



# Knowledge Laboratory of the Early life Course

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Statistics NZ, Conference Room  
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**MINISTRY OF BUSINESS,  
INNOVATION & EMPLOYMENT**  
HIKINA WHAKATUTUKI

- ▣ What is microsimulation?
  - ▣ A simple example
  
- ▣ MEL-C
  - ▣ Key features, Results, Insights & observations
  
- ▣ Knowledge Lab of the Early Life Course
  - ▣ Aims
  - ▣ 3 models: Obesity, **Education** & Mental health
  - ▣ Web deployment using Shiny

# What is Microsimulation?



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- Simulates plausible data for micro-level units (i.e., people, businesses, ...)
- It (typically) uses empirical data as a basis to simulate real or alternative worlds, and their futures
- It enables experimentation in a virtual lab

# Microsimulation: A virtual world

- Start with a real (or realistic synthetic) sample of people
- Apply statistically-derived rules to reproduce patterns via a stochastic process
- We have created a virtual world (our simulation model)
- Predict what might happen if conditions were to change (i.e., by altering parameters)

# A simple worked example (made up)

- Suppose every child born has the same probability of attending early childhood education (ECE)
- $p = 0.50$
- And that those who **do attend** have the probability of leaving school with qualifications (SCQUAL):
- $p = 0.80$
- And that those who **don't attend** have the probability of leaving school with qualifications:
- $p = 0.50$

# A simple worked example

- Simulation is a **stochastic** process, so you get different results each time
  - On each simulation run, different units may be simulated as
    - (i) attended ECE
    - (ii) left school with qualifications
- Best to take a number of runs and average...
- For 5 runs & 20 units
- $A_v = 10.2/20$  attended ECE
- $A_v = 13.2/20$  left school with qualifications

# A simple worked example



- Suppose an intervention is suspected to increase the probability of children attending ECE to
- $p = 0.80$
- But the probability of leaving school with qualifications remains the same ( $p=0.80$  for attenders;  $p=0.50$  for non-attenders)
- What would happen??

# A simple worked example



- For 5 runs & 20 units,
- $A_v = 16/20$  attended ECE
- $A_v = 14.8/20$  left school with qualifications, an increase from  $13.2/20$  (8% increase)
  
- A very simple model for which simulation probably not needed...  
...But if lots of factors affect ECE attendance, and its association with school qualifications (through potentially multiple pathways)

Microsimulation can capture this in one model,  
and allows counterfactuals to be tested

# A real simulation model: Modelling the Early Life-course (MEL-C)



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## 1. Goals ... what did we do?

- ❑ Developed a software application as a decision-support tool for policy-making

## 2. Rationale ... why did we do it?

- ❑ To improve policymakers' ability to respond to issues concerning children and young people

## 3. Means ... how did we do it?

- ❑ By building a computer simulation model (n=5000) with data from existing longitudinal studies to quantify the underlying determinants of progress in the early life course

# MEL-C

## - Conceptual framework

### Structural level

#### Child characteristics

- *(age)*
- *gender*
- *ethnicity*

#### Parental characteristics

- *age at birth of child*
- *ethnicity*
- *education level*

#### Socio-economic position

- *SES at birth of child*
- *(single-parent status at birth)*

### Intermediate level

#### Family/household characteristics

*e.g. single-parent status, number of children, household size*

**Employment** *e.g. parental employment, welfare dependence*

#### Material circumstances

*e.g. housing: accommodation type, owned-rented, bedrooms number*

#### Psychosocial factors

*e.g. family functioning: change of parents, change of residence*

#### Behavioural factors

*e.g. parental smoking*

#### Other factors

*e.g. perinatal factors*

### Outcome

#### Health service use

*e.g. GP visits, hospital admissions, hospital outpatient attendances*

#### Education

*e.g. reading ability*

#### Social/Justice

*e.g. Conduct disorder*



- ❑ Able to model early life-course very well
  
- ❑ Changing factors in children's lives often had weak effects on child outcomes
  - ❑ Is that just the reality of policy impact?
  - ❑ Need to change multiple factors?
  - ❑ Most important factors sometime not the most policy amenable (maternal education)
  
- ❑ Policy relevance increased by increasing range of outcomes & factors

## ▣ Astute observation 1

- ▣ There are many well-established estimates for factors that impact the lives of children, but these exist in isolation; micro-simulation offers a way to bring these together

– John Lynch, Professor of Public Health, University of Adelaide

## ▣ Astute observation 2

- ▣ ‘Best’ estimates are thought to be derived from systematic reviews/meta analyses, but it is difficult to test their validity.

– David Gough, Professor of Evidence Informed Policy and Practice, Institute of Education

# Knowledge Laboratory - Aims

- ❑ Identify key determinants of child and adolescent outcomes
- ❑ Integrate estimates from systematic reviews/meta analyses into working model of early life course
  - ❑ Developed from MEL-C (n=5000); extended in breadth (more determinants and outcomes), and length (to age 21)
- ❑ Use as knowledge laboratory
  - ❑ Test the validity of 'best' estimates
  - ❑ Test policy scenarios using validated model

- ❑ Important role of policy reference “End User” group
  - Engage key people from government agencies
  - Use their expertise to get better model & policy-relevant scenarios
  
- ❑ Seven agencies involved
  - Health
  - Education
  - Social Development
  - Justice
  - Te Puni Kōkiri
  - Children’s Commission
  - SuPERU



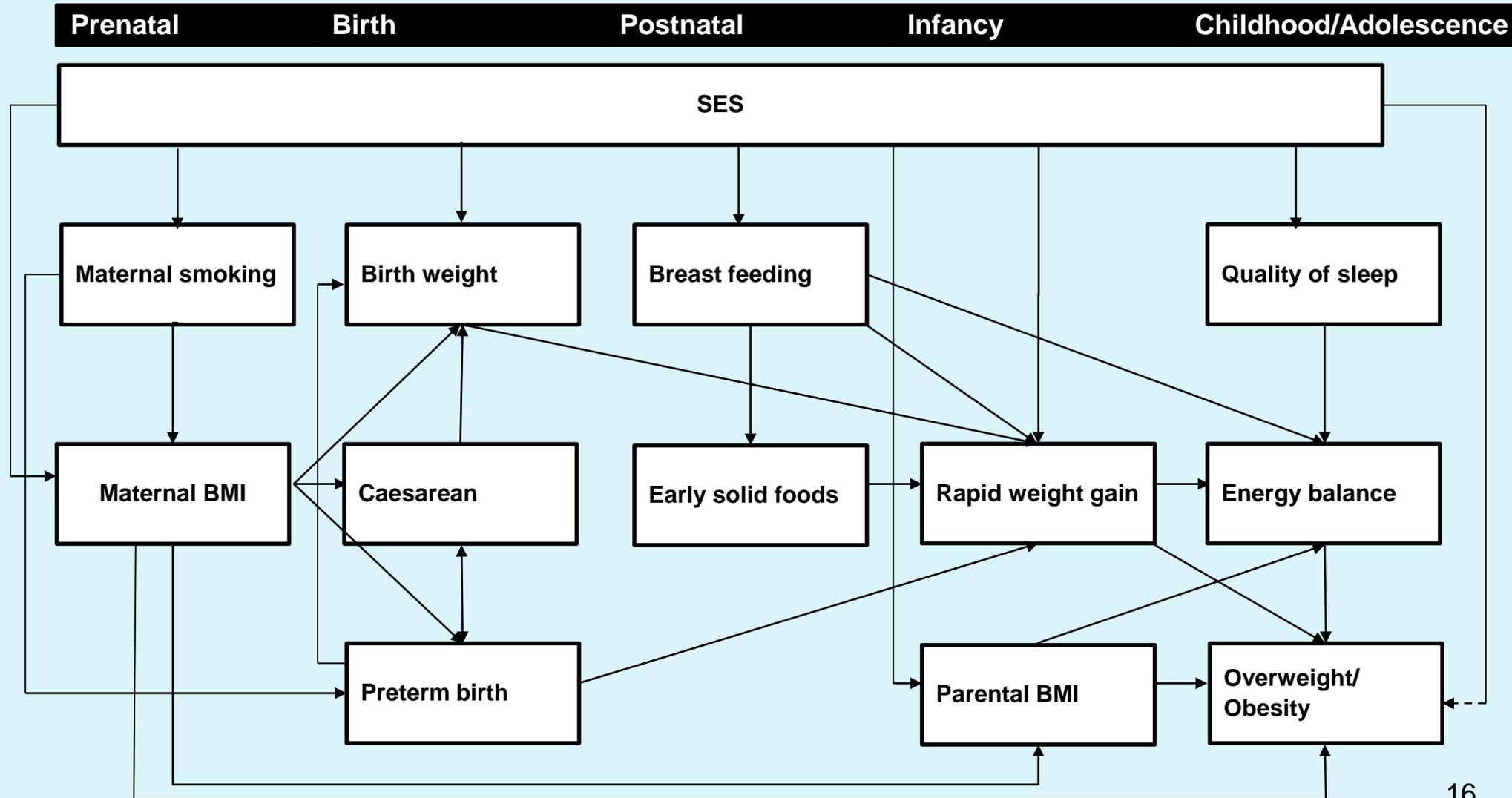
## ▣ Focus on three outcomes

- ▣ Obesity
- ▣ Education
- ▣ Mental Health

## ▣ For each outcome

- ▣ Determine conceptual framework
- ▣ Get NZ prevalences and inter-relations for each predictor in the conceptual framework
- ▣ Get meta-analytic estimates for each path in the conceptual framework
  - Harder than you might think...
  - Quality assessments undertaken

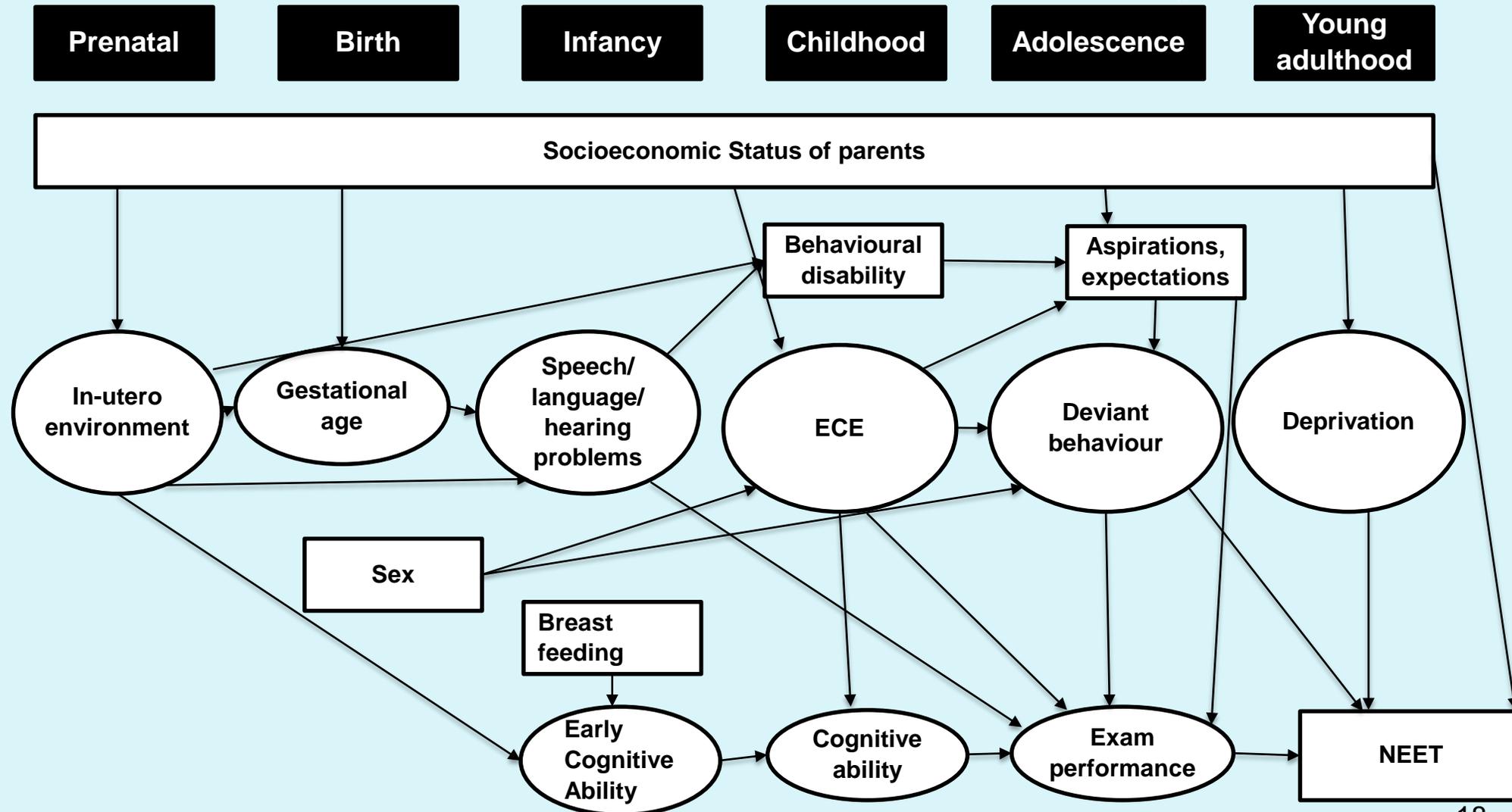
# Obesity - Conceptual framework



# Obesity model - Summary

- ❑ Modest effects of breakfast consumption and maternal obesity
  
- ❑ Effect of risk factors on population obesity determined by
  - ❑ Size of effect of risk factors
  - ❑ Prevalence of risk factor in population
  - ❑ ...as such, often small population effects, though bigger effects for the group that has been changed

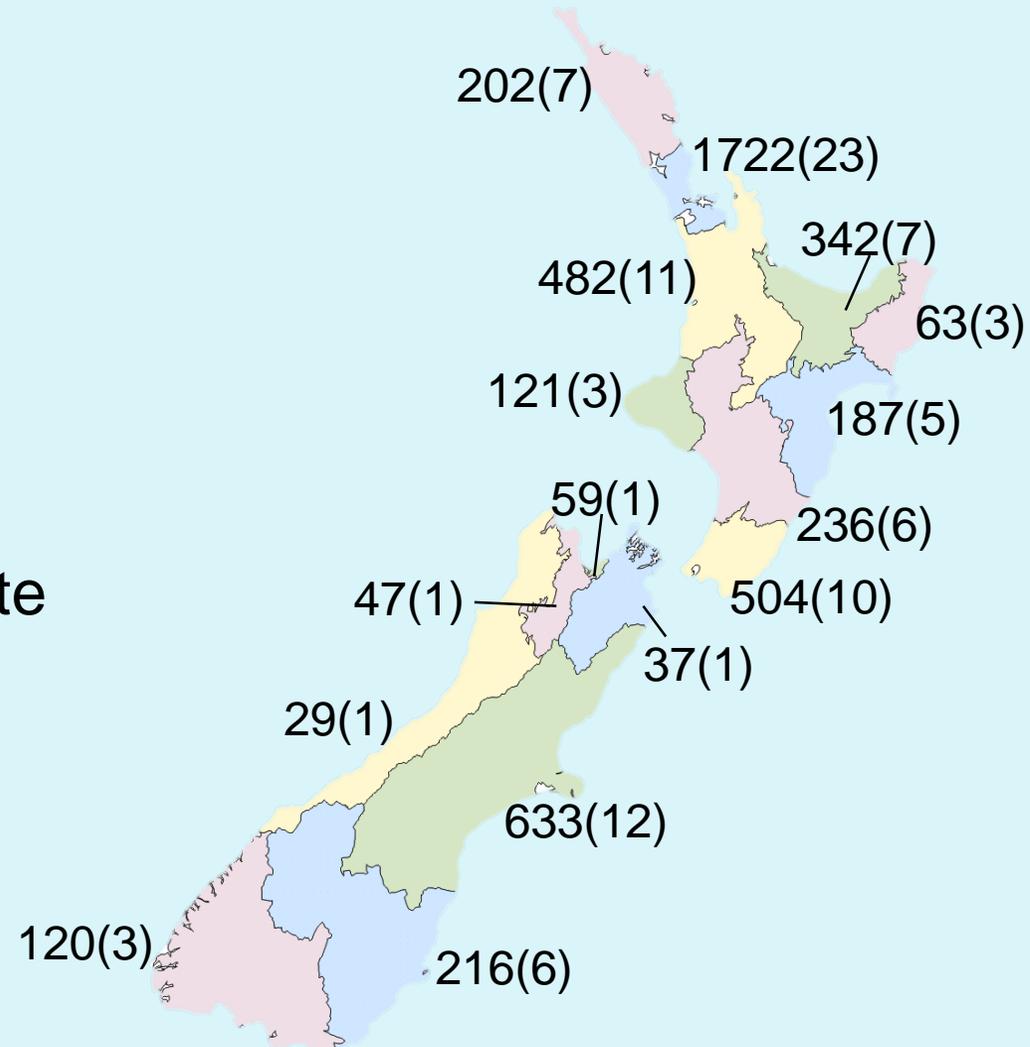
# Education - Conceptual framework



- ❑ To allow school interventions to be modelled
  - ❑ Education, but also Obesity and mental health
- ❑ And to allow for school- and/or teacher and/or peer-level effects
  
- ❑ Nest children within schools in the simulation
  - ❑ More realistic simulation as can account for dependence in data
  - ❑ Child who attend same school more similar
  
- ❑ One (easiest?) way to do this:
  - ❑ Assign children to regions (deterministically)
  - ❑ Assign children to schools within regions (stochastically)

# School and region effects

- ▣ 5000 Children
- ▣ 16 Regions
- ▣ 100 Schools (from 479)
  - ▣ 69 Secondary, 31 Composite
  - ▣ 79 Co-ed, 12 Girls, 9 Boys
  - ▣ 7 Kura Kaupapa
  - ▣ 3 Designated Character



# Education Scenario: 1. Breastfeeding

## ➤ Breastfeeding

- Base: 35.7% never breastfeed, 23.1% breastfed >6 months
- Scenario: Decrease never breastfed to 18%;  
Increase breastfed >6 months to 40%

	Cognitive Development (IQ)			NCEA 2 Attainment (%)		
	Base	Scen	Diff	Base	Scen	Diff
<b>All</b>	99.9	100.4	0.5 (0.1-1.0)	79.0	79.5	0.5 (-0.6-2.0)
<b>Māori</b>	99.4	100.0	0.6 (-0.3-1.8)	66.8	67.4	0.6 (-1.9-2.6)
<b>Pasifika</b>	99.9	100.2	0.2 (-1.8-2.1)	74.3	75.7	1.4 (-5.0-7.3)
<b>Low SES</b>	99.7	100.5	0.7 (-0.2-1.9)	71.2	72.4	1.2 (-1.6-4.1)

# Education Scenario: 2. Otitis media

## ▣ Otitis media

- ▣ Base: 40% of children, at least episode age <5 years
- ▣ Scenario: Reduce to 20%

	Cognitive Development (IQ)			NCEA 2 Attainment (%)		
	Base	Scen	Diff	Base	Scen	Diff
<b>All</b>	99.9	100.9	1.0 (0.7-1.5)	79.0	79.9	0.9 (-0.5-2.3)
<b>Māori</b>	99.4	100.4	1.0 (0.0-2.3)	66.8	67.7	0.9 (-2.5-3.3)
<b>Pasifika</b>	99.9	100.9	1.0 (-0.9-3.3)	74.3	75.7	1.3 (-6.7-8.3)
<b>Low SES</b>	99.7	100.7	1.0 (0.0-2.0)	71.2	71.9	0.7 (-2.2-3.4)

# Education Scenario:

## 3. Early Childhood Education (ECE)

- ❑ ECE Enrolment
  - ❑ Not enrolled 95.9%; Enrolled 4.1%
- ❑ What if the small number of children not receiving ECE ALL received it?

### Setting the Scenario

#### Variable Adjustment

Level	Early Childhood Education
No (%) ▾	0.00
Yes (%) ▾	1.00

#### Base value

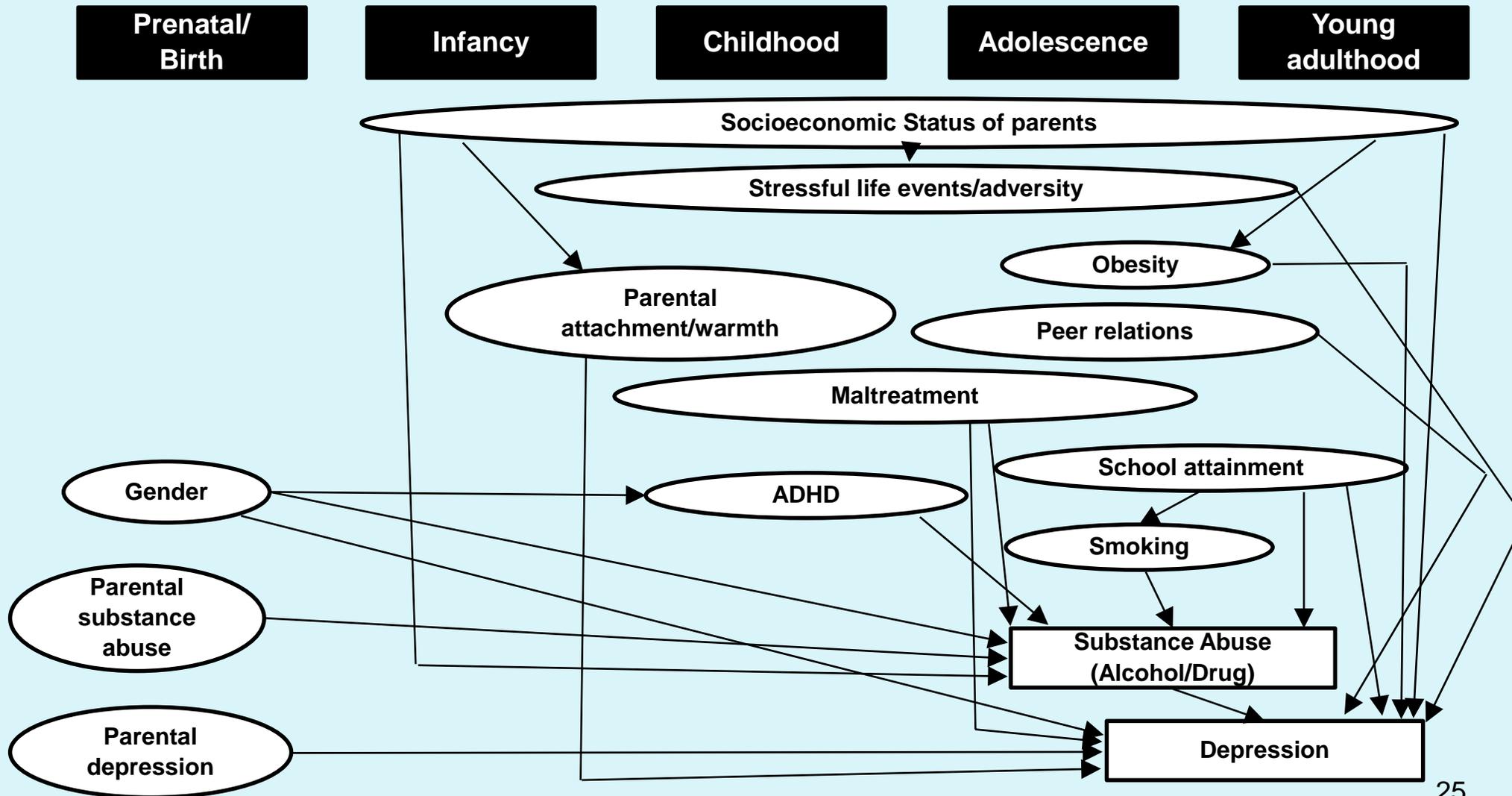
Early Childhood Education ⚡	
No	4.12
Yes	95.88

# Education Scenario: 3. Early Childhood Education (ECE)

- ❑ ECE Enrolment
  - ❑ Not enrolled 95.9%; Enrolled 4.1%
- ❑ What if the small number of children not receiving ECE ALL received it?

	NCEA 2 Attainment (%)		
	Base	Scen	Diff
<b>All</b>	60.1	69.3	9.2 (0.8-18.1)

# Mental health - Conceptual framework



- ❑ Knowledge Lab is a microsimulation model focussing on three outcomes: Obesity, Education and Mental Health
  - ❑ Transitions in the model derived from meta-analytic estimates
- ❑ It can be used to tests scenarios/counterfactuals
  - ❑ May be policy amenable; may not be
- ❑ Will be web-deployed (end 2016) using SHINY
  - ❑ Sneak peak coming up!

# Demonstration - Start



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## Knowledge Lab



🏠 First Page

📈 Model input

🔄 Scenario Builder

📊 Table Builder

### Project upload

#### Choose Project File

Choose File No ... sen

### Saved Scenarios

#### Select saved Scenario:

#### Name the Project:

## Developing a knowledge laboratory of the early life-course using systematic reviews and meta analyses

This is a three -year project funded by the Ministry of Business, Innovation and Employment through its health and Society fund in 2013.

We will identify key determinants of child and adolescent outcomes, and will integrate estimates from systematic reviews and meta-analyses for these determinants into a working model of the early life-course (developed from an existing model we have created). We will use the working model as a "knowledge laboratory" to (i) test the validity of the underlying behavioural equations and specific knowledge sources (meta-analyses, systematic reviews), and (ii) test policy scenarios by carrying out experiments on the 'virtual cohort' created by the working model.

This research will involve the development of a micro-simulation model and associated computer software that allows users (policy makers, planners, analysts) to easily programme simulations and view the results. The end product will be an expert decision-support tool that will be available to the public policy community.

The research plan involves (i) identifying published systematic reviews and meta analyses relating to key outcomes for children and adolescents (to age 18); (ii) integrating estimates from these studies into, and thus enhancing, an existing micro-simulation model of the early life-course; (iii) validating the enhanced model, and thus published estimates, by comparing simulated results to published New Zealand benchmarks; and (iv) using the validated enhanced model to test the impact of various policies on key child and adolescent outcomes.

In using these best estimates to develop a micro-simulation model with which policy scenarios can be tested, our proposal will benefit NZ families/whanau by determining the policies that have the greatest impact on the lives of New Zealand children. Moreover, we will be uniquely placed to assess the impact of distinctive Maori programmes, such as Kohanga reo and Whanau Ora.



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# Demonstration - Table Builder



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Knowledge Lab

First Page

Model input

Scenario Builder

**Table Builder**

Project upload

Choose Project File

Choose File No ... sen

Saved Scenarios

Select saved Scenario:

Name the Project:

Save Project

Variable

Select Summary Measure

Percentage

Variable

Accommodation undetached

Select ByGroup:

None

Select Subgroup for subgroup formula:

None

Operators (And/Or/Complete/Reset):

Please select an operators below

Subgroup formula:

Confidence Interval

Show

Download Table

Download Plot

Base Scenario Barchart Line plot

# Demonstration - Table Builder



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Knowledge Lab

First Page  
Model input  
Scenario Builder  
Table Builder

Project upload

Choose Project File  
Choose File No ...sen

Saved Scenarios

Select saved Scenario:

Name the Project:

Save Project

Latest Update:  
2016-07-01

Variable

Select Summary Measure  
Percentage

Variable  
Overweight in childhood

Select a level to compare:  
Overweight

Select ByGroup:  
None

Select Subgroup for subgroup formula:  
None

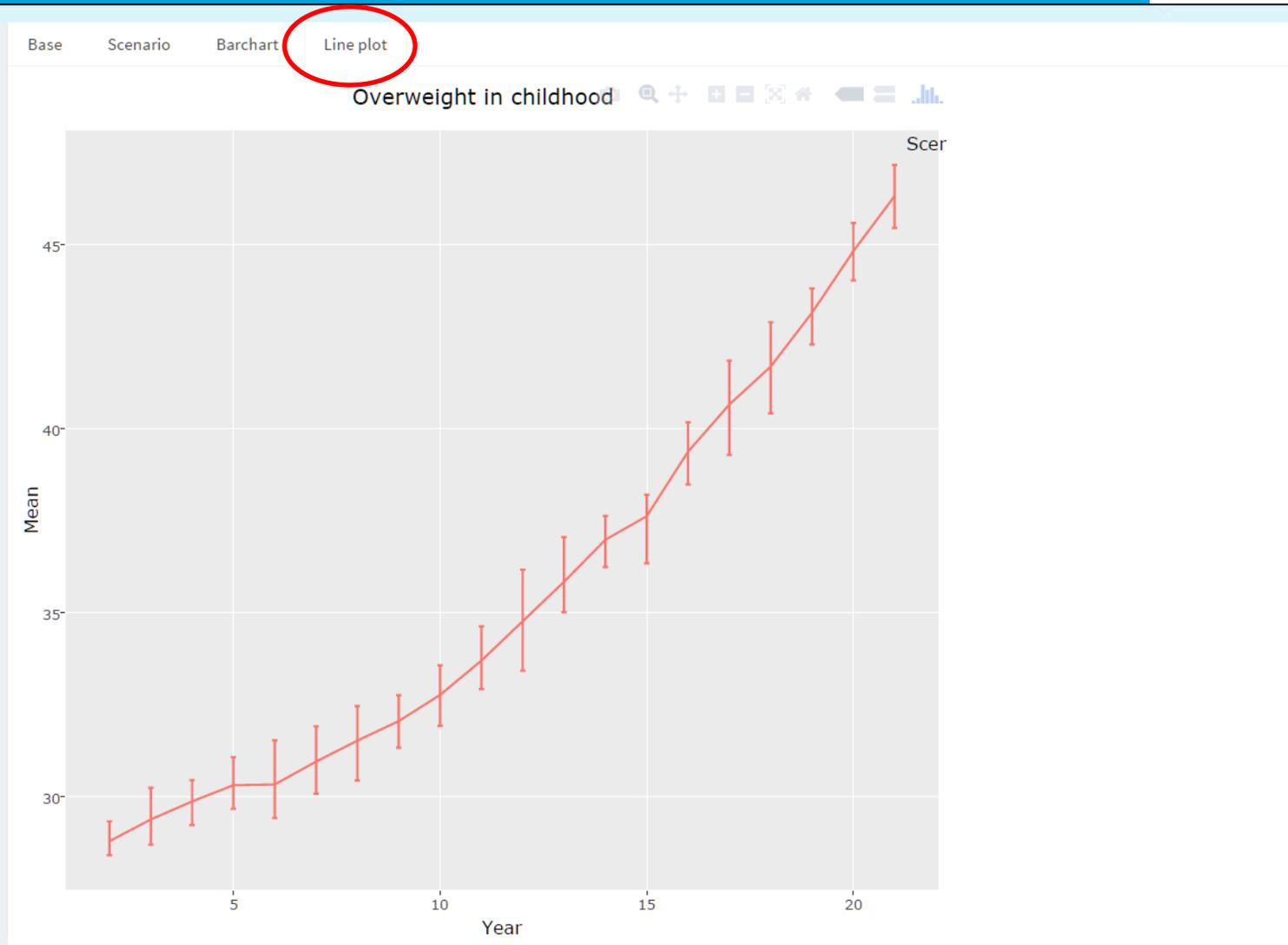
Operators (And/Or/Complete/Reset):  
Please select an operators below

Subgroup formula:

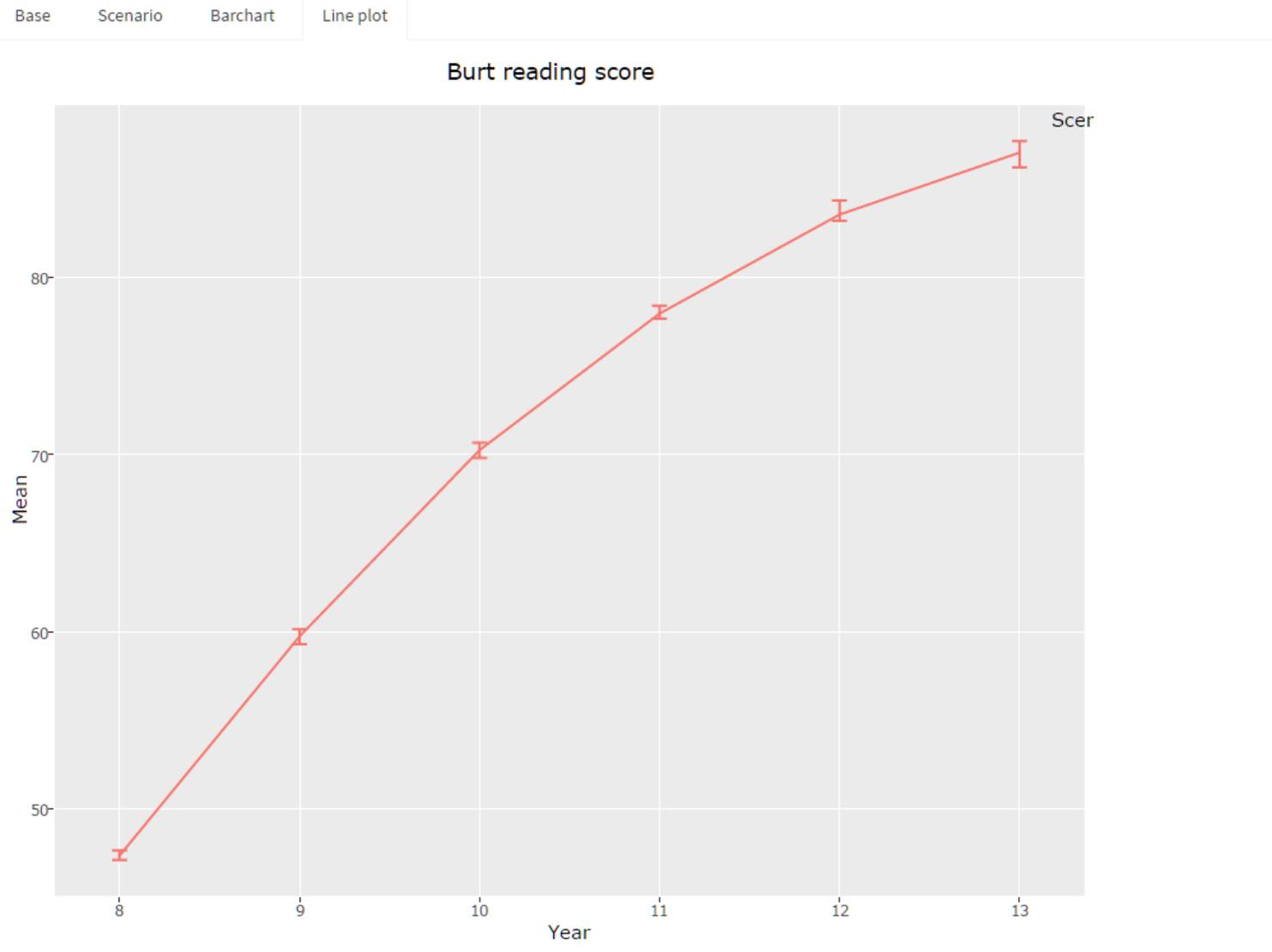
Confidence Interval

Show  
Download Table  
Download Plot

# Demonstration - Line graph



# Demonstration - Line graph



# Demonstration - Table Builder (subgroup)



**Knowledge Lab**

- First Page
- Model input
- Scenario Builder
- Table Builder**

**Project upload**

**Choose Project File**

Choose File No ... sen

**Saved Scenarios**

**Select saved Scenario:**

Breakfast80to100

**Variable**

Select Summary Measure

Percentage

Variable

Overweight in childhood

Select a level to compare:

Overweight

Select ByGroup:

None

Select Subgroup for subgroup formula:

Child ethnicity

Child ethnicity

Maori

# Demonstration - Table Builder (subgroup)



Base	Scenario	Barchart	Line plot
Year	No_Mean	Overweight_Mean	
2	71.28	28.72	
3	70.26	29.74	
4	70.24	29.76	
5	69.7	30.3	
6	69.82	30.18	
7	69.01	30.99	
8	69.05	30.95	
9	68.85	31.15	
10	67.25	32.75	
11	65.45	34.55	
12	63.94	36.06	
13	64.04	35.96	
14	62.81	37.19	
15	63	37	
16	61.04	38.96	
17	59.61	40.39	
18	58.45	41.55	
19	56.87	43.13	
20	54.84	45.16	
21	54.49	45.51	

# Demonstration - Scenario builder



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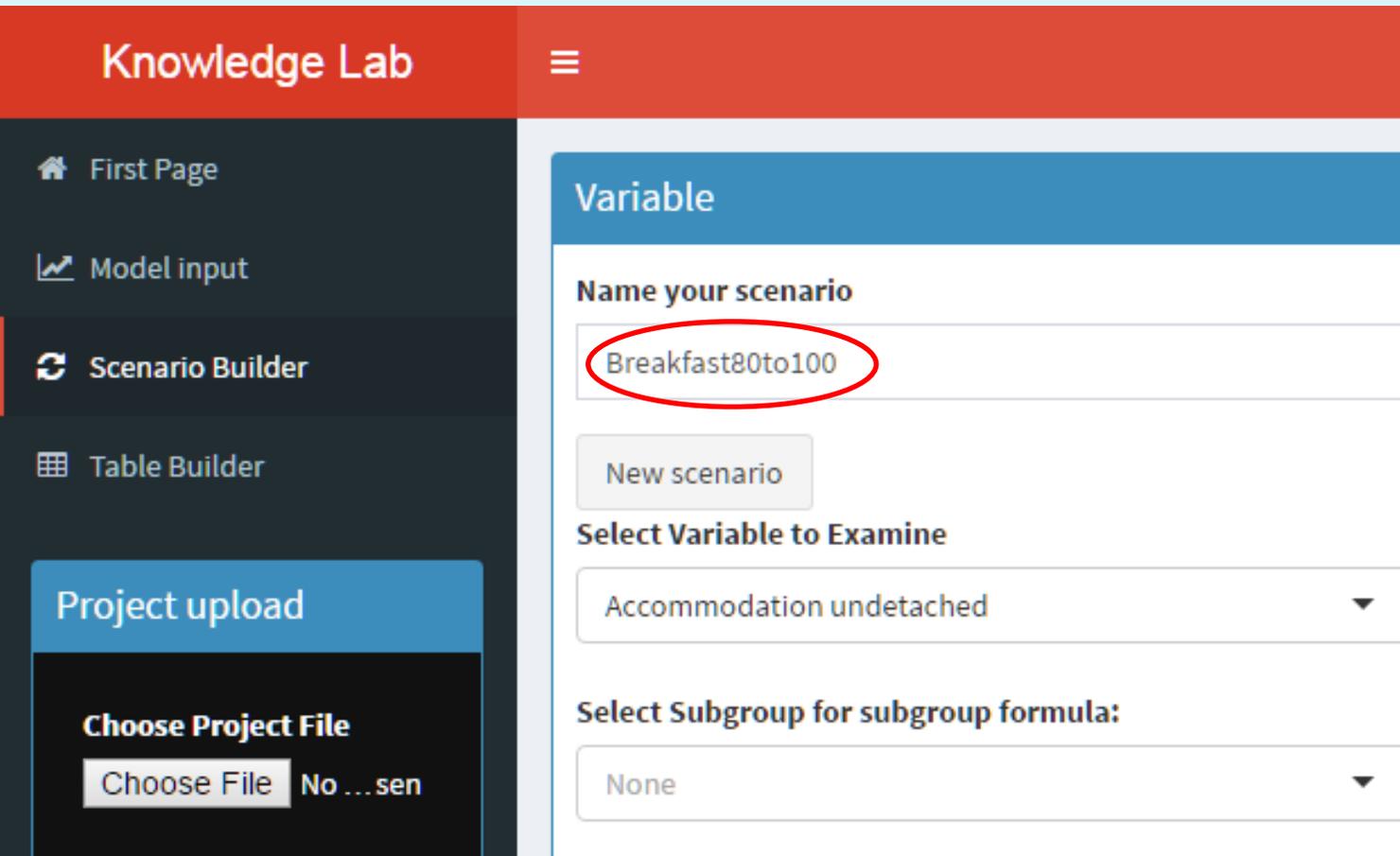
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The screenshot shows the 'Knowledge Lab' interface. On the left is a dark sidebar with navigation options: 'First Page', 'Model input', 'Scenario Builder' (circled in red), and 'Table Builder'. Below these are sections for 'Project upload' (with a 'Choose Project File' button), 'Saved Scenarios' (with a dropdown menu), and 'Name the Project:' (with a text input field and a 'Save Project' button). At the bottom of the sidebar, it says 'Latest Update: 2016-07-01' and 'Contact email:'. The main content area is titled 'Variable' and contains the following fields: 'Name your scenario' (text input), 'New scenario' (button), 'Select Variable to Examine' (dropdown menu with 'Accommodation undetached'), 'Select Subgroup for subgroup formula:' (dropdown menu with 'None'), 'Operators (And/Or/Complete/Reset):' (dropdown menu with 'Please select an operators below'), 'Subgroup formula:' (text input), 'Preview' and 'Add Scenario' (buttons), 'Number of Runs:' (dropdown menu with '4'), and 'Run Scenario' (button). At the bottom, there is a 'Scenario simulation log:' section with a text area containing 'NULL' and an empty input field below it.

# Demonstration - Naming Scenario

- Testing the effect of increasing breakfast consumption on obesity



**Knowledge Lab**

- First Page
- Model input
- Scenario Builder**
- Table Builder

**Project upload**

**Choose Project File**

Choose File No ...sen

**Variable**

**Name your scenario**

Breakfast80to100

New scenario

**Select Variable to Examine**

Accommodation undetached

**Select Subgroup for subgroup formula:**

None

# Demonstration - Selecting vars to change



The screenshot shows the 'Knowledge Lab' interface. On the left is a dark sidebar with navigation options: 'First Page', 'Model input', 'Scenario Builder', and 'Table Builder'. Below these is a 'Project upload' section with a 'Choose Project File' button and a 'Choose File' button. The main content area is titled 'Variable' and contains the following fields:

- Name your scenario:** A text input field containing 'Breakfast80to100'.
- New scenario:** A button.
- Select Variable to Examine:** A dropdown menu with 'Breakfast consumption' selected. This field is circled in red.
- Select Subgroup for subgroup formula:** A dropdown menu with 'None' selected.

# Demonstration



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**Knowledge Lab**

- First Page
- Model Input
- Scenario Builder**
- Table Builder

**Project upload**

**Choose Project File**

Choose File No ...sen

**Saved Scenarios**

Select saved Scenario:

Variable

**Name your scenario**

Breakfast80to100

New scenario

**Select Variable to Examine**

Breakfast consumption

**Select Subgroup for subgroup formula:**

None

**Operators (And/Or/Complete/Reset):**

Please select an operators below

**Subgroup formula:**

Preview Add Scenario

**Base value**

	1
No	18.24
Yes	81.76

# Demonstration



### Knowledge Lab

- First Page
- Model Input
- Scenario Builder
- Table Builder

#### Project upload

Choose Project File

Choose File No ...sen

#### Saved Scenarios

Select saved Scenario:

Name the Project:

Save Project

### Variable Adjustment

Level	Breakfast consumption
No (%)	0.00
Yes (%)	1.00

### Variable

Name your scenario

Breakfast80to100

New scenario

Select Variable to Examine

Breakfast consumption

Select Subgroup for subgroup formula:

None

Operators (And/Or/Complete/Reset):

Please select an operators below

Subgroup formula:

Preview Add Scenario

Number of Runs:

4

Run Scenario

# Demonstration



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## Knowledge Lab

🏠 First Page

📈 Model input

🔄 Scenario Builder

📄 Table Builder

### Project upload

Choose Project File

Choose File No ... sen

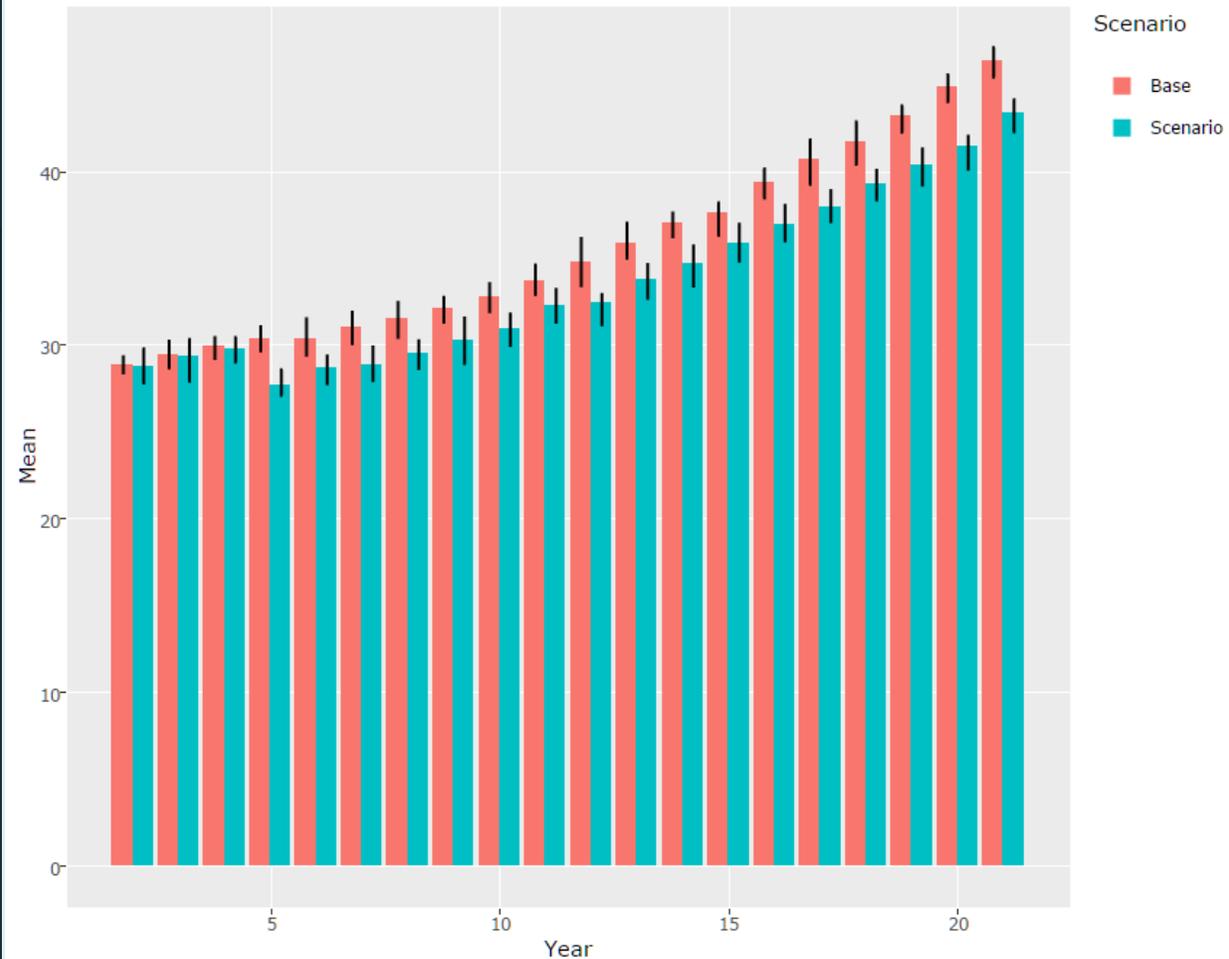
### Saved Scenarios

Select saved Scenario:

Breakfast80to100 ▼

Base Scenario Barchart Line plot

### Overweight in childhood



# Demonstration - ECE scenario

- Testing the effect of increasing ECE on school qualifications

Setting the Scenario

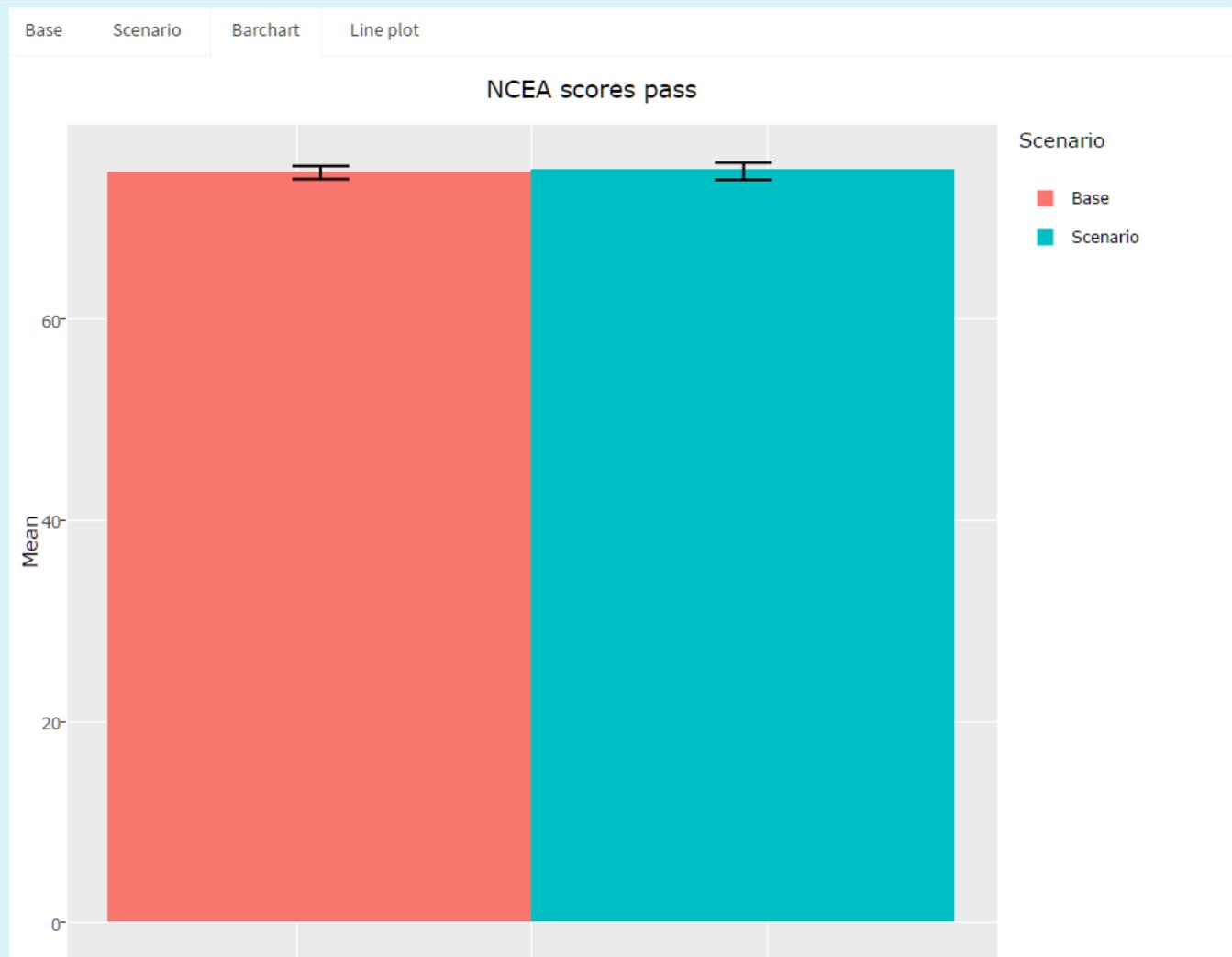
### Variable Adjustment

Level	Early Childhood Education
No (%)	0.00
Yes (%)	1.00

### Base value

	Early Childhood Education
No	4.12
Yes	95.88

# Demonstration



# Demonstration



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- But... School qualifications do change from 62% to 70% among those who previously had not attended ECE

# Demonstration - Saving projects



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## Knowledge Lab

🏠 First Page

📈 Model input

🔄 Scenario Builder

📊 Table Builder

### Project upload

#### Choose Project File

Choose File No ...sen

### Saved Scenarios

#### Select saved Scenario:

#### Name the Project:

breakfast scenario

📁 Save Project

# Demonstration - Uploading projects



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## Knowledge Lab

🏠 First Page

📈 Model input

🔄 Scenario Builder

📊 Table Builder

## Project upload

### Choose Project File

Choose File ECE...ta

ECE.RData

# THANKS!!



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## ▣ Thanks to

- ▣ Nichola Shackleton, Kevin Chang, Jessica McLay, Martin von Randow, Roy Lay-Yee, Pater Davis, Oliver Mannion, Janet Pearson
- ▣ All members of end user group since 2011 (MELC)
  - MOH: Martin Tobias, Pat Tuohy, Jackie Fawcett
  - MOE: Ann Armstrong, Lynne Whitney, Barclay Anstiss, Jasmine Ludwig, Roger Clark
  - MSD: Evan Thompson, Christina Connolly, many others
  - MOJ: Robert Lynn, Maragaret McArthur
  - TPK: Nathaniel Pihama
  - OCC: Kathleen Logan, Donna Provoost
  - SuPERU: Jeremy Robertson, Alex Collier