National Science Challenges

A BETTER START

E Tipu e Rea

Modelling the future: Dynamic microsimulation

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Host Institution

The University of Auckland | Liggins Institute

UC University of Canterbury

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The University of Waikato

Massey University

Victoria University of Wellington

AgResearch

Background

- Need to evaluate the impact of a policy change or intervention
- Expensive to try out and see
- Simulation offers possibility to model interventions on a virtual world
  - Can model the complexity of multiple associations and pathways

Microsimulation

- 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/realistic (synthetic) sample of people
- Apply statistically-derived rules to reproduce patterns via a stochastic process
- Create 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 ← **transition probability**

- And that those who **do attend** have the probability of leaving school with qualifications (SCQUAL):
- p = 0.80 ← **transition probability**

- And that those who **don't attend** have the probability of leaving school with qualifications:
- p = 0.50 ← **transition probability**

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

Imagine 2 individuals

	Run1				Run2			
	p(ECE)	**ECE?**	**p(ScQ)**	**ScQ?**	**p(ECE)**	**ECE?**	**p(ScQ)**	**ScQ?**
Abby	0.5	Yes	0.8	Yes	0.5	No	0.5	No
Brian	0.5	No	0.5	No	0.5	No	0.5	Yes

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…
- <u>For 5 runs & 20 units</u>
- Av=10.2/20 attended ECE
- Av=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,
- Av=16/20 attended ECE
- Av=14.8/20 left school with qualifications,
  an increase from 13.2/20 (8 percentage point 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

Modelling the Early Life-course (MEL-C)

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

Knowledge Laboratory

- 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; extended in breadth (more determinants and outcomes), and length (to age 21)
- Use as ‘knowledge laboratory’
  - Test policy scenarios

https://compassnz.shinyapps.io/knowlabshiny/

End user engagement

- Important role of policy reference “End User” group
  - Use their expertise to determine what they’d like modelled policy-relevant scenarios

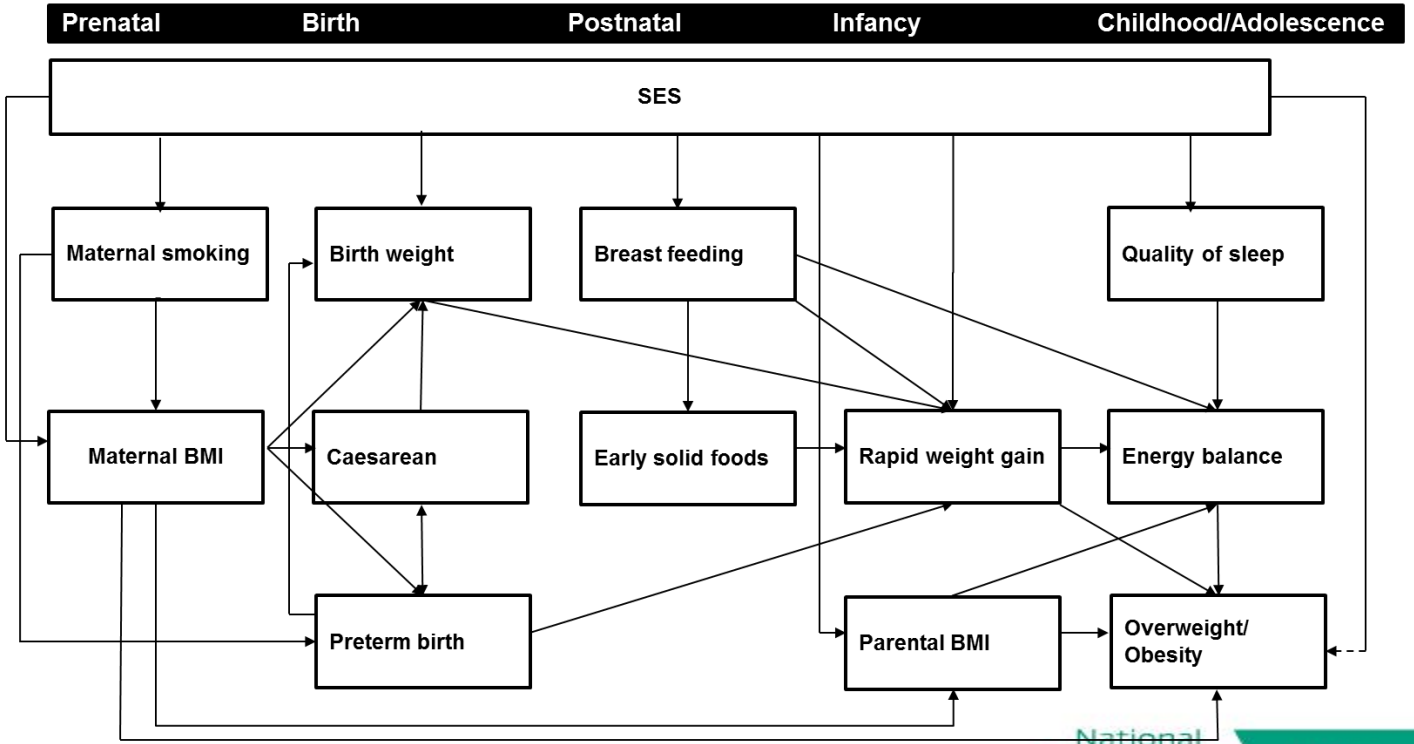
- Seven agencies involved
  - Health, Education, Social Development, Justice, Te Puni Kōkiri, Children’s Commission, SuPERU

Knowledge Lab Outcomes

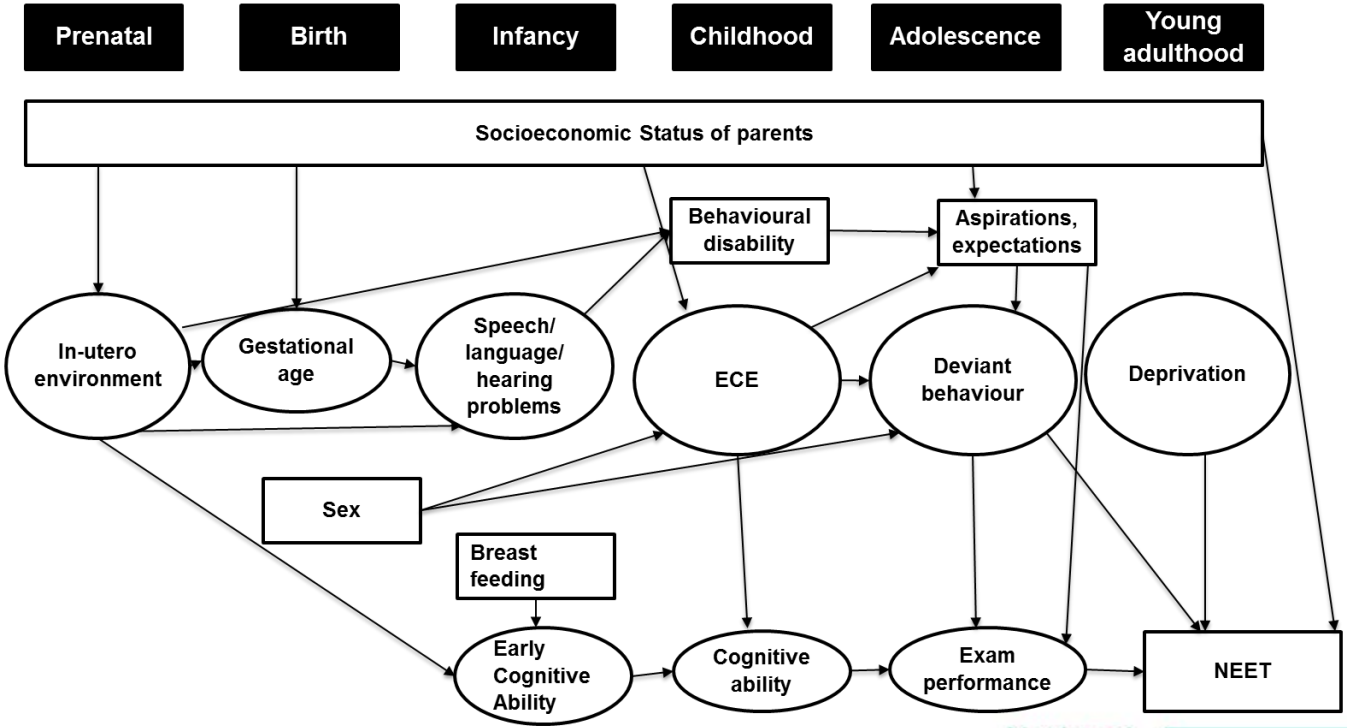
- Focus on three outcomes
  - Obesity
  - Education
  - Mental Health

- 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
  - Build (upon) a computer simulation model to quantify the underlying determinants of obesity, education and mental health

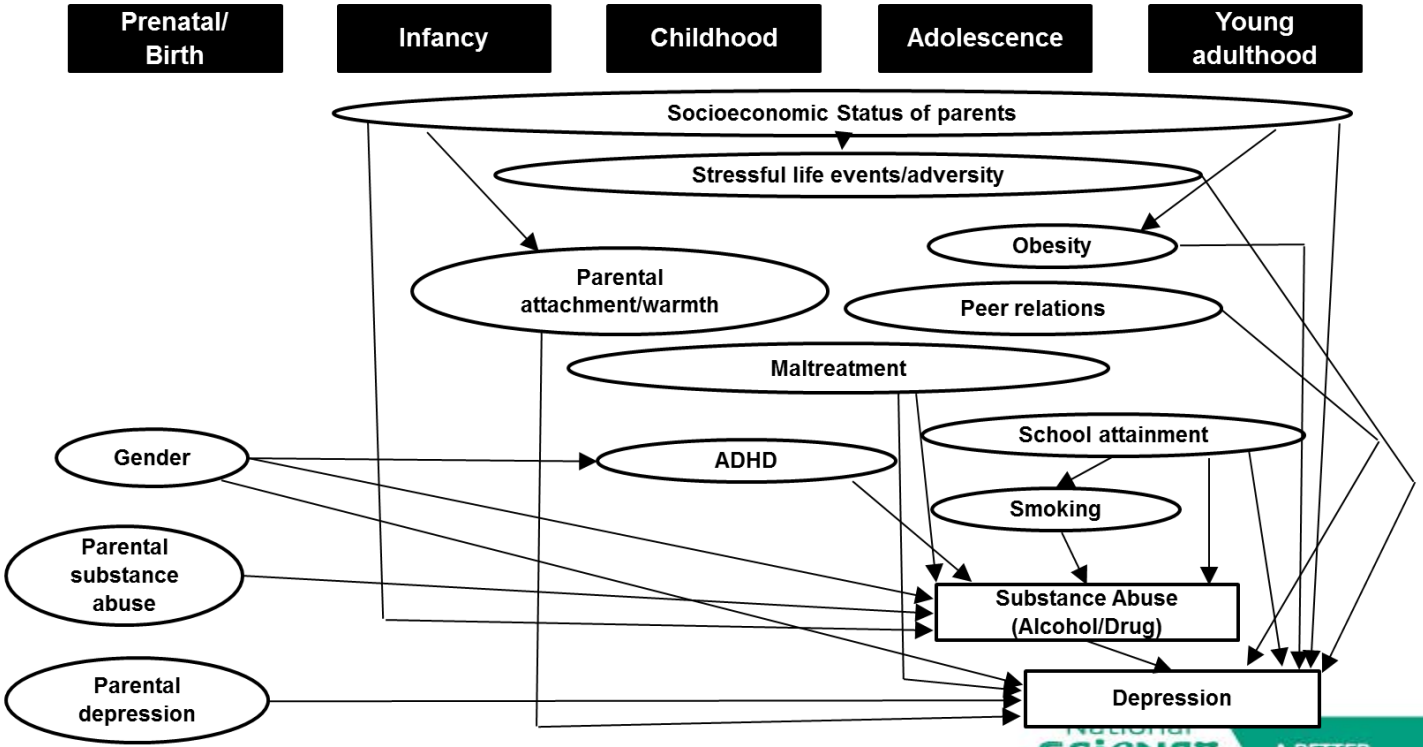
Conceptual framework: Obesity

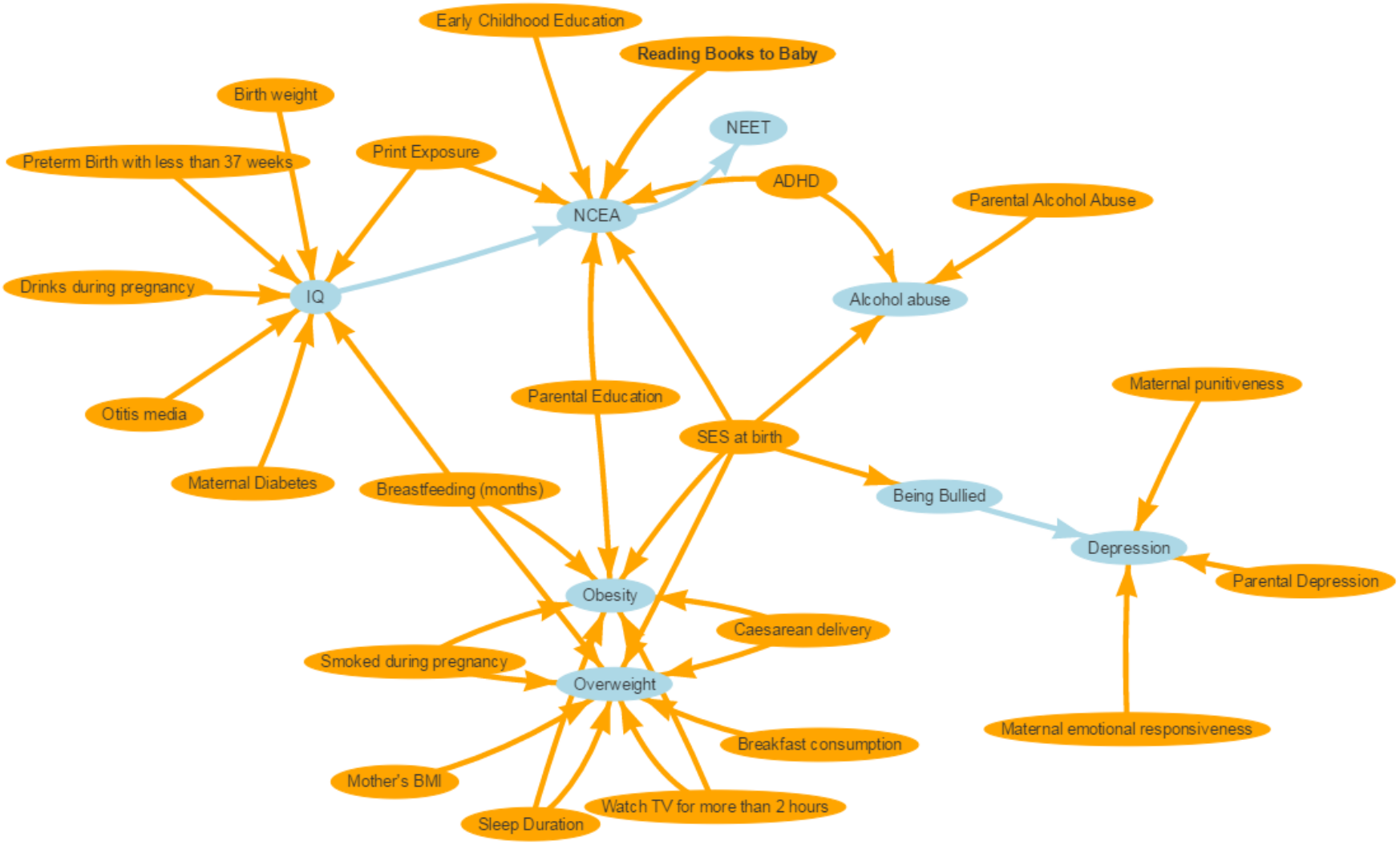


Conceptual framework: Education

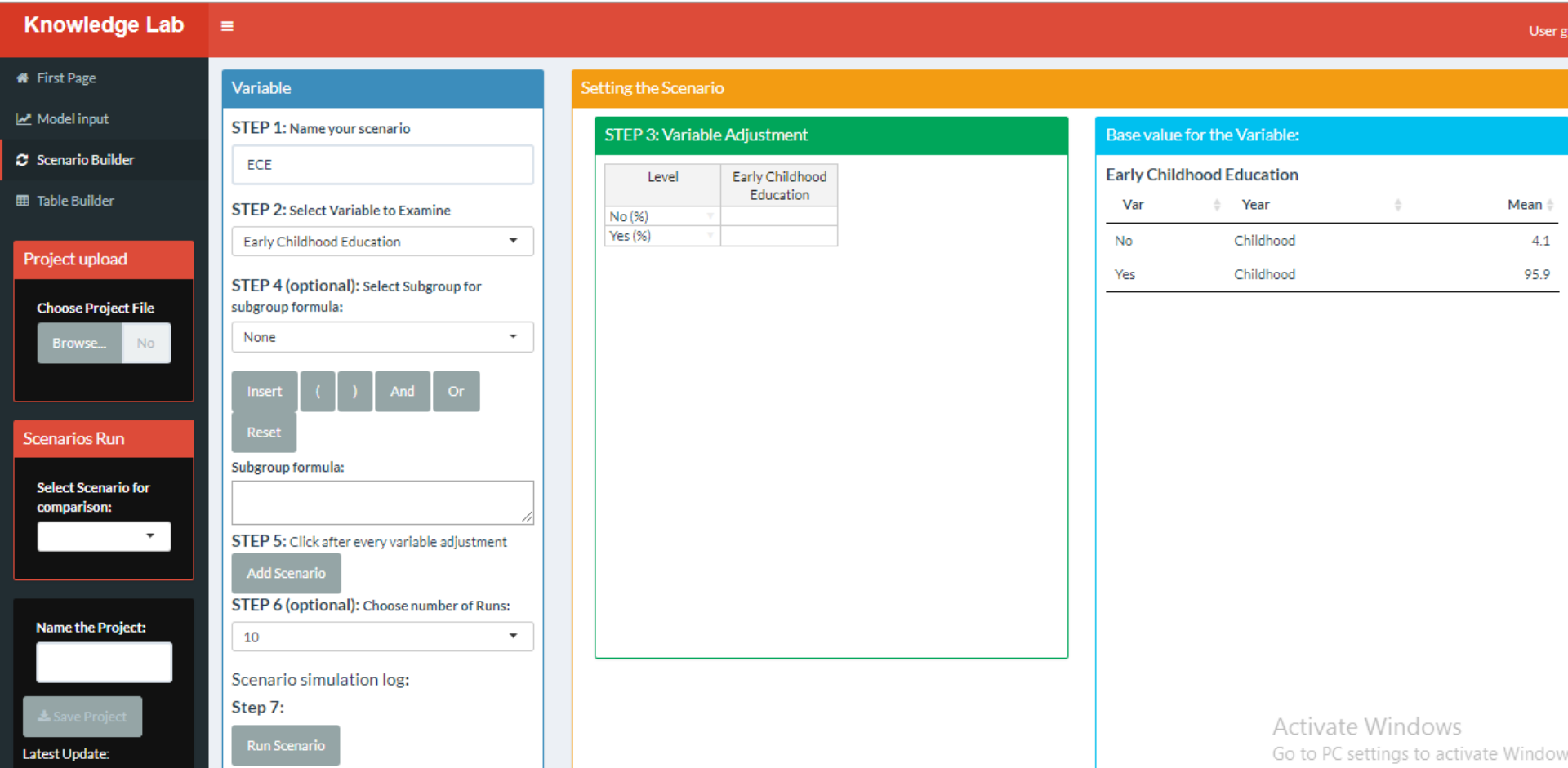


Conceptual framework: Mental health




Early Childhood Education
Reading Books to Baby
Birth weight
NEET
Preterm Birth with less than 37 weeks
Print Exposure
ADHD
Parental Alcohol Abuse
NCEA
Drinks during pregnancy
IQ
Alcohol abuse
Maternal punitiveness
Parental Education
Otitis media
SES at birth
Maternal Diabetes
Breastfeeding (months)
Being Bullied
Depression
Parental Depression
Obesity
Caesarean delivery
Smoked during pregnancy
Overweight
Maternal emotional responsiveness
Breakfast consumption
Mother's BMI
Watch TV for more than 2 hours
Sleep Duration

https://compassnz.shinyapps.io/knowlabshiny/



Testing healthy weight scenarios

- What interventions will have a sizeable impact on childhood overweight?
- Which intervention has the best cost-benefit profile?
  - Costs from intervention literature
  - Lifetime cost of overweight estimated at $109,000 (Gary Jackson, utilising BODE3 estimates)

Shackleton et al. under review, IJO

Testing healthy weight scenarios

- breakfast consumption (universal free breakfast program in school increased breakfast consumption to 95%),
- smoking during pregnancy (interventions including an incentive component (RR=0.76 (95%CI 0.71;0.81)),
- breastfeeding (interventions in developed countries decreased no breastfeeding (RR=0.73 (95%CI 0.57-0.95)),
- sleep (brief sleep intervention focusing on behavioural sleep strategies had effect size of 0.42, equivalent to an additional 15 minutes sleep),
- sedentary activity (meta-analysis of RCTs aimed at reducing screen time reduced it by 4.63 (95%CI 1.59;7.68) hours per week on average),
- caesarean section rates (multifaceted strategies (RR=0.73 (95%CI 0.68;0.79)).

Estimates for 1 year cohort (n=60,000)

Intervention	Estimated change (percentage point)	Cases prevented	$ saved per person
Increasing breakfast consumption from 83% to 95%	-1.71 (-1.96;-1.15)	1026	$1,241.90
Reducing smoking during pregnancy from 21.7% to 16.5%	-0.46 (-0.70; 0.20)	276	$193.76
Increasing breastfeeding from 64% to 74%	-0.33 (-0.57;0.08)	198	-$74.30
Increasing sleep for bottom 25% of distribution by 15 mins	-0.67 (-0.92;-0.41)	402	$534.55
Decreasing % watching 2 hours TV from 45% to 20%	-3.76 (-4.01;-3.54)	2268	$2,839.20
Reduction of Caesarean section rates from 12.6 to 9.2%	-0.45 (-0.71;-0.20)	270	-$3,843.30

Comment

- Micro-simulation a good way to assess the impact of policy changes/interventions, and can be deployed in a format amenable to policy maker use
- Can capture complexity, and is flexible
- A tool - not a substitute for epidemiology
- Local context is important, as are communities (may not be best captured by meta analyses)

Literature comparing effect sizes for Māori vs non-Māori

- 103 interactions reported (from the 38 papers)
- 63 reported that associations differed between Māori and non-Māori
  - Involving obesity (deprivation, rurality) – accounted for
- 40 reported that associations did not differ between Māori and non-Māori

Obesity interventions

1. Dotter D. Breakfast at the desk: The impact of universal breakfast programs on academic performance. *Department of Economics, University of California* 2012.
2. Lumley J, Chamberlain C, Dowswell T, Oliver S, Oakley L, Watson L. Interventions for promoting smoking cessation during pregnancy. *The Cochrane database of systematic reviews* 2009; (3)**:** CD001055-CD001055.
3. Haroon S, Das JK, Salam RA, Imdad A, Bhutta ZA. Breastfeeding promotion interventions and breastfeeding practices: a systematic review. *BMC Public Health* 2013; **13**(Suppl 3)**:** S20-S20.
4. Quach J, Hiscock H, Ukoumunne OC, Wake M. A brief sleep intervention improves outcomes in the school entry year: a randomized controlled trial. *Pediatrics* 2011**:** peds. 2011-0409.
5. Wu L, Sun S, He Y, Jiang B. The effect of interventions targeting screen time reduction: A systematic review and meta-analysis. *Medicine* 2016; **95**(27)**:** e4029.
6. Chaillet N, Dumont A. Evidence-based strategies for reducing cesarean section rates: a meta-analysis. *Birth* 2007; **34**(1)**:** 53-64.