive insights: Examples from Prevention Centre DSM projects

Prescriptive insights of various types were generated across many of the reviewed DSM projects.

The **National DiSCAO** project demonstrated that implementing all age-group settings-based interventions together with a sugar-sweetened beverage tax of 20% suggested there was a synergistic effect of about 5-7% for health improvements. While another what-if scenario showed that a simulation implementing the suite of settings-based interventions across the life course would be needed to achieve a comparable reduction in the prevalence of obesity to a 20% SSB tax alone. These two insights provided alternative prescriptions for achieving health gains, providing recommendations that could support decision makers considering health policy objectives.

This model also demonstrated cost-effectiveness analysis, providing another lens for future policy decision support. Settings-based interventions overall were not cost-effective when simulated, with only the 20% SSB tax assessed to be cost-effective. These health gains insights overlaid with cost-effectiveness insights provided a nuanced comparative analysis for policy makers, as they were based on better quality data on intervention effectiveness.

Similarly, the Queensland **Endgame Smoking** model provided both projective insights (the implications of a ‘do the same thing approach’) and prescriptive insights, which highlighted the various implications of changing this trajectory. High-reach interventions that directly affect initiation and cessation rates, that is mass media campaigns and tobacco licensing, in this model were shown to have the greatest impact on smoking prevalence. The simulated effects of separate interventions were mostly additive so greater reductions in smoking prevalence could be achieved by implementing multiple interventions in combination. These types of prescriptive insights provide support for decision makers who may need to argue that multiple interventions are beneficial for both clinical and population health and financial gains.

Prescriptive insights were integral to the objectives of the initial version of the **NSW PP CO&O model**. Thorough testing of the model demonstrated that implementing the then current suite of NSW Health Strategic Directions (child health and nutrition programs) alone was not likely to produce the targeted 5% reduction in the prevalence of childhood overweight and obesity across NSW. As such, additional strategies, or combinations of strategies, were required to achieve the Premier’s target. The Ministry of Health proposed a series of wider interventions that could be included, including physical activity vouchers and healthy food policies in childcare and school settings that supported the achievement of the target within the Ministry’s timeframe.

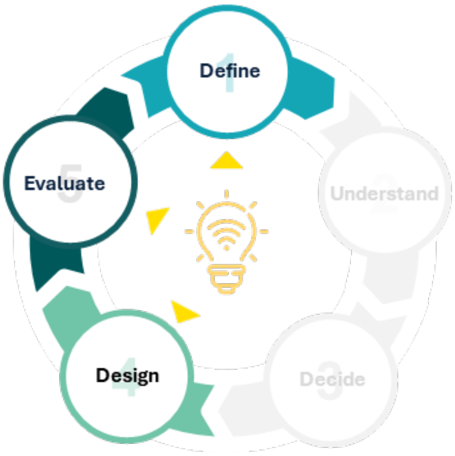
The **Tasmania Alcohol Strategy** model also presented a prescriptive insight indicating that some existing harm-reduction programs, such as random breath testing combined with young driver education campaigns, are likely fully effective at their current level – with minimal benefit to be achieved from scaling up. However, reducing these programs would lead to adverse consequences.

6. Communicative insights

Communicative insights involve the clear and engaging presentation of complex information. These insights focus on effectively conveying data, findings and recommendations to stakeholders in a manner that is easily understandable and actionable, and causes the audience to think differently about the problem, the system and/or possible solutions. By using visualisations, summaries and compelling narratives, communicative insights bridge the gap between technical analysis and practical application.

Value proposition

In the context of chronic disease prevention, communicative insights are essential for ensuring that health data and policy recommendations are understood and embraced by all stakeholders, including policy makers, healthcare providers and the public. These insights enhance transparency, foster stakeholder engagement, and facilitate the implementation of interventions. By making complex information accessible and persuasive, communicative insights help drive informed decision-making and collaborative action.



Communicative insights are particularly valuable during the stages of **defining** the problem and supporting the response with evidence, as well as **designing,** planning and implementing solutions. At the problem definition stage, these insights help articulate the scope and urgency of chronic disease issues, making a compelling case for action. During the design and implementation phase, communicative insights ensure that strategies and interventions are clearly understood and supported by all relevant stakeholders, facilitating coordinated and effective action. Additionally, during the **evaluation** and monitoring phase, these insights help present findings and outcomes in a way that stakeholders can easily comprehend and use to inform future actions.

Potential constraints

Several logistical constraints can impact a modelling project's ability to produce high-quality communicative insights. Model quality and clarity are essential; without a well-organised model with logical output parameters, it is challenging to create clear and compelling presentations. Time constraints can also be a significant limitation, as developing high-quality visualisations and narratives requires considerable effort and expertise. Moreover, these insights are often produced at the tail end of a project, risking being cut short in projects where time is highly constrained. Stakeholder engagement is another crucial factor; effective communication depends on understanding the audience's needs, preferences and levels of technical knowledge. Financial resources are also important, as producing professional-grade materials and using advanced communication tools often require investment.

Communicative insights: Examples from Prevention Centre DSM projects

Despite the complexity of the **Sydney lockouts agent-based model**, with its multiple behavioural rules guiding alcohol consumption by various sub-populations and numerous settings, this model was able to be used to tell real-world stories, by fine-tuning specific scenarios and using its individual agent structure to describe drinking behaviours. For example, the model was used to tell a story of what might occur when combining a policy of 3:00am licensed venue closing time plus 1:00am lockout with an expansion of treatment service coverage to 20% of heavy drinkers. In this case, the model suggested a 33% reduction in acute alcohol-related harms. The model could be used to communicate a large range of alternative scenarios that might engage the media, political leaders and the public.

The policy partners involved in this project appreciated the complexity in identifying communicable messaging following model runs, but also recognised the importance of developing a shared understanding of the model among the range of policy agencies forming the boundaries of this systemic issue.

Key communicative insights from the **GoHealth model** were the demonstration of the kaleidoscopic and combinatorial effect of multiple interacting risk factors on disease burden (see earlier example in the diagnostic insights section). The visualisation of this insight as a chord diagram (radial network diagram) was an important research communication tool to explain the impact of this layered effect of risk factor relationships on diseases at a population level.

The **ASAPa model** whole-of-systems map of physical activity was a highly visual tool that clearly reflected the (a) Core influences on physical activity, (b) Interventions by strategy and setting, and (c) System-level enablers/leverage points.

This simplified map facilitated a number of systems-related applications – including a national physical activity policy audit, co-production of an integrated physical activity policy framework, and planning for a physical activity community of practice knowledge hub – demonstrating its use for policy engagement and communication.

Although the **National DiSCAO** model project team was judicious in its use of projected insights, it still found a way to communicate changing prevalence over time while limiting baseline forecasted rates. The model was able to communicate the implications of any likely changes by modelling childhood and adolescent obesity outcomes, measures of comorbidity, the length of time per weight status, and implications of further cohort distinctions in the population, such as socioeconomic disadvantage. Quantitative outputs and projections were contextualised with uncertainty in this model, however high-level policy interest in model outcomes was generated.

Demonstrations of the **Tasmania Alcohol Strategy** model with its live interface communicated differential intervention findings to a diverse policy audience. The value of communicating the limited impact of alcohol treatment to a wider audience was meaningful. “There’s only so much you can do in terms of treatment and support in the health sector. Getting consumption down has the biggest effect of all.”[7] In alcohol harm reduction there are short-term impacts (on acute presentations, from acute poisoning, assaults and vehicle accidents) and long-term impacts (on chronic liver disease and cancers). Demonstrating the different impacts live in the model by adjusting the time horizon of interest was a useful communication technique.

Finally, the Health Minister for a Day Communication Tool (**HMfaD model**) aimed to find a way to develop and enhance communicative insights from DSM, by developing digital tools that could explain the impact of prevention to a lay audience, through an interactive simulation and decision-support tool described as 'Health Minister for a Day'. Although there was limited availability of use-case insights in this pilot study, hack-a-thons and other rapidly built online interactive simulations using pre-existing DSMs represent an opportunity to engage a wider public audience and craft a messaging framework for prevention.

Most cases for prevention rely on a rational appeal to the business case; that is, they push the idea that prevention is good value for money. However, decades later the investment in prevention by the health sector is still proportionately low. This work (HMfaD model) aims to prove that there are other ways to 'sell' prevention – by making it interesting and more immediately visible in people's lives.[7]

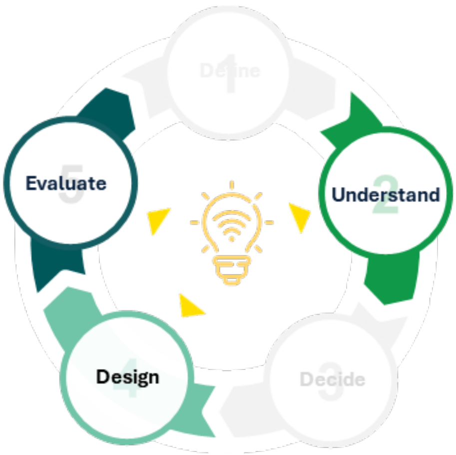
7. Learning and capacity building insights

Learning and capacity building insights involve the use of models as educational tools to enhance understanding of systems and develop skills among stakeholders. These insights focus on fostering continuous learning and improvement by providing stakeholders with the knowledge and tools needed to engage effectively with the system and make informed decisions.

Value proposition

In the context of chronic disease prevention, learning and capacity building insights are crucial for empowering health professionals, policy makers and community stakeholders with the skills and knowledge needed to understand complex health systems and implement effective interventions. These insights ensure stakeholders are better equipped to design, execute and evaluate prevention strategies, leading to more sustainable and impactful health outcomes.

Learning and capacity building insights are particularly valuable during the stages of **understanding** the problem and its causes and **designing** and implementing solutions. By using models to simulate different scenarios and explore the effects of various factors, stakeholders can develop a comprehensive understanding of the problem, leaving them better prepared to develop effective interventions. During the implementation phase, continuous learning and capacity building ensure that stakeholders can adapt to new information and refine their strategies accordingly. These insights also support the **evaluation** and monitoring phase, providing stakeholders with the skills to assess the effectiveness of interventions and make the necessary adjustments.



Potential constraints

Several logistical constraints can impact the generation and use of learning and capacity building insights. Time constraints often pose a challenge, as developing comprehensive training programs and educational resources requires significant effort and expertise. These insights are often considered secondary to immediate project goals and may be deprioritised or rushed, especially in time-sensitive projects. Stakeholder engagement is critical, as without active participation and commitment, the effectiveness of capacity-building efforts can be compromised. Additionally, financial resources are necessary to develop, implement and sustain high-quality learning and capacity-building initiatives, including the creation of materials and facilitation of training sessions.

Learning and capacity building insights: Examples from Prevention Centre dynamic simulation projects

Almost every modelling project reviewed for this knowledge synthesis contained learning and capacity-building insights, noting that when the Prevention Centre was established in 2013, very few, if any, DSMs had been developed with health policy partners in Australia. The process and field were only just starting to be recognised as a research and policy tool in the health sector. Thus, a lot of learning about modelling with Australian population health datasets, engagement with policy makers and processes to support engagement and communication emerged because of the Prevention Centre's engagement with this systems science methodology and its strong support of systems thinking applications to preventive health.

The hyperglycaemia in pregnancy in the ACT model **(HiP model)** surfaced insights on the heterogeneity of disease origin and progression and impact on different people. As an agent-based model, it provided a great diversity in exploring physiological differences in diabetes manifestation, allowing ACT clinicians and policy makers to consider the impact of these differences in a patient and health system and consider the impact of maternal weight status interventions on the incidence of hyperglycaemia.

One shared learning was that DSMs can mature as new evidence becomes available and methods are advanced to facilitate further development. This was true of the **HiP model**, which evolved to reflect updated diabetes patient data and international research, the **National DiSCAO** model, which used a participatory environment to draw on new research and used an innovative approach by accessing individualised datasets to build summary statistics, and the **NSW PP CO&O model**, which over several years identified new opportunities to add key components or updated population data to the model structure to support improved calibration.

Another lesson about the process of model building was the importance of understanding different purposes for different projects. In some cases, the aim was to bring all stakeholders together to build a shared understanding of the complex problem, especially to identify and engage non-health sector actors to identify the extent of 'other sector' responsibilities in these systemic issues.

The Sydney lockouts agent-based model was one of the first DSMs initiated by the Prevention Centre. It embraced involvement by the broader modelling and participatory team in access to datasets and in developing a detailed understanding of complexity of alcohol consumption behaviours in individuals. As a mainly local stakeholder group, these participants were able to meet relatively frequently and in-person to develop organisational relationships. However, this pilot study of preventive chronic disease burden had varying levels of participant engagement; many found it difficult to maintain interest for this national project, especially as health priorities shifted to infectious disease modelling by many of the project's policy partners.

The development of the subsequent **GoHealth** model was impacted by limited engagement opportunities and complexity of the technical model, which meant it was difficult to build a shared understanding of the model itself or of all insights. Limited participatory opportunities due to time constraints and travel restrictions contributed to this, however online webinar opportunities did help to improve understanding.

The **Tasmania Alcohol Strategy** model provided a strong platform to strengthen Tasmania's cross-sectoral efforts to reduce alcohol-related harm. There was active participation of representatives from central and regulatory policy agencies, who before this project had limited interaction with program planners or multidisciplinary researchers. Insights from the model have provided an indication of the types of interventions that are likely to deliver the greatest future reductions in both acute and chronic-related harms in the Tasmanian population. Participants from Treasury, Liquor and Gaming Commission, Department of Health, hospital emergency departments, treatment counsellors, Transport Tasmania, police force and youth educators were all able to share these insights as a group.

It was recognised towards the end of the **ASAPa model** that there was limited opportunity to realise a fully developed quantified model, however the qualitative steps and products in this project have found useful policy applications nationally. The project acknowledged that approaches such as qualitative mapping are preliminary and highlighted the need for further progress using full system dynamics approaches to identify the most effective combination of interventions for addressing physical inactivity in an equitable and cost-effective manner.

At the other end of the computational spectrum, ACT Health has partnered on the development of two Prevention Centre-funded agent-based models over the past seven years—the **health food intervention model** and the **HiP model**. Both have required access to significant patient population characteristic datasets. These computationally dense models required significant resource workloads and partner-agency support, however they have each delivered uniquely insightful and ACT-relevant models.

8. Consensus-building insights

Consensus-building insights involve creating a common language or understanding of a problem among stakeholders. These insights facilitate agreement and alignment on the issues at hand, promoting collaborative decision making and unified action. By providing clear and shared perspectives, consensus-building insights help bridge gaps between different viewpoints and interests.

Value proposition

In the context of chronic disease prevention, consensus-building insights are vital for ensuring that all relevant stakeholders are on the same page, including policy makers, healthcare providers, community leaders and the public. These insights foster a shared understanding of the challenges and the necessary actions to address them, leading to more cohesive and coordinated efforts. By aligning stakeholders, consensus-building insights help mobilise resources, streamline interventions, and enhance the overall impact of prevention strategies.

Consensus-building insights are valuable during all stages of the policy cycle. When **defining** and **understanding** the problem, these insights help ensure that all stakeholders have a unified understanding of the scope and urgency of the issue, fostering a collective commitment to action. During the **decision** stage, consensus-building insights facilitate joint understanding and ownership of the decisions that are made and empower stakeholders to engage in the decision process. During the **design** and implementation phases, consensus-building insights facilitate collaborative planning and execution, ensuring that all parties are aligned on the goals, strategies, and roles. Additionally, during the **evaluation** and monitoring phase, these insights help maintain stakeholder engagement and support, allowing for continuous feedback and adjustment of interventions.

Potential constraints

Several logistical constraints can affect the ability of a modelling project to generate and leverage consensus-building insights effectively. Stakeholder engagement is paramount; achieving consensus requires active participation and open communication among all relevant parties. Time constraints can also pose a challenge, as building consensus often requires extensive discussions, negotiations and iterative feedback processes. Additionally, financial resources are necessary to support facilitation, meetings, and other activities that promote stakeholder alignment. Without adequate funding, the process of building consensus may be hindered.

Consensus-building insights: Examples from Prevention Centre DSM projects

The **Sydney lockouts agent-based model** showed policy partners that complex problems often require multi-strategic, cross-agency responses. This project demonstrated that combining different interventions delivered by different agencies such as health, police, justice, welfare departments and other government, academic and community organisations can have a synergistic benefit. Policy partners believed this project helped make a compelling case for cross-agency cooperation to deliver coordinated and effective responses to address alcohol misuse and related harms.[8] Other consensus insights included a valued understanding of the modelling process, a 'glass box process' by policy partners who demonstrated an appreciation of the assumptions and limitations involved.

Stakeholder engagement, especially diversity of expertise, was important for the **National DiSCAO** project. The project team and partners reflected on its overarching role in improving model development, by reducing structural uncertainly through an actively engaged group of stakeholders.

The **Tasmania Alcohol Strategy** project was recognised as an important project that strengthened Tasmania's cross-sectoral efforts to reduce alcohol-related harm (see also the previous Communicative Insights section). There was active participation of representatives from central and regulatory policy agencies who, prior to this project, had limited interaction with health and education program planners or multidisciplinary researchers. This project allowed data custodians from three key agencies to share their data for the first time and collectively understand the impact of this problem. This progress did require ongoing coordination to align model development with the development and release of the state's five-year Drug Strategy.

Likewise, consensus insights surfaced in the development of the **HiP model**, which brought together primary health and other specialist clinicians, population health policy and epidemiologists, highlighting their similarities or common ground, much more frequently than they experienced in their usual work. When this project encountered technical barriers while building the model, including data barriers, it helped to have wide and diverse policy engagement. For example, when some participants requested interest in testing particular scenarios in the model, it was informative for all to learn there was no existing evidence to model these scenarios. The participatory-modelling approach built consensus about understanding the potential degree of health gains among pregnant women, and the specific constraints in data and knowledge that may currently limit further prescriptive insights.

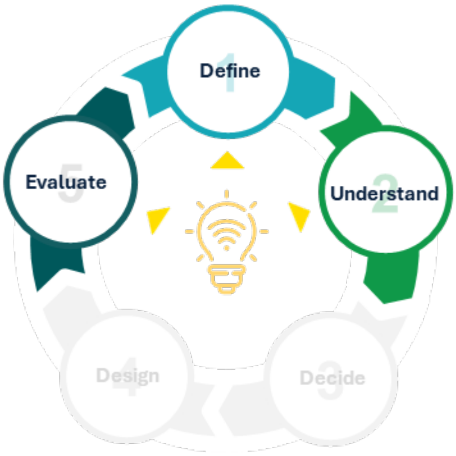
Finally, the **ASAPa model** found that, despite scope limitations for full simulation modelling, the project provided a unique opportunity in the physical activity policy area to a build a comprehensive and cross-sectoral approach, which sometimes challenged stakeholders who were used to operating in a more siloed, narrow policy space.

9. Gap-identification insights

Gap-identification insights pinpoint deficiencies, unmet needs and areas lacking adequate information or resources within a system. These insights help identify where improvements are needed and highlight gaps that may hinder achieving desired outcomes. They also surface assumptions made to overcome these gaps, allowing them to be critically examined and tested. Recognising that decisions sometimes need to be made despite limited understanding and evidence and identifying these assumptions facilitates a more transparent decision-making process.

Value proposition

In chronic disease prevention, gap-identification insights are crucial for ensuring that all aspects of disease prevention and management are comprehensively addressed. DSMs are particularly effective at identifying not only where evidence is missing, but also where existing evidence is not actionable or policy relevant. These insights enable health policy makers and practitioners to recognise areas where interventions are insufficient, where data is missing, or where additional resources are required. Stakeholders can enhance the quality and reliability of their decisions by surfacing and scrutinising the assumptions made to bridge these gaps. This approach ensures that efforts are directed towards the most impactful areas, fostering informed and accountable decision making. Ultimately, gap-identification insights contribute to more effective and sustainable policy solutions by making assumptions explicit and subject to critical examination.



Gap-identification insights are particularly valuable when **defining** the problem and supporting the response with evidence, **understanding** the problem, as well as **evaluating** and monitoring impact. At the problem definition and understanding stages, these insights ensure a thorough understanding of the existing landscape, highlighting areas that require attention and revealing underlying assumptions. During the evaluation and monitoring phase, gap-identification insights reveal shortcomings in current interventions, identify opportunities for improvement, and assess the validity of previously held assumptions. Continually assessing and addressing gaps allows stakeholders to refine their strategies to achieve better health outcomes.

Potential constraints

Two key logistical constraints have the potential to impact the generation of gap-identification insights. Time constraints can pose a challenge, as conducting thorough gap analyses requires sufficient time for data collection, analysis and interpretation. Having sufficient time to comprehensively search for, and appraise, data and evidence is necessary to accurately identify if and where gaps exist.

Additionally, stakeholder engagement is crucial for understanding what assumptions are being used to overcome existing data gaps. Without active participation from stakeholders, the identified gaps may not fully reflect realities on the ground.

Gap-identification insights: Examples from Prevention Centre DSM projects

The Pilot of preventive burden model was primarily an exploration of the population health data limits and granularity of risk factor data needed to build simplified projections. Data limitations were very apparent in this pilot stage, which led to simplified presentation of metrics attributable to risk factor prevalence. The requirement to use nuanced, disaggregated risk factor data and model disease specific relationships between all risks was an important learning and gap-identification insight, which progressed to phase 2 of the **GoHealth** model.

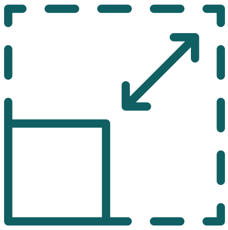
Access to a high level of current and historical stratified population health data was integral to the development of the **GoHealth** model. Underlying risk factor prevalence and incidence data by age and sex was necessary to determine disease progression trends, including length and quality of life with chronic disease, mortality and related healthcare system and productivity costs in future years. Limits in the availability and existence of this data for all nine risk factors included was noted to have an impact on reliability of future models that aim to predict or project preventable chronic disease burdens for an Australian population and dominated the limits to application of this model as a policy tool.

The range of population risk factor incidence and prevalence data needed to support the reliability of this model was significant, and without improvements in certainty of that trend data its use as a policy tool is compromised.[9]

Examples of gap-identification insights were also evident in several reviewed obesity models. The **PP NSW CO&O** noted that limited access to measured data in NSW meant reliance on observed BMI datasets, which was considered potentially biased towards normal and healthy body BMIs. Similarly, the **National DiSCAO** model observed that the lack of national quality obesity data meant that model calibration to historical datasets was over narrower time horizon. Both these insights have been amplified in the National Obesity Strategy 2022-2032 and the National Preventive Health Strategy 2021-2030; strategies that have both called for enhanced population health monitoring and surveillance methods and data.

Equally, in the **HiP model** the underlying physiological complexities of the generation of diabetes and hyperglycaemia in pregnancy and subsequent birthed infants created modelling challenges around current levels of specific physiological knowledge in these domains. For example, separating the portion of diabetes prevalence that may be genetically based is complex and evidence is still emerging. This model highlighted these knowledge gaps, however still produced a robust and reliable policy decision tool.

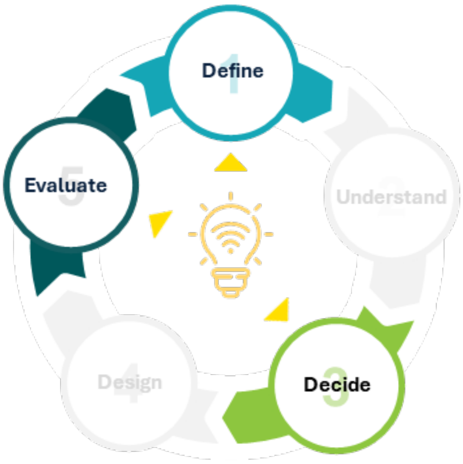
10. Contextual insights



Contextual insight involves understanding and situating specific pieces of evidence or aspects of a problem within the broader context of the entire system in which the issue exists. This type of insight helps stakeholders grasp how individual elements or findings relate to and are influenced by larger systemic forces and dynamics. DSMs are particularly adept at surfacing and explaining why evidence of intervention effects, which may show strong internal validity at the individual level, may not demonstrate an equal effect size at the population level. These models help contextualise evidence by highlighting how factors such as population diversity, resource availability, and systemic barriers can modulate the impact of interventions when scaled up.

Value proposition

In chronic disease prevention, contextual insights are critical for setting realistic expectations and understanding the true potential impact of interventions at scale. For instance, while a dietary intervention may show significant positive outcomes in a controlled trial with specific individuals, these effects might diminish when applied to a broader, more diverse population due to variations in socioeconomic conditions, cultural practices, and healthcare access. By providing a holistic view, contextual insights enable policy makers and practitioners to anticipate these variations and design more effective, scalable interventions. This broader understanding ensures that interventions are not only theoretically sound but also practically viable, enhancing their overall impact and sustainability.



Contextual insights are invaluable throughout the decision-making cycle. At the problem **definition** stage, they help frame issues within the broader system, ensuring all relevant factors are considered. During the **decision** stage, these insights can be critical in understanding the potential population-level impacts of interventions trialled on a smaller scale or in specific populations. They can also provide insight on proper selection of evaluation metrics for intervention selection. During the design stage, these insights guide the design of interventions by revealing how different system components interact and potentially amplify or diminish effects. In the implementation and **evaluation** stages, contextual insights help understand how systemic factors influence outcomes, providing a clearer picture of intervention effectiveness and aiding in the identification of unintended consequences.

Potential considerations

Generating contextual insights requires comprehensive and high-quality data that capture a wide range of variables and their interactions within the system. Data limitations, such as incomplete or biased datasets, can hinder the accuracy of these insights. Additionally, this type of analysis demands sophisticated modelling techniques and a deep understanding of the system, necessitating significant expertise and computational resources. Effective stakeholder engagement is also crucial, as diverse perspectives can enrich the understanding of system complexities. Without these elements, the ability to produce meaningful contextual insights may be limited, potentially leading to an oversimplified view of the system and its dynamics.

Contextual insights: Examples from Prevention Centre DSM projects

The **National DiSCAO** model placed a strong emphasis on providing qualitative insights, as many quantitative outputs or projections were contextualised with uncertainty. Nevertheless, this model was able to demonstrate several strategies had minimal and modest effects on obesity, reiterating the slow and inconsistent nature of current successes in obesity prevention, while simultaneously showing other strategies with a broad exposure of prevention over the life course can often be the most effective. This contextualising of prevention impact insights for policy makers provided greater lessons in the application of evidence than single research studies or systematic reviews of intervention effectiveness could demonstrate. Applying a real-world population to an evidence-based intervention and comparing this *in silica* to other potential interventions of interest can provide policy makers with actionable insights that are highly relevant to their local populations.

A contextual insight from the first iteration of the **PP NSW CO&O** model was the significance of the size and continuation of impact of existing health programs that target the early years (0–2-year-olds). In the model, these showed a relatively much stronger impact on population obesity target reductions relative to prevention interventions targeting children in later school years, due to the long-term nature of population-level weight change. Again, this application of known evidence-based interventions produced comparative and actionable insights.

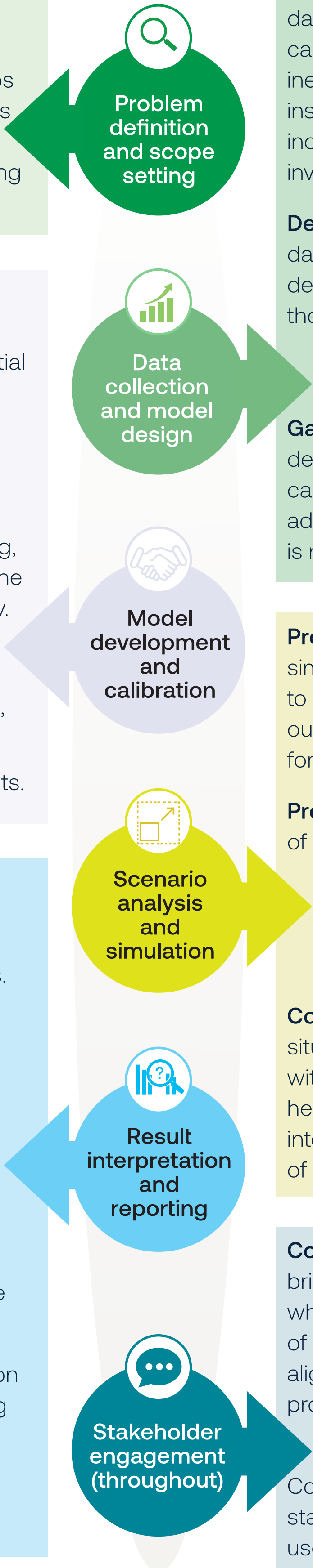
Another important contextual insight was observed in the **HiP model**. Interventions targeting high-risk individuals for hyperglycaemia in pregnancy were known to be beneficial and clinical necessary for individuals, and indeed this individual-level model demonstrated these results. However, they delivered small reductions in overall population incidence rates of hyperglycaemia.

How do DSMs produce insights?

DSMs produce insights through a structured yet flexible process. Each stage of the DSM process generates various types of insights by systematically exploring, analysing and interpreting the system's dynamics. Insights emerge as either planned outcomes from specific analyses or organically during the model development process.

Figure 3 describes the key stages of the DSM process, with examples of insights that can emerge at each stage.

Figure 3: Key insight types from dynamic simulation models and the policy decision-making process



Descriptive: During this initial stage, the focus is on clearly defining the problem and setting the scope of the modelling exercise. This process helps to summarise and visualise the issue's key characteristics and dimensions, providing a foundational understanding that guides further modelling efforts.

Diagnostic: In this stage, collecting data and conceptualising the model can help surface gaps, bottlenecks, and inefficiencies in the system. Diagnostic insights emerge as issues are highlighted, indicating areas that may require further investigation or intervention.

Descriptive: Gathering and organising data and evidence also generates descriptive insights, as it summarises the existing state of the system and clarifies its components and their relationships.

Gap identification: Insights about deficiencies in data availability or quality can be identified, highlighting where additional data collection or refinement is needed.

Explanatory: During this stage, explanatory insights emerge as the model's behaviour may differ from initial expectations. This discrepancy offers a valuable opportunity to re-examine and challenge our assumptions and beliefs about how different parts of the system interact. It helps uncover gaps in our conceptual understanding, prompting deeper investigation into the relationships and mechanisms at play.

Learning and capacity building: Engaging in the model development process also enhances stakeholders' understanding and skills, fostering learning and capacity-building insights.

Projections: This stage involves running simulations under various scenarios to project potential future states or outcomes, providing valuable insights for planning and decision-making.

Prescriptive: By evaluating the outcomes of different scenarios, the model can suggest optimal strategies, generating prescriptive insights that recommend specific actions to achieve goals.

Contextual: These emerge as the model situates specific evidence or findings within the broader system context, helping to understand the potential interactions and systemic implications of different interventions

Diagnostic: Interpreting simulation results can further identify specific problem areas within the system, offering additional diagnostic insights.

Prescriptive: This stage refines the recommendations made during scenario analysis, ensuring they are actionable and relevant.

Communicative: Reporting the results involves presenting complex data and findings in a clear and engaging manner help stakeholders understand and use the information effectively.

Contextual: Analysis and interpretation help contextualise findings, explaining why certain effects observed at the individual level may differ at the population level, and set realistic expectations for outcomes.

Consensus building: The entire process brings together different viewpoints which fosters a shared understanding of the system and its challenges, aligning different perspectives and promoting collaboration.

Learning and capacity building: Continuous engagement helps build stakeholder capacity to interpret and use the model's outputs, and a new language to discuss the problem, enhancing their ability to contribute to the decision-making process.

The projects reviewed for this report generated a diverse range of insight types, with each project contributing multiple insights across various categories.

Prevention Centre dynamic simulation modelling projects reviewed for synthesis

Fourteen DSM research projects funded by the Prevention Centre between 2015 and 2023 were identified for inclusion in this report. Table 1 provides a brief description of the models reviewed.

Table 1: Summary of reviewed projects

Project A: Simulation modelling of alcohol consumption and the effectiveness of harm-reduction policies in NSW, 2015–2017 (Referred to as the 'Sydney lockouts agent-based model')
This simulation model of alcohol use in NSW was developed to forecast the effectiveness of a variety of regulatory approaches to reduce alcohol consumption and related harms. The agent-based model was populated with 75% of the NSW population to explore the relationships of individual drinking behaviours on recognised individual harms. It tested several NSW-relevant regulatory and policy scenarios that might impact availability of alcohol consumption, particularly the closing times of venues and the expansion of treatment services. The model included individual alcohol consumption behaviours (frequency, amount, location, relative risk for disease or harm) and features of the alcohol consumption environment in NSW, consisting of licensed venues (bars, pubs, nightclubs) grouped to represent entertainment precincts of varying density where individuals could consume alcohol. The model also contained workplaces, bottle shops (retail outlets) where alcohol could be purchased, and homes where alcohol could be consumed. Individuals in the model consumed alcohol at licensed venues (bars, pubs, nightclubs), peer events (parties) and home. In the model, alcohol could be obtained from bottle shops for consumption at home, peer events and for pre-loading purposes (the practice of consuming alcohol at a private residence before going to a place where alcohol access might be expensive, limited or prohibited). Large population, behavioural, spatial (residence, licensed venues) and other datasets were used to construct this complex model.[2]

Project B: Building a compelling case for prevention - a pilot approach to modelling the preventable burden of chronic disease in Australia: proof-of-concept phase, 2017–2018 (Referred to as the 'Pilot of preventive burden')
This was the original system dynamics 'model of prevention', a pilot study aimed to demonstrate the capacity of system dynamics in modelling a range of chronic disease risk factors and their related burden together. It demonstrated how dynamic systems models can forecast health burden outcomes such as the prevalence of risk factor behaviour, change in prevalence over time, years of life lost due to risk factor-related disability, and key economic indicators such as labour-related gross domestic product. It brought together key national health policy agencies to understand the priorities in preventive health strategies (before the National Preventive Health Strategy was established). It tested four example single risk factor-related prevention interventions as a demonstration of model capability and difference in intervention type on the population: increase in tobacco pricing (smoking), 20% volumetric tax (alcohol consumption), universal access to bariatric surgery (obesity) and LiveLighter marketing campaign (physical activity). The project identified and worked to build a shared understanding of how a selected exemplar intervention might impact the overall preventable proportion of disability adjusted life years (DALYs), as recognised by the AIHW Australian Burden of Disease Study.

Project C: GoHealth system dynamics model of interrelated risk factor preventable chronic disease economic burden, 2018–2022 (Referred to as 'GoHealth')

This project built a dynamic simulation aggregate model that allowed for a full exploration of the challenge of projecting chronic disease burden, including the relationship between key known risk factors, by age and sex, the top 20 chronic diseases by burden in Australia, and then explored economic projected outcomes. Essentially, this system dynamics model took the known epidemiological data available for selected chronic diseases, the relative risks of nine modifiable risk factors (based on prevalence), including adjusting for their interactions, and drove a dynamic population of Australia through the model to project forward dynamic disease burden and related economic outcomes, including productivity. It aimed to predict the economic costs of preventable chronic disease over 30 years and demonstrate which risk factors in combination would have the most significant impact on any potential reductions in chronic disease prevention. The intention was to produce a tool for policy makers that forecast the bulk of preventable disease burden over 30 years, and to allow for multiple risk factor-related policy scenario testing.

This national simulation, known as the GoHealth model, used system dynamics modelling to test the overall impact of nine known risk factors. The GoHealth model assessed the trajectories of risk factors together, in combination or on their own, and recognised the role of risk mediation and co-disease burden, and the option to take a birds-eye view of the chronic disease system changes or dig down into the complexities of specific age and sex risk-distributions. Counteracting risk factor trends within sex and age groups are evident in the historical trend data, while replication of these trends for forecasting allowed more detailed projections.

Health system costs (by disease) and household and business productivity costs were added to support economic analysis that calculates disease burden attributable by both risk factor and disease.

Project D: NSW Premier's Priority Childhood Overweight and Obesity Model, 2016–2018 and extensions through to 2020 (Referred to as 'PP NSW CO&O')

This project was initially commissioned and funded through the Prevention Centre in partnership with the NSW Ministry of Health (MoH), Office of Preventive Health. Two extensions of the project were funded by the MoH. This work was conducted by the Sax Institute for all three model extensions.

In 2015, the then NSW Premier unveiled 12 Premier's Statewide Priorities (PP), which included a target to reduce overweight and obesity in children (5–16 years) by 5% over 10 years. The MoH commissioned a system dynamics model to reduce childhood overweight (including obesity) in 2016 with the question, "Can the 5% target be met through existing strategies alone? And if it can be met, what is the earliest date this can be achieved?" The intent was to demonstrate the impact of any program implementation on the stock (prevalence) of school-aged children 5–17 years with either overweight or obesity. The model did not discriminate between intervention effects that impacted a per unit BMI reduction.

The model was expanded twice, in 2018 and 2020, to include further cross-agency strategies and hypothetical interventions (referred to as 'broader policy intervention switches' in the updated model) outside the current health promotion programs, known as Strategic Directions 1–4. The purpose of these planned expansions was to ascertain the extent to which additional strategies would be required to ensure the target could be met by 2025.

The model was calibrated to existing NSW Health prevalence data and featured key outputs: total cost ($M), Net Present Value (NPV) of costs ($M), and NPV cost offsets of cases of overweight and obesity averted. A comprehensive description of the initial model and its linkages including the key model structures that drive the overweight and obesity was published in 2018.[3]

The 2019–20 extension of this model enabled the integration of data from NSW HealthStats of large gestational age (LGA) births. This accommodated data of overweight mothers and the likelihood of LGA births, including the links to premature delivery of these infants, to improve the calibration of growth rates of overweight in younger children, and expanded partnership with the NSW Office of Sport to access specific aggregated data in relation to the implementation Active Kids voucher program. An online interface was developed and updated several times to accommodate these initiatives and graphed results.

Project E: Harnessing big data and dynamic simulation modelling to tackle child and adolescent overweight and obesity and unsustainability healthcare expenditure in Australia 2018–2020, extended to 2023 (Referred to as 'National DiSCAO')

This project aimed to build a national decision-support tool (learning from earlier local model applications NSW and ACT) for tackling the complex problem of child and adolescent overweight and obesity, for and with the Australian Government Department of Health. Its focus was to support decisions on chronic disease growth, healthcare expenditure and health system burden.

This decision tool was developed using a system dynamic methodology and incorporated participatory approaches where topic experts could guide estimates where needed and select appropriate interventions to test. The system dynamics model contained four main sub-structures:

1. An Australian national population age-chain structure from 1 year to 49 years of age (split into 14 age groupings) and sex, which captured dynamics in the population through changes in three BMI categories, migration, deaths and births
2. An energy balance structure which included dietary intake and energy expenditure, to estimate changes in BMI. In addition to a cohort's expected behaviour, this module reinforced changes in behaviours through child-to-child and adult-to-child role modelling
3. Equations to calculate the relationships between energy deficits or surplus and the impact on BMI categories
4. An intergenerational structure that estimated the proportion of children that enter the age-chain with overweight or obesity, based on adult BMI prevalence and exogenous infant behaviours.

The primary outcome of this model was the prevalence of overweight and obesity in each age-gender group. Three BMI categories were defined using age-specific cut-off points for children and adolescents (Cole, et al. 2000), these represented combined underweight and healthy weight, overweight, and obesity. Five interventions targeting three specific age ranges (and one all-ages) were tested: (a) Early childhood prevention (mothers and 0-2 year olds), (b) Childcare-based interventions (2-3 and 3-5 year olds), (c) School-based interventions (6-8, 9-11,12-14, 15-17 year olds), (d) Sports vouchers (6-8, 9-11, 12-14, 15-17 year olds) and, (e) Sugar-sweetened beverage tax (all age groups).

Although the interventions tested in this model were all targeted to childhood and adolescent settings, the flow-on effects could be seen over a longer age span than in the PP NSW CO&O model. Modelling population BMI distributions up to 49 years of age in this model allowed model users to observe and compare the long-term impact of interventions (this was not possible in the PP NSW CO&O model).

Project F: Gestational diabetes (hyperglycaemia in pregnancy) in the ACT hybrid model, 2015–2019 (Referred to as the 'HiP model')

This project was funded by the Prevention Centre partnership in collaboration with researchers from University of Saskatchewan, Canada and ACT Health. This multiscale model was developed to understand reasons behind increasing rates of hyperglycaemia in pregnancy (HiP) among birthing women in the ACT and the significant impact on health service demand and resources. The model was developed to understand which population health interventions would have greatest impact on reducing HiP.

The agent-based model of female ACT residents and their offspring focused on relevant risk factors and physiological transitions at an individual level associated with hyperglycaemia in pregnancy (including gestational diabetes, and pre-existing Type 1 and Type 2 diabetes) and other health impacts on women and their babies in the ACT. It also included discrete-event modelling of treatment pathways in the ACT Health system and additionally used system dynamics to represent the physiological processes underlying the development of diabetes, for example, glycemia and beta cell depletion. The model was calibrated against a range of empirical data.

The individual ABM coupled two key individual physiological components in pregnant women and their infants over multiple generations (more than 120 years):

- body composition and weight dynamics – dynamics of mass, stature growth in children, calibrated caloric intake and expenditure distribution, breastfeeding adherence and impacts on child and mothers.
- glycaemic regulation and diabetes progression – interaction between glycemia, insulin, β-cell mass; evolution of β-cell mass and function, weight and trimester-specific insulin sensitivity in pregnancy, and insulin sensitivity as influenced by interventions.

The impact of maternal weight status interventions on incidence of HiP, pre-pregnancy interventions and inter-pregnancy interventions were the scenarios explored using this advanced DSM.

Project G - Australian Systems Approaches to Physical Activity whole-of-systems mapping, 2019-2022 (Referred to as the 'ASAPa model')

ASAPa is a national project designed to contribute a practical implementation focus to a systems-based practice of physical activity at the population level. A conceptual whole-of-systems map for Australia was developed as part of Getting Australia Active III, a systems approach to physical activity for policy makers, with funding through the Prevention Centre in 2019 under the Medical Research Future Fund Boosting Preventive Health Research Program with Australia's National Physical Activity Network; the work was led by The University of Sydney, Prevention Research Collaboration. This included developing a national physical activity program guide and establishing a surveillance system for physical activity.

To support understanding and promote discussion and policy planning around the multiple factors that influence physical activity, a conceptual systems map (drawing on system dynamics group model building practice) for physical activity that supports systems approaches was developed. National meetings were convened with federal and state government representatives to identify physical activity-related policies and programs. Policies and programs were audited to develop an understanding of the existing physical activity system. A whole-of-system conceptual map for physical activity was developed using feedback from system stakeholders, existing materials, and related work in obesity.

This qualitative 'systems map' underwent several iterations with colleagues to produce a simplified map from 4 to 3 levels:

(1) core influences on physical activity

(2) interventions by strategy and setting

(3) system-level enablers/leverage points.

Comparisons with other international frameworks allowed for gap identification and further policy inclusions. No further quantitative simulation modelling processes were undertaken as they were not in scope for this initial project.

Project H: Strategy planning to reduce chronic and acute Alcohol Harms Tasmania using system dynamics modelling, 2017–2019 (Referred to as the 'Tasmania Alcohol Strategy')

This project was commissioned and funded by the National Medical Research Council, Australian Government Department of Health, NSW Ministry of Health, ACT Health and the HCF Research Foundation through the Prevention Centre and in partnership with the Tasmanian Department of Health and Tasmanian Drug Strategy Advisory Group.

The Sax Institute project team was tasked with developing a dynamic simulation model that served as a what-if tool to test the likely impacts over time of a range of policies and programs to reduce alcohol-related harms in Tasmania. This was a model to support the strategic plan development for Tasmania's next five-year alcohol and drugs plan, a state with some of the highest alcohol consumption rates.

The project used a participatory process to develop the model building. This meant the team could engage stakeholders across many sectors in Tasmania central to decision-making about alcohol-related harms as part of the Tasmanian Drugs and Alcohol Strategic Plan Alcohol Advisory Group. This group consisted of liquor licensing, regulatory bodies, primary health care, emergency departments (ED), alcohol and drug counsellors, epidemiologists, clinical researchers and service providers and health policy makers.

The system dynamics simulation model provided a logically consistent framework that integrated best available evidence, data and expert knowledge, and incorporated the Tasmanian population, its alcohol consumption patterns and trends, its local risk of related hospitalisations and mortality, including for vehicle-related injuries. It tested both scaling up of health-related short-term interventions (GP-led counselling and rehabilitation) and regulatory change to licensing (both hours and size which both affected availability and alcohol consumption), alcohol floor price, in addition to health promotion campaigns, such as the drink driving education marketing.

There were two primary outputs of interest for this model: acute harms, defined as the number of alcohol-related ED presentations per year (modelled up to the year 2031) and chronic harms, defined as the number of people living with alcohol-related chronic disease, and modelled up to the year 2051. Acute harms included ED presentations relating injuries and falls, violence, alcohol poisoning and a sub-category of alcohol-use disorder defined as acute intoxication.

The model could forecast several other outputs related to acute harms and consumption, including alcohol-related road fatalities and serious crashes. These outputs were validated against the Tasmanian road accident dataset from 2011–2016. Population-level alcohol consumption was also modelled as an output, based on national apparent consumption levels, calculated by the Australian Bureau of Statistics on national sales data as no Tasmanian sales data were available at the time. An interactive model dashboard was produced to be used by members of the Drug Strategy Advisory Group to test strategic scenarios over selected time horizons.

Project I: Modelling endgame smoking policy impacts for Queensland, 2017-2018 (Referred to as 'Endgame Smoking')

This dynamic simulation model was developed to deliver strategic policy support to the Queensland Government to reach its target of reducing the smoking rate to 8% by 2026. Multiple strategies had seen the smoking rate in Queensland halved to 12% in the last 20 years and there was interest in knowing which strategies would contribute to reducing smoking further.

The Queensland Government commissioned a system dynamics model, with Prevention Centre support, to inform its smoking reduction strategy by identifying and testing key priority interventions to see which were most likely to make an impact over eight years.

The model included policies designed to reduce product accessibility, acceptability and affordability (including novel options such as licensing of tobacco retail outlets) and increase smoking cessation, and determine what combination of these approaches would produce the greatest public health gains both for the whole Queensland population and those populations with significantly higher smoking rates, including Aboriginal and Torres Strait Islander communities.

The modelling process involved three workshops bringing together key stakeholders in tobacco control, including policy makers, academics and the non-government sector. Representatives from across government, including from the departments of housing and Premier and Cabinet, as well as from interstate governments, also had input into which interventions were likely to work and where energy and time were best invested. This expert input was then combined with research and data to develop a tool that could be used to test and forecast the likely impact of different interventions or combinations of interventions over time. The model captured the whole of Queensland population, their transitions into initiating smoking, maintenance of smoking and attempts to quit smoking, and those who ceased smoking.

Project J: Modelling the impact of COPD in NSW, 2017-2019 (Referred to as 'COPD')

Chronic obstructive pulmonary disease (COPD) has been estimated to affect 7.5% of Australians aged over 40 years, with cumulative symptoms leading to progressive loss in productivity, quality of life, and increased use of the health system. Addressing smoking is the key to preventing COPD and researchers have learned from previous studies that the frequency and duration of quit attempts reduces the risk of developing COPD. However, due to the complexity of COPD and lung function, the future impact on burden of COPD was uncertain.

The Prevention Centre supported this project to develop an ABM to reflect quit attempts in individual smoker behaviours, facilitate forecasting the future burden of COPD in smokers, and allow decision makers to better understand how to target interventions to support smokers to quit.

The project brought together multiple data sources to develop an agent-based model that simulated the behaviour of individual smokers in the real world. Considering individual characteristics, local context and the broader economic and policy environment, the model forecast how adults' smoking behaviour would impact COPD in NSW over the next 50 years.

Unlike previous studies, the model measured how COPD risk was affected by how much people smoke and the length and frequency of their quit attempts. It calculated smoking harms daily, meaning it could predict in more detail the long-term benefits of cutting down or quitting for relatively short periods of time. Calculations were based on recent literature that showed how smokers who attempt to quit tend to overestimate how much they smoke. These biases were investigated, and the model findings were tested against self-report quit attempt data of current and former smokers collected by the Sax Institute's 45 and Up Study.

Project K: Health Minister for a Day Communication Tool - Piloting the use of simulation models as science communication tools, 2019 (Referred to as 'HMfaD')

This Prevention Centre-supported project aimed to prove that there are other ways to 'sell' prevention, than the often-used business case – the idea that prevention is good value for money – through testing different forms of engagement and public visibility.

Simulation modelling was one of the small pilot work streams of this project, with the aim of finding novel approaches to communicate the value of prevention to the public. This component of the project was a partnership with the Australian National Centre for Public Awareness of Science, to set up a suite of internship projects to explore different approaches to communicating the science of prevention. This work stream was the development of a prototype for a computer game named Health Minister for a Day to illustrate the reach and effect of healthy public policies. This activity utilised the generic simulation modelling structure from several existing chronic disease prevention system dynamics models developed with Prevention Centre funding, made available for computer science students to use in two separate software development Hackathons (at the Australian National University and National University of Singapore is) to build digital public policy applications to promote prevention policies. This pilot tested the interest and gauged reactions to using modelling in this way, with a mostly software engineering student target audience.

System dynamics model outputs from multiple runs of pre-existing alcohol and smoking models were produced, exported and described for use by computer science students participating in the ANU and NUS student Hackathons. The data used by these models was publicly available input data drawn from models produced with previous Prevention Centre (NHMRC) funding. These outputs allowed students to develop prototypes of online, interactive dashboards that would facilitate engagement with typical public policies of primary prevention (e.g. risk factor reduction), secondary prevention (e.g. screening) and and/or regulatory restrictions for potential use as public policy simulation tool.

Project L: Three single chronic disease risk ABMs with ACT Health - Healthy Food Policy Interventions ABM, 2018-2019 Alcohol Harm-Reduction ABM and Smoking Reduction (Referred to as the '3 ACT single risk-factor ABMs')

Alongside the Prevention Centre's support to develop an aggregate multiple risk factor simulation model (Project C), ACT Health partnered with the Prevention Centre as a pilot site to build several individual or agent-based models that would explore the impacts of each of these priority risk factors on health, using a combination of behavioural, incidence and administrative data: healthy weight/food regulatory environment, tobacco use and alcohol harms. These three exploratory sub-models could potentially have been used to integrate with the GoHealth, but were essentially used as policy analysis tools by ACT Health to test hypothetical scenarios to understand the potential reach of preventive approaches.

The Healthy Food Intervention Model was an ABM of life in the ACT as it related to overweight and obesity levels. Individuals (youth and adults) interact with a variety of entities and environments, such as schools, the food environment, and territory-controlled venues, which affect their food choices and kilojoule consumption. This was the primary lever of the model: by changing attitudes, available foods, and facilitating better choices, kilojoule consumption changes. As weight changes, so do associated costs and health harms.

The model was designed to include many elements in a simple fashion: for example, weight dynamics focus on energy imbalance and youth consume fewer kilojoules if parents make healthier decisions. It was designed to approximate many real-world weight distributions, cost outcomes, and other trends to validate this approach. The model was run to 2030. Multiple hypothetical interventions were tested, four had notable effects on overweight and obesity levels:

- Business engagement and healthier choices (scaling up and idealised scenarios)
- Healthy Food and Drink Choices Policy
- Unhealthy food and drink marketing changes

The alcohol-use model brought together ACT epidemiologists, researchers, policy officers and computer scientists to develop an agent-based dynamic simulation model that explored strategies to limit acute and chronic harms from risky alcohol consumption. It described a population of 'person' agents who could drink alcohol at drinking events. Once per day, all people had the chance to attend a drinking event, either with their peers or on their own. People must also make alcohol purchasing decisions, which provides a constraint on the amount of alcohol available for consumption. The amount people consume in a given night is impacted by their goal, the effects of intoxication, and the drinking behaviour of any friends at the same event. Model outputs included overall alcohol consumption in solo and social contexts, and levels of chronic and acute alcohol-related harms. The model tested one hypothetical intervention: a minimum price per standard drink.

In the final risk factor model, an agent-based model was developed to explore the impact of modifying three hypothetical regulatory and health promotion interventions to reduce tobacco use in the ACT population: (1) Increasing the minimum purchasing age for tobacco products, (2) Reducing retail sales of tobacco products to persons under the minimum purchasing age, and (3) Reducing secondary sharing of tobacco products to persons under the minimum purchasing age using health promotion messaging.

The model was also built using a participatory approach that engaged policy officers, health promotion officers, epidemiologists, biostatisticians and computer scientists. The structure of the model included interacting agent 'persons' with a smoking use status, level of concern about tobacco use (engagement status) and a pro-smoking score. The pro-smoking score was a function of several risk factors including engagement, social effect of having more or fewer smoking peers, addiction and withdrawal levels and access to tobacco products. Of the three hypothetical interventions simulated, increasing the minimum purchasing age from 18 to 21 years had the greatest impact on smoking prevalence across the population. The interventions that aimed to reduce the sale of tobacco products to minors and reduce secondary sharing produced small reductions on their own.

Practical guidance for policy makers on dynamic simulation modelling

It is important to understand the full extent of dynamic simulation modelling (DSM's) capabilities and limitations before incorporating it into your decision-making process. Below are 12 practical tips for consideration.

1. Clarify your objectives

Before embarking on a DSM project, clearly define your policy question and what you hope to achieve with the model – whether it is to explore potential outcomes, identify the most effective interventions, or gain a deeper understanding of the system's dynamics. A well-defined objective will guide the design and focus of the model, ensuring that it serves your needs.

2. Determine your policy issue

DSM is particularly valuable for addressing dynamic, complex problems, where patterns of behaviour change over time. Can you describe your problem by drawing it as a curve over time that you would like to bend, such as reducing the incidence of a disease, slowing the growth of healthcare costs, or improving health outcomes? If your policy issue involves these kinds of time-dependent patterns and interactions, DSM can help show how different factors contribute to these trends and explore strategies to influence them.

3. Identify and prioritise desired insights

Reflect on the types of insights you hope to gain from the modelling process and consider which ones are critical to your decision-making needs. Some may be more valuable at certain stages of the decision-making process, such as diagnostic insights during problem identification or projection insights during planning. Prioritise key insights to help focus the model's development and ensure it aligns with your strategic goals.

4. Reflect on how you intend to use the model

Consider how you intend to use the DSM process and its outputs. The true strength of DSM lies in its explanatory power – its ability to uncover why things happen and how they can be changed. Reflect on whether your question is more about predicting what will happen, or understanding why things are happening, and how to influence them. The most powerful applications of DSM focus on the latter, offering deeper insights into system dynamics and potential interventions.

5. Consider stakeholder engagement and sustained participation

Successful DSM projects often require extensive input from various parties, including policy makers, researchers, healthcare providers and the community. Will you have sustained buy-in and participation from these stakeholders throughout the project. Do you have the resources – both financial and organisational – to maintain this engagement over time? Sustained stakeholder involvement is crucial for ensuring the model reflects diverse perspectives, remains relevant, and supports implementation of model-derived insights. Also, engaging stakeholders from the start helps ensure the model reflects diverse perspectives and meets the needs of all parties. Ongoing engagement fosters buy-in and supports implementation of model-derived insights.

6 Ensure data availability and quality

The effectiveness of a DSM depends heavily on the quality and availability of data. Before starting, evaluate if you have access to reliable data that accurately represents the key variables and relationships in your system. If data are lacking, consider if additional data collection is feasible or if the model can still provide valuable insights through scenario exploration, even with some data limitations.

7 Embed yourself in the modelling process

For policy makers, actively embedding yourself in the DSM development process is crucial to fully appreciate the model's value. This will help ensure you absorb learnings and insights generated throughout the process, making you better equipped to communicate these insights to others. Identify 'champions' in your organisation who can dedicate sufficient time to actively engage with the model development from start to finish. These champions will gain a deeper understanding of the model and its outputs; they will be prepared to take ownership of the model, ensuring its continued relevance and application. Active participation is key to leveraging DSM's full potential.

8 Be realistic about time and resources

Building and refining a dynamic simulation model is a resource-intensive process. It requires time, technical expertise, and financial investment. Ensure you have the necessary resources and that the timeline aligns with your policymaking process. Rushing development of a DSM can compromise the quality of the insights it provides.

9 Use DSM as a decision-support tool, not a decision maker

DSM is designed to support, not replace, human decision making. The insights generated by the model will help inform your decisions but should be considered alongside other forms of evidence, expert judgement, and the values and priorities of stakeholders. DSM can offer valuable guidance, but it is ultimately a tool to enhance, not dictate, your decision-making process.

10 Prepare for iterative refinement

DSM is not a one-time exercise. As new data become available or as policy contexts change, models should be revisited and refined. Be prepared to iterate on the model, incorporating new information and adjusting assumptions as needed. This iterative process can lead to more accurate and actionable insights over time.

11 Focus on communication and transparency

The value of a DSM lies not just in the results it produces, but in how they are communicated. Ensure there is enough time and effort allocated to present the insights clearly and transparently, making the underlying assumptions and limitations of the model explicit. This will help build trust in the model's findings and facilitate informed discussions with stakeholders.

12 Engage modellers early, but know it is never too late

Incorporating DSM in the policy process early allows for integration of the modellers' expertise throughout the policy's development. Early engagement ensures the modelling aligns with the policy's goals and helps avoid misalignments later in the process. However, even if you are well into the policy process, it is never too late to bring in modellers. They can still provide valuable insights that can refine and improve decision-making at later stages.

Conclusion: Understanding the broader value of dynamic simulation modelling

Dynamic simulation modelling offers a powerful tool in the decision-making toolkit for policy makers, providing a range of insights that extend far beyond traditional predictive capabilities.

Reflecting on George Box's famous quote, "All models are wrong, but some are useful", it is important to reflect the potential use cases for models in the chronic disease prevention space, while also acknowledging that that no model can perfectly represent reality. Therefore, the true utility of a model lies not in its ability to perfectly predict the future, but in its capacity to fill the insights gaps that are needed to advance decision making.

While predictive accuracy is often seen as the hallmark of a model's value, the real strength of DSMs lies in their ability to explore, explain and illuminate the complexities of the systems we seek to influence. By enhancing our understanding of relationships, mechanisms and dynamics within these systems, DSMs empower us to make more informed, strategic decisions. This broader perspective challenges us to rethink what we mean by 'useful' when it comes to modelling.

The 10 types of insights discussed – projection, explanatory, diagnostic, prescriptive, communicative, learning and capacity building, descriptive, consensus-building, gap identification and contextual – demonstrate the breadth of value that DSM can bring to the policy process. Each type of insight contributes uniquely to different stages of decision making, from problem identification to the implementation and evaluation of solutions. This diversity in insight types underscores the need to reassess how we evaluate the utility of modelling in the context of public policy.

Economic insights

Although not specifically mentioned in this report, DSMs can also produce economic insights for finance and budgetary agencies. Several of the models reviewed in this report contained economic variables and calculated costs and benefits, in addition to supporting health outcome insights. The added value of DSM can be demonstrated through alternative scenarios that allow economic agencies to build cost-effectiveness arguments and evidence.

In this knowledge synthesis report, we explored real-world examples from the Prevention Centre's DSM projects to illustrate how these insights emerge in practice. These projects demonstrate the diverse ways DSM can contribute to the research, policy and decision-making landscape, offering valuable lessons on how to harness the full potential of modelling. These examples help show how this type of modelling has uncovered critical insights across a range of public health challenges, providing a more nuanced understanding of complex systems.

We need to broaden our perspective on the role of modelling in decision making. Just as Box's quote prompts us to acknowledge the limitations of all models, it also encourages us to focus on their practical value. It is an invitation to re-examine where and how DSM could add value to the policy process, and provide a deeper understanding and strategic guidance for policy. We also need to understand the stages of the policy cycle and where these insights can be most impactful, and how engaging with the modelling process can enhance the quality and effectiveness of policy interventions.

By embracing a more holistic view of what DSM can offer, policy makers can unlock new opportunities for innovation, improve the robustness of their strategies, and ultimately make better-informed decisions that are more likely to achieve sustainable outcomes. Now that we have established DSM for prevention, it is time to rethink DSM's value proposition and explore its potential for transforming our approach to complex policy challenges.

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